TECHNICAL MANUAL

DX 25U MEDIUM WAVE TRANSMITTER

994 9168 001

I Introduction/Specifications
II Installation
III Operation
IV Theory
V Maintenance
VI Troubleshooting
VII Parts List

Subsections

VIII RF
- Oscillator
- Buffer Amplifier
- RF Amplifier Modules
- Driver Combiner/Motherboard
- Driver Supply Regulator
- RF Multimeter
- RF Combiners
- Output Sample Board &
  Output Monitor

IX Audio
- Analog Input Board
- Analog to Digital Converter
- Modulation Encoders
- DC Regulator
- External Interface

X Control
- Controller
- LED Board
- Switch Board/Meter Panel
- Driver Encoder/Temp Sense Board

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TABLE OF CONTENTS

Section I
Introduction/Specifications

Introduction 1-1
Scope and Purpose 1-1
Equipment Description 1-1
Block Diagram 1-1
Specifications 1-1

Section II
Installation/Initial Turn On

Introduction 2-1
Delivery And Storage 2-1
Returns And Exchanges 2-1
Unpacking 2-1
Factory Test Data 2-2
Transmitter Placement 2-2
Removing the Combiner Crossover Bar 2-2
Cabinet Positioning 2-2
Cabinet Bolts 2-3
Cabinet Ground Strap 2-3
Cabinet Grounding Plate 2-3
Air System And Cooling 2-3
Electrical Installation 2-3
Step Start Panel 2-3
AC Power 2-3
Interconnection Wiring 2-4
Transformer Tap Settings 2-4
Component Installation 2-4
PA Combiner Output Bar 2-4
Transmitter Grounding 2-4
RF Output Connection 2-5
Dummy Antenna Information 2-5
Customer Interface Connections 2-5
Audio Input 2-5
Modulation Monitor Connection 2-6
Frequency Monitor Connection 2-6
External RF Input 2-6
External Interlock (Failsafe) 2-6
Pre-Turn On Checks (Mechanical) 2-7
Pre-Turn On Checks (Electrical) 2-7
Initial Turn On Procedure 2-7
Power Supply Test 2-7
Underdrive Overload Test 2-8
PA Power Supply Check 2-8
Fan Rotation Check 2-8
Driver Operation Check 2-9
Raise/Lower Function Check 2-9
Power Amplifier stage Turn On Check 2-9
Setting Modulation Monitor Sample Levels 2-10
Modulation Check 2-12
Setting Audio Input Level 2-12
Audio Input Phasing Check (Optional) 2-12
Controller Battery Backup 2-12
Recording Normal Meter Readings 2-13
AM Stereo Installation and Tuning Hints 2-13
Interfacing For Stereo 2-13
Bandpass Tuning 2C1 2-13
Remote Control Connections 2-13
Control Inputs 2-13
Analog Monitoring Outputs 2-13
Status Monitoring Outputs 2-13

Section III
Operators Guide

Introduction 3-1
Operating Procedures 3-1
Daily Preoperational Checkout 3-1
Transmitter Turn-On Procedure 3-1
Transmitter Turn-Off Procedure 3-1
Transmitter Operations 3-2
Routine Meter Readings 3-2
Fault Conditions 3-2

Section IIIA
Controls and Indicators

Section IV
Overall System Theory

Introduction 4-1
Block Diagram Description 4-1
RF Section 4-1
Audio and Modulation Section 4-2
Controller Section 4-2
Power Supplies 4-2
Low Voltage Power Supply: Circuit Description 4-2
Power Distribution Board, A39 4-4
PA Power Supply: Circuit Description 4-4
Step Start Panel 4-4
PA Supply Discharge Circuit (Crowbar) 4-4
Power Supply Shorting Switches 4-4
PA Power Supply Transformer T1 4-4
Interphase Transformer T3 4-4
+230 VDC Supply 4-4
+115 VDC and +60 VDC Supplies 4-4
Supply Current Meter, M2 4-5
Secondary Winding Fuses 4-5
Supply Fuses 4-5
Fan Motor Fuses 4-5
A24 and A25 Fuse Board Sample Circuits 4-5
AC Power Protection Circuits 4-5
Overvoltage and Undervoltage Protection 4-5
Loss of Phase and “Brown-Out” Protection 4-5
Air System and Sensing Circuits 4-5
Fans 4-6
Air Flow and Temperature Sensing 4-6
Interlocks 4-6
Door Interlock Circuit 4-6
External Interlock Circuit 4-6
RF Circuits 4-6
RF Drive Splitter, A15 4-6
RF Drive Cables 4-6
Power Amplifier Description 4-7
Combiner Description 4-7
RF Samples from the Output Combiner 4-8
Output Network Description 4-8
Bandpass Filter 4-8
PI Matching Network 4-8

Spark Gap, E2 4-8
Digital Modulation Principles 4-8
Digital Terms and Concepts 4-8
Analog to Digital Conversion 4-9
RF Amplifier Control 4-9
Amplitude Modulation in the DX-25U 4-10
Power Amplifier Stage 4-10
Summary: Digital Modulator 4-10

Section V
Maintenance/Alignments

Introduction 5-1
Maintenance 5-1
Maintenance Logbook 5-1
Preventive Maintenance 5-1
Maintenance Of Components 5-1
Module Replacement/Alignment 5-3
Modules Which Can Be Replaced With No Adjustments 5-3
Buffer Amplifier (A16) 5-3
Predriver 5-3
PA Modules 5-3
RF Drive Splitter Removal 5-4
RF Drive Splitter Replacement 5-4
Boards Which Require Preset Switch Settings or Jumper Plug Positions 5-4
Modulation Encoder (A37) 5-4
Controller A38 5-5
Binary Combiner/Motherboard, Main Combiner/Motherboards (A5-A8) 5-5
Driver Combiner/Motherboard A14 5-5
Printed Circuit Boards Which Require Adjustments 5-5
Analog to Digital Converter (A34) 5-6
Analog Input Board (A35) 5-6
Oscillator (A17) 5-7
Driver Supply Regulator (A22) 5-8
DC Regulator (A30) 5-8
Output Monitor (A27) 5-9
LED Board (A32) 5-11
Driver Encoder/Temp Sense Board (A19) 5-13
Switch Board/Meter Panel (A31) 5-14
Frequency Change Procedure 5-15
Test Equipment Required for Frequency Change 5-15
Frequency Determined Components 5-15
Frequency Determined Jumpers and Switches 5-15
Output Network Dry Tune 5-15
RF Circuits Checkout 5-16
Initial Driver Tuning and Setup 5-17
Initial Tuning At Low Power 5-18
Tuning At High Power 5-19
Completion of Basic Frequency Change of Transmitter 5-19
Other Adjustments 5-20

Section VI
Troubleshooting

Introduction 6-1
Symptom: Transmitter will not turn ON - No ColorStat™ panel indicators are illuminated. 6-6
Possible Causes 6-6
Symptom: Transmitter will not turn on - all ColorStat™ panel indicators are illuminated Green. 6-6
Possible Causes 6-6
Symptom: Transmitter will not turn on - one or more ColorStat™ panel indicators are illuminated RED. 6-7
Possible Causes 6-7
Symptom: Transmitter will turn ON but immediately turns OFF - one or more ColorStat™ panel indicators illuminate RED. The transmitter may try to turn on twice and a fault indicator illuminates AMBER then RED. 6-7
Possible Causes 6-7
Symptom: Transmitter turns On (LOW, MEDIUM or HIGH buttons illuminate) but there is no power output and no PA current is indicated. Supply voltage is indicated on the multimeter. 6-7
Possible Causes 6-7
Symptom: Transmitter is running, but power is lower than normal. 6-7
Possible Causes 6-7
Symptom: Unable to raise power past a certain point. ColorStat™ panel ANT and/or FILTER LED indicate RED. 6-8
Possible cause 6-8
Symptom: Unable to raise power past a certain point. No ColorStat™ panel indicators Illuminated RED. 6-8
Possible cause 6-8
Symptom: Transmitter turns ON (Low, Medium, or High Indicators Illuminate) but will not modulate. 6-8
Possible Causes 6-8
ColorStat™ panel Overcurrent Fault Indication 6-8
Random Faults With Program Audio. Possible Causes: 6-8
Faults With Tone Modulation. Possible Causes: 6-9
Overloads on Turn On. Possible Causes: 6-9
ColorStat™ panel Overvoltage Fault 6-9
Possible Causes 6-9
ColorStat™ panel Supply Fault 6-10
Possible Causes 6-10
ColorStat™ panel Underdrive Fault 6-10
Possible Causes 6-10
ColorStat™ panel Overdrive Fault 6-11
Possible Causes 6-11
ColorStat™ panel Door Interlock 6-12
Possible Causes 6-12
ColorStat™ panel External Interlock 6-12
Possible Causes 6-12
ColorStat™ panel Air Interlock 6-12
Possible causes 6-12
ColorStat™ panel Oscillator Fault 6-12
ColorStat™ panel Buffer Fault 6-13
ColorStat™ panel Predriver Fault 6-13
ColorStat™ panel RF Amp Fault 6-13
ColorStat™ panel Analog Input Board: +15V and -15V Supply Faults 6-13
ColorStat™ panel Analog to Digital Converter 6-13
+15V, -15V, and +5V Supply Faults 6-13
Conversion Error Fault 6-13
ColorStat™ panel Modulation Encoder: Cable Interlock Fault 6-13

WARNING: Disconnect primary power prior to servicing.

Possible Causes 6-14
ColorStat™ panel DC Regulator B+ and B- Supply Faults 6-14
ColorStat™ panel Output Monitor Faults 6-14
+5V and -5V Supply Faults 6-14
VSWR Faults 6-14
Symptom: Loss Of Positive Peak Capability 6-16
Possible Causes 6-16
Symptom: Higher Than Normal Audio Distortion 6-16
Possible Causes 6-16
Symptom: Consistent Loss of RF Amplifiers 6-17
Repeated Loss of Same RF Amplifier In Any Position 6-17
Consistent Loss Of An RF Amplifier In One Particular Position 6-17
Consistent Loss Of Modules In Random Positions 6-17
Other Troubleshooting Techniques 6-18
Handling MOSFET's 6-18
Testing MOSFET's 6-18
Finding A Missing Step 6-18
Using FlexPatch™ for Bypassing a Failed PA Module 6-18
Using FlexPatch™ for Isolating Modulation Encoder/RF Amplifier Problems 6-19
Measuring Drive Level 6-19
Measuring Drive Phasing 6-19
RF Amplifier Drain Phasing 6-20

Section VII
Parts List

Section VIII
Diagrams

Introduction 8-1

Section A
Oscillator (A17)

Introduction A-1
Location A-1
Principles of Operation A-1
Circuit Description A-1
Supply Voltages and Voltage Regulators A-1
Oscillator Stage A-1
Buffer/Squaring Amplifier A-1
Frequency Divider A-1
External Input A-1
Normal or Combined Transmitter Operation A-1
Frequency Monitor Output A-1
Oscillator Sync A-1
Oscillator Output (Buffer-Driver) A-2
"RF Present" Output A-2
Troubleshooting A-2
Symptom: Oscillator LED on ColorStat™ panel is Red, transmitter will not operate. A-2
Symptom: No RF Output, External Oscillator Used . . . A-3
Symptom: Frequency Instability. A-3
Symptom: Output At Incorrect Frequency A-3
Symptom: Oscillator LED on ColorStat™ panel is Red but transmitter operation is normal.. . . . . . A-3

Section B
Buffer Amplifier (A16)

Introduction B-1
Principles of Operation B-1
Circuit Description B-1
Buffer Amplifier Supply Voltage B-1
First RF Amplifier Stage (U1) B-1
Second RF Amplifier Stage (Q1 and Q2) B-1
Third RF Amplifier Stage (Q3 and Q4) B-1
Output Coupling Network B-1
Buffer Amplifier RF Sense B-1
Predriver Supply B-1
Troubleshooting B-1
Symptom: Buffer Amplifier LED on ColorStat™ panel is Red, transmitter will not operate. B-1
Symptom: Buffer Amplifier LED on ColorStat™ panel is Red, transmitter will operate. B-2

Section C
RF Amplifier

Introduction C-1
Principles of Operation C-1
RF Amplifier: Basic Theory Of Operation C-1
RF Amplifier: Half Quad Configuration C-1
RF Amplifier: Full Quad Configuration C-1
RF Amplifier Module On/Off Control Circuit C-1
RF Transformer Primary Current: Amplifier Off C-3
Oscillator Sync Signal C-3
Circuit Description C-3
Supply Voltage C-3
LED Indicators C-4
Cable Interlock C-4
RF Drive C-4
Control Section C-4
RF Output C-5
Troubleshooting C-5
Symptom: Blown Fuse Indicator Illuminated C-5

Section D
Driver Combiner/Motherboard (A14)

Introduction D-1
Circuit Description D-1
Buffer Amplifier Connections D-1
Predriver D-1
Driver Stage D-1
Control Signals D-1
RF Drive Combiner D-1
Driver Tuning D-1

Section E
Driver Supply Regulator (A22)

Introduction E-1
Location E-1
Principles of Operation E-1
Circuit Description E-1
+15 Volt Regulator E-1
Control +VDC Reference E-1
Power MOSFET Operation (A Short Review) E-1
Regulator Section Circuit Description E-2
DC Amplifier Stage (Q2) E-2
Series Pass Transistors Q3, Q4, and Q7 (For Section D8A Supply Voltage) E-2
Series Pass Transistors Q5, Q6, and Q8 (For Section D8B Supply Voltage) E-2

WARNING: Disconnect primary power prior to servicing.

Metering Circuits E-3
Troubleshooting The Driver Supply Regulator. E-3
Symptom: Driver Sect D8A +VDC and Sect D8B +VDC Both High E-4
Symptom: One Output Voltage Is +100 To +110 Volts, Other Can Be Adjusted.. . . . . E-4
Symptom: Both Driver Supply Regulator Output Voltages Are Zero. E-4
Symptom: One Driver Supply Output Voltage is Zero, the Other Can Be Adjusted. E-4
Symptom: Section D8B Voltage Increases Before Section D8A Voltage Reaches +100 Volts.. . . . . E-4
Symptom: Open Loop Operation is Correct, Closed Loop Operation is Faulty.. . . . . E-4

Section F
RF Multimeter (A23)

Introduction F-1
Circuit Description F-1
Metering Driver Section Parameters F-1
Multimeter Probe F-1

Section G
RF Combiners:
Binary Combiner/Motherboard (A1)
and Main Combiner/Motherboards (A2 through A4)

Introduction G-1
Principles of Operation G-1
Circuit Description G-1
Main Combiner/Motherboards (A2 through A4) G-1
Binary Combiner/Motherboard (A1) G-1

Section H
Output Sample Board (A26) and
Output Monitor (A27)

Introduction H-1
Circuit Description H-1
Output Sample Board. H-1
Output Monitor. H-1

Section J
Analog Input Board (A35)

Introduction J-1
Circuit Description J-1
Audio Input. J-1
Bessel Filter J-1
Instrumentation Amplifier (U6, U9) J-1
Buffer Amplifier (U7) J-1
Maximum Power Adjust (U7, R27) J-1
Analog Divider (U10) J-2
Digitally Controlled Potentiometer (U8). J-2
Analog Buffer (U4) J-2
Differential Amplifier/Inverter U4. . . . . J-3
-(Audio + DC) Sample To DC Regulator J-3
Analog Input Board Power Supplies J-3
BCD (Binary Coded Decimal) Coding J-4
Troubleshooting J-4
Symptom: Normal Signal At TP4, No Signal At TP7 (Digitally Controlled Potentiometer Output). J-4
Symptom: Power Increases or Decreases in Steps, Not Continuously J-4
Symptom: +15 VDC or -15 VDC faults J-4

Section K
Analog To Digital Converter (A34)

Introduction K-1
Principles of Operation K-1
Circuit Description K-1
Converting a PA Sample to the A/D ENCODE Pulse (T1, U29, Q9) K-1
Frequency Divider (U29, Q9) K-1
ENCODE Signal Pulse Width (Q9) K-1
Analog to Digital Converter Circuit. K-1
Error Detecting Circuits K-2
One-Shot Operation (U13, U14) K-2
Big-Step Sync Circuit K-3
Reconstructed Audio Circuit K-3
Maintenance K-4
Printed Circuit board Maintenance. K-4
Adjustments. K-4
Troubleshooting K-4
Symptom: ColorStat™ panel CONVERSION ERROR Indicator is RED, transmitter operates normally. K-4
Symptom: ColorStat™ panel CONVERSION ERROR indicator is RED, transmitter can be turned ON. No RF out. K-4
Technical Assistance. K-5
Replaceable Parts Service. K-5

Section L
Modulation Encoder (A37)

Introduction L-1
Principles Of Operation L-1
Modulation Encoding: Explanation and Example L-1
Circuit Description L-1
Supply Voltages L-1
Digital Audio Data Circuits L-2
Inverter/Driver Circuits. L-2
Cable Interlock Circuit L-2
PA Off Circuit. L-3
Blown Fuse Circuits L-3
Clip Circuit L-4
FlexPatch™. L-4
Example. L-4
Single RF Amp Momentary Test L-4
Troubleshooting L-5
Symptom: Suspected Faulty Modulation Encoding L-5
Symptom: Red “PA Off” Indicator Illuminated L-5
Symptom: Cable Interlock Indication L-5

SECTION M
DC REGULATOR (A30)

Introduction M-1
Principles Of Operation M-1
Circuit Grounds on the DC Regulator M-1
UC3834 Integrated Circuit Linear Regulator. M-1
B+ (+5.75 VDC) Regulated Supplies (DC Regulator) . M-2
Modulated B- Supplies M-3
Modulated B- Supplies: Circuit Description M-3
Other Negative Regulated Supplies in the Transmitter. M-3
Regulator Output Inhibit Circuit (U2) M-3
+5 VDC Supply M-4
-5 VDC Supply M-4

Fault Detection Circuits M-4
B+ Fault Circuit M-4
B- Fault Circuit M-4
Interlock Status Circuit M-4
LCD Multimeter M-4
Troubleshooting M-5
Symptom: B+ Fault M-5
Symptom: B- Fault M-5

Section N
External Interface (A28)

Introduction N-1
Principles Of Operation N-1
Circuit Description N-1
Status Outputs (Type A) N-1
Control Inputs (Type B) N-1
Monitor Voltage Outputs N-3
External Interlock N-3
Audio Input N-3
Combiner Interconnect N-3
“PA TURN OFF” and “OFF CONTROL” N-3
External Interface Power Supplies N-4
Troubleshooting N-4
Symptom: No Remote Control Inputs Operate N-4
Symptom: Some Remote Control Inputs Do Not Operate N-4
Symptom: Remote Status Outputs Do Not Operate . . . N-4
Symptom: Some Status Outputs Operate, But One Or More Does Not (fault Indication On Transmitter ColorStat™ panel But No Remote Status Indication) N-4
Symptom: One Or More Remote Status Indications Remain “ON”; Transmitter Status Indication is Off (Green) N-5
Symptom: No Monitor Outputs (Analog Signal Outputs) N-5

Section P
Controller (A38)

Introduction P-1
Function P-1
Location P-1
Block Diagram Description P-1
Transmitter Turn-on/Turn-off Control Logic P-1
Transmitter Power Control Logic P-4
Turn-on/Turn-off Control Logic: Circuit Descriptions P-5
“K1 Turn-on One-Shot” (Monostable U56A-13) P-5
One-Shot Trigger and Operation During Transmitter Turn-on P-6
Delay Circuits: Description P-6
PA Off And Overdrive Inhibit Gate U52-6 . . . . P-6
PA Turn-off (U53-3, U52-6, and S2) P-7
Power Control Logic: Circuit Description P-7
Command Inputs P-7
Switch De-bounce (U45) P-7
Priority Encode/Decode P-7
“Power Level Change” Pulse P-8
Power Level Latch (U40) P-8
Latched “Off” Command P-8
Power Level Latch Outputs P-9
Inhibit Gates U39-3, U39-6 AND U39-8 . . . . P-9
Turn-on Request Gate (U52) and Inverter (U55) P-9
Up-Down Counters: Setting and Storing Digital Power Data P-9
Up-Down Counter Control Gates (U1, U2, U14, U26) P-11
Data Strobe Gates (U1-3/8/11 and U13-8) P-11
Up-Down Counter “Inhibit” Circuits P-11
Multiplex and Output Buffers For BCD Power Data (U9-U11, U21-U23, and U33-U35) P-12
“Data Strobe” Output and Delay (U13-8, U62-10) . . . P-13
Power Control Status Indicator Drivers (U46, U47) . . P-13
Clock Inhibit Gate (U1-6) P-13
Clock Frequency Divider and Delay (U24, U38, and U50-4/10) P-13
Interlock Status Logic: Circuit Description P-14
Interlock Status Logic: Inputs P-14
Interlock Status Logic: Outputs P-16
Interlock Status Logic: Basic Circuit Description P-16
External Interlock: Normal Operation P-16
Door Interlock: Normal Operation P-16
External Interlock: Fault Condition P-16
Door Interlock: Fault Condition P-16
Interlock String Operation P-17
+5B Reset Circuit P-17
+5B Reset-L Output (U37-1) P-17
+5B Reset-H Output (U37-14) P-17
Power Supplies P-18
Voltage Regulator Integrated Circuits P-18
+5B (Backup) Supply P-18
Battery Back-up P-18
Supply Fault Circuits P-18
Regulator “Fault Alerts” P-18
“Regulator Fault Summary” Indicator, DS1 . . . . P-18
“Fast On-Slow Off” Delay Circuit (U49-4) P-18
“Data Clear-L” signal P-19
“Supply Fault-L” signal to LED Board P-19
Analog Metering Buffer/Drivers P-19
Forward and Reflected Power Metering P-19
VSWR Detector Null Metering (U64) P-19
Supply Volts Metering (U63C) P-19
AC Power Recycle (Recycle “On” After Power Failure) P-19
Generates Turn-on Request P-19
Inhibited OFF command P-19
Supply Fault-L, Five second “Off” delay P-19

Section Q
LED Board (A32)

Introduction Q-1
Location Q-1
Transmitter Fault Types Q-1
Type 1 Fault: Turns Transmitter Off Q-1
Type 2 Fault: Recycles Transmitter Off/On One Time . Q-1
Type 3 Fault: Lowers Transmitter Power Q-1
Type 4 Fault: Applies PA Turnoff Q-1
Type 5 Fault: Clears Modulator Data Q-1
Type 6 Fault: PA Module Blown Fuse Indication Q-1
Block Diagram Description Q-1
Type 1 Faults Q-2
Type 2 Faults Q-4
Type 3 Faults Q-4
Type 4 Faults Q-4

Type 5 Faults Q-4
Type 6 Faults Q-4
RF Sense Circuits. Q-4
Reset Circuit. Q-4
Circuit Descriptions Q-5
Reset Circuit. Q-7
Type 1 Fault Circuits Q-7
Type 2 Fault Circuits Q-10
Type 3 Fault Circuits Q-12
Type 4 Fault Circuits Q-16
Type 5 Faults Circuit Q-18
Type 6 Fault Circuit. Q-18
"RF Sense" Circuits on the LED Board Q-18
OSC TEST switch S1 . . . . Q-20
Maintenance Q-20
Printed Circuit Board Maintenance Q-20
Adjustments Q-20

Section R
Switch Board/meter Panel (A31)

Introduction R-1
Power Control. R-1
Multimeter Circuit (M1) R-1
Supply Current Meter Circuit (M2). R-1
Power Meter Circuit (M3) R-1
Maintenance R-2
Adjustments. R-2
Troubleshooting R-2
Symptom: Incorrect Meter Indications. R-2

Section S
Driver Encoder/Temp Sense Board (A19)

General Description S-1
Theory Of Operation S-1
Driver Turn-On Control S-1
Temperature Sensor/Power Foldback S-3
Air Flow Detection S-4
Cable Interlock Monitor S-5
Power Supplies S-5
Maintenance S-5
Adjustment S-5

Appendix A
Lightning Protection Recommendation

Introduction. a-1
Enviornmental Hazards. a-1
What Can Be Done?. a-1
AC Service Protection a-2
Conclusion. a-3

MANUAL REVISION HISTORY 994 9168 001 888-2297-XXX			
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002-A1	12-12-94	Errata	Misc pages - reference to 839 7855 068 & 839 7855 122 changed to 839 7855 151
002-B	01-09-95	39470	Title Page, MRH-1/MRH-2, and pages 7-4 to 7-7
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002-D	08-17-95	40081	Title Page, MRH-1/MRH-2, pages 7-28 to 7-32 and 7-41
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002-N	07-08-96	41326	Title Page, MRH-1/MRH-2, and pages 7-38 & 7-39
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002-R	11-11-96	41384	Title Page, MRH-1/MRH-2, and pages iv to ix, 1-1, all of the following sections 2, 4, 5, 6, 7, 8, H, P, Q, & R
002-S	05-02-97	41732	Title Page, MRH-1/MRH-2, P-14 and all of Section VII
002-S1	05-29-97	41726	Title Page, MRH-1/MRH-2, P-14 and all of Section VII
002-T	06-13-97	TBD	Title Page, MRH-1/MRH-2, and page 5-22
002-T1	06-25-97	41845	Title Page, MRH-1/MRH-2, and pages 7-2 & 7-3
002-T2	06-27-97	41809	Title Page, MRH-1/MRH-2, and pages 7-24 to 7-26 & L-7
002-U	08-05-97	41856	Title Page, MRH-1/MRH-2, and page K-1
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002-Y	02-10-99	42629	Title Page, MRH-1/MRH-2, and page 2-5
002-Z	05-22-00	46105	Title Page, MRH-1/MRH-2, and page 5-15
002-Z1	06-02-00	Errata	Title Page, MRH-1/MRH-2, and page 5-16
002-AA	08-09-00	46332	Title Page, MRH-1/MRH-2, chapter II, pages 3A-13 and 4-4

1.1 Introduction

The DX-25U Medium Wave Transmitter is a 25 kW transmitter that is designed to be able to be upgraded quickly to a 50 kW unit (thus becoming a DX-50 Transmitter). This upgrade requires very little time and the newly configured system would be back in operation at the new power level in a minimum of time.

1.1.1 Scope and Purpose

This technical manual contains the information necessary to install and maintain the DX-25U MEDIUM WAVE TRANSMITTER. The various sections of this technical manual provide the following types of information.

a. Section I, Introduction/Specifications, provides introduction to technical manual contents.

b. Section II, Installation/Initial Turn-on, provides detailed installation procedures and initial turn on instructions.

c. Section III, Operators Guide, provides identification and functions of panel and board mounted controls and indicators as well as of components located in the interior of the transmitter.

d. Section IV, Overall System Theory, provides a block diagram description of the overall transmitter and operation of the various sections of the transmitter not covered in later sections.

e. Section V, Maintenance, provides preventive and corrective maintenance information as well as alignment procedures.

f. Section VI, Troubleshooting, provides a listing of the protection devices in the transmitter as well as low power and high power troubleshooting procedures.

g. Section VII, Parts List, provides an itemized parts list for individual transmitter modules and the overall transmitter.

h. SECTION VIII, Diagrams

i. The following sections provide principles of operation for boards and modules in the DX-25U TRANSMITTER:

- Section A, Oscillator (A17)
- Section B, Buffer Amplifier (A16)
- Section C, RF Amplifier Modules (A101-A244)
- Section D, Driver Combiner/Motherboard (A14)
- Section E, Driver Supply Regulator (A22)
- Section F, RF Multimeter (A23)
- Section G, RF Combiners: Binary Combiner/Motherboard (A19) and Main Combiner/Motherboard (A2 through A4)
- Section H, Output Sample Board (A26) and Output Monitor (A27)
- Section J, Analog Input Board (A35)
- Section K, Analog To Digital Converter (A34)
- Section L, Modulation Encoder (A37)
- Section M, DC Regulator (A30)
- Section N, External Interface (A28)
- Section P, Controller (A38)
- Section Q, LED Board (A32)
- Section R, Switch Board/Meter Panel (A31)
- Section S, Driver Encoder/Temperature Sense Board (A19)

j. Appendix A, Lightning Protection Recommendation, provides information on environmental hazards and possible steps to minimize their effects.

1.2 Equipment Description

The DX-25U is a solid state medium wave amplitude modulated transmitter with a rated output power level of 25 kW. The transmitter is capable of 30 kW and has three user-set power levels. The frequency range is from 531 kHz to 1605 kHz.

1.3 Block Diagram

A Block Diagram description is contained in Section IV, Overall System Theory.

1.4 Specifications

The brochure at the end of the manual gives specifications for the DX-25U transmitter.

NOTE

Harris maintains a policy of continuous improvements on its equipment and therefore reserves the right to change specifications without notice.

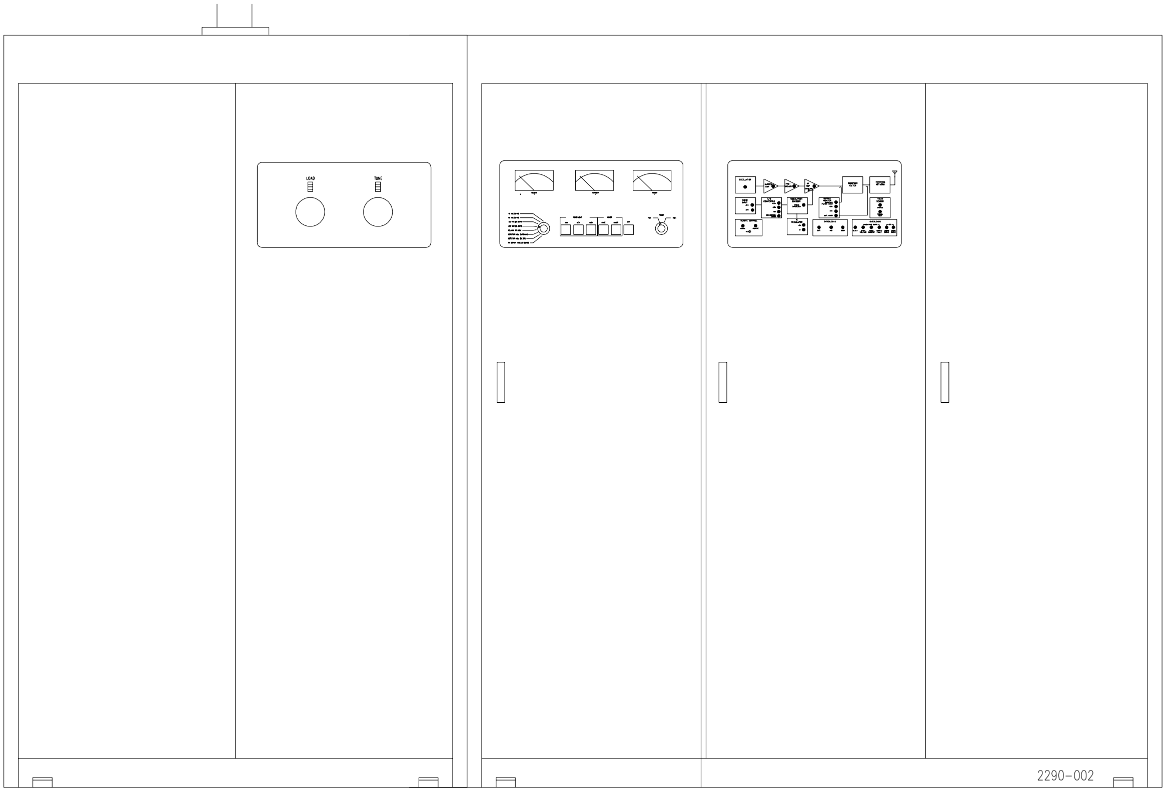

Figure 1-1. DX 25U Front View with Doors Closed

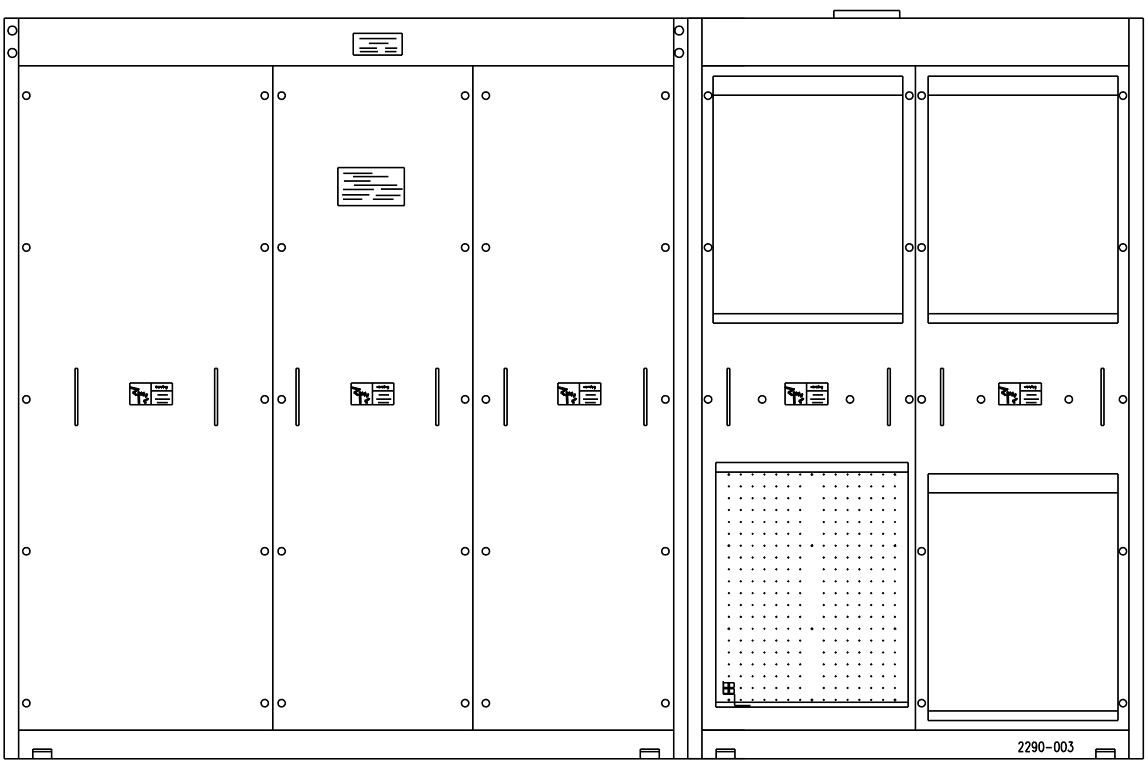

Figure 1-2. DX 25U Rear View with Doors Closed

2.1 Introduction

This section provides information and instructions necessary for the installation and initial turn on of the HARRIS DX-25U MEDIUM WAVE TRANSMITTER, including AM Stereo Installation and Remote Control connections. The instructions are given to minimize the installation time required. Care and precautionary measures are given to prevent problems or injury from occurring during installation.

Planning and Preparation are the most important factors in a successful, efficient, and safe installation of a new transmitter. This section should be read thoroughly prior to installation for a basic understanding of the operation, circuitry, and nomenclature of the transmitter.

The transmitter equipment installation PHASES or STAGES should be planned before the equipment arrives and a detailed plan worked out and written down. Determine what installation equipment and materials are supplied with the transmitter and what equipment the station must supply. In general, a transmitter installation requires that the following areas be addressed:

- In a new installation, WILL THE BUILDING/TRANSMITTER ROOM BE COMPLETED? Electronic equipment can be damaged or made inoperable by dust and dirt. Interior walls should be in place, ceiling work should be complete, concrete floors should be aged and well sealed. Even a plastic covering placed over the transmitter rarely keeps out concrete dust and plaster dust created from drywall installation.
- In a new installation, WILL ELECTRICAL POWER BE AVAILABLE WHEN NEEDED? Often transmitter installation and checkout is held up because primary power is not available for the transmitter.
- In an existing facility, MUST AN EXISTING TRANSMITTER REMAIN ON THE AIR during installation of the new equipment? Plan how this is to be done to minimize off-air time.
- STAGING AREA. An area should be chosen and set aside to place all boxes and crates that contain the smaller parts and assemblies. A separate area should be used to stage all installation material (wire, conduit and accessories, hardware, etc.). Each piece of equipment should be inspected for shipping damage. Inventory all equipment and the contents of each box and compare to the packing list.
- UNLOADING. Will the proper lifting and moving equipment be available when the transmitter arrives? Will there be enough workers to help unload the transmitter?
- EQUIPMENT PLACEMENT. Using a station layout drawing, determine equipment placement AND IN WHAT ORDER EQUIPMENT SHOULD BE SET IN PLACE. If possible, lay out equipment location with lines marked on the floor.
- HANGING HARDWARE. Ensure that all pipe hangers, conduit hangers, threaded rod, beam clamps, Unistrut and Unistrut hardware is on site.
- TOOLS. Ensure that all necessary tools will be on site when needed. Make sure all tools are in good shape. Check technical manuals for the transmitter and other equipment to see if specialized tools are required. Make arrangements to obtain them if necessary.
- During the various stages of installation different personnel may be employed, (i.e. contractors, hired help, general labor). Since they may not be involved in the initial turn on of the transmitter it is vital that their work be closely supervised and checked to avoid any damage or failures to equipment. It is extremely important to prevent debris, especially metal filings and hardware, from getting dropped and lodged into the subassemblies of the transmitter.

2.2 Delivery And Storage

The DX-25U is normally delivered mounted on shipping skids. Smaller components are shipped in cardboard cartons. Any obvious damage should be noted at the time of receipt and claims filed with the carrier.

Equipment capable of handling a 3,000 pound (1,320 Kg) load will be needed to unload the transmitter. Extreme care should be taken during the unloading operation to prevent injury to personnel or damage to the equipment.

If the transmitter is to be temporarily stored, all units require inside storage. Do not stack items except for small cardboard cartons. The storage area should be dry and clean.

2.3 Returns And Exchanges

Damaged or undamaged equipment should not be returned unless a Return Authorization is issued. When communicating with Harris Corporation, Broadcast Division, specify the order number or invoice number. Include complete details regarding circumstances and reasons for return in the request. Custom or special order equipment is not returnable. In instances where return or exchange of equipment is at the request or convenience of the customer, a restocking fee will be charged. Special shipping instructions and coding will be provided to insure proper handling. All returns will be sent freight prepaid and properly insured by the customer.

2.4 Unpacking

Carefully unpack the transmitter and save all packing material. Inspect thoroughly for any damage incurred in shipment. Retain all PACKING CHECK LISTS to help locate and identify any components or assemblies removed for shipping. Remove any shipping supports, and straps prior to initial turn on.

Table 2-1. Recommended Installation Materials NOT SUPPLIED

Ground Strap or Rigid Transmission Line
Welding Torch Set
Oxygen and Acetylene Tanks
Welder's Mask or Goggles
Power Band Saw (can be rented) and Extra Blades
Silver Solder 1/16 inch diameter, 30%-45%, Hard Stay-Silv #45, Aladdin #45, HARRIS part number 099 0002 238
Paste flux (Engelhard Ultra-Flux 1 lb jar) HARRIS part number 099 0002 241
(HARRIS part number 086 0004 040, 16 oz bottle)
Muriatic Acid (quart)
Rubber Hammer
Garden Hose
Baking Soda (two 1-pound boxes)
Three plastic 5-gallon buckets or containers with open tops
Scotch Brite, Scuff Pad/Sand Paper
Steel Wool
Emery Cloth (roll type like plumber uses)
Basic Wiring and Installation
Wire Strippers
Wire Cutters
Lugging Tool
Socket Set 3/8 inch drive with 6 inch extension
Table or Bench
Carpenters Square
Level
Plumb Bob
Chalk Line
Hacksaw and Extra Blades
Wrenches
Prybar
Crowbar
Rope
Saw Horses or Cutting Table
Cable Hoist or Chain-Fall Hoist
Ladders
Files
25-Ft Tape Measure
Claw Hammer
Materials Not Supplied
105kVA wire (See Cabinet Outline for Size)
Copper Strap
Electrical Conduit
Transmission Line
Circuit Breaker or Fused Disconnects
Transmission Line Matching Hardware
Audio Cable
Remote Control Cable

CAUTION

KEEP THE PA CABINET EXHAUST AND ACCESS HOLES COVERED DURING INSTALLATION!

2.5 Factory Test Data

During installation and initial turn on procedure, reference will be made to FACTORY TEST DATA. This data is normally packed with the transmitter or may be inserted in the technical manual. It includes meter readings, measured performance data, frequency determined parts and adjustments for your transmitter.

2.6 Transmitter Placement

Refer to the DX-25U Cabinet Outline, 839-7855-152, in the Drawing Package for important DIMENSIONS, WEIGHT, AIR FLOW, and ELECTRICAL information.

The DX-25U consists of three main components:

- PA Cabinet
- Output Network Cabinet
- Step Start Panel

The PA and Output Network Cabinets are bolted together on-site after positioning and leveling.

Depending on the height of the doors at the site, the Cabinets may have to be removed from their skids. Also the Combiner Crossover bar and cover on top of the PA Cabinet may have to be removed and re-installed later.

2.6.1 Removing the Combiner Crossover Bar

NOTE

Only remove the crossover bar if additional height clearance is needed to move the transmitter during installation.

- Remove the rear access panels from the RF Amp Compartment.
- Locate the combiner crossover bar on top of the Power Amplifier Cabinet. Refer to sheet 1 of the Cabinet Outline Drawing, 839-7855-152.
- Remove the 14 screws that hold the Combiner Cover in place to expose the combiner bar and the Neutralization Board. Remove the screws holding the Neutralization Board and unplug J1.
- Remove the two 3/16 inch Allen head bolts holding each end of the crossover bar to the combiner bar and remove the bar and Neutralization Board.

Once the PA Cabinet is in position, it will be necessary to put the Combiner bar back in place. When tightening the hex head bolts, torque to 80 inch pounds. After the bar is installed, verify that J1 on the Neutralization Board is connected.

2.6.2 Cabinet Positioning

Remove shipping bolts and carefully move cabinets off of the skids. The PA Cabinet is the heaviest and should be positioned first. The center of gravity is near the Power Supply/Driver

Compartment end of the cabinet and should be fork lifted from this end. If roller bars are used, lead with the heavier end.

CAUTION

UNIT MUST NOT BE DROPPED. MAKE A RAMP TO ROLL FROM SKID TO FLOOR.

NOTE

ALONG THE BOTTOM OF THE CABINET FRAME ARE LEVERAGE POINTS FOR ELEVATING THE CABINET TO ALLOW HEAVIER PRY-BARS TO BE POSITIONED UNDERNEATH THE FRAME.

After the PA Cabinet is in position, position the Output Network Cabinet. Maneuver the Output Network Cabinet carefully when joining the two cabinets together so as not to damage any of the exposed fan blades. Make sure that none of the interconnecting wires are exposed while positioning the cabinets. Shim and level the cabinets before bolting together.

If the transmitter is to be positioned into a predetermined wall opening, be sure to allow for the fan blades of the Output Network Cabinet and any final leveling needed when determining the wall opening dimensions.

2.6.3 Cabinet Bolts

Fasten the cabinets together using the 1 inch 1/4-20 stainless steel bolts, flat washers, split washers, and nuts provided in the installation hardware kit. Plastic plugs are provided to cover the hardware access holes in the cabinets. These will prevent air leakage for optimum transmitter cooling.

2.6.4 Cabinet Ground Strap

After the two cabinets are bolted together, fasten the 2 inch copper interconnect strap from the PA Cabinet to 2E1 in the Output Network Cabinet.

2.6.5 Cabinet Grounding Plate

Unbolt the Cabinet Grounding Plate on top of the PA Cabinet and rotate 180 degrees. Secure to the PA Cabinet and Output Network Cabinet with 10-32 screws, flat washers and split washers.

2.7 Air System And Cooling

Refer to Sheet 2 of the DX-25U Cabinet Outline Drawing, 839-7855-152, for information on air flow CFM, heat dissipation and duct work dimensions.

Cooling air for the transmitter enters through the rear of the Output Network Cabinet and exhausts through the top-front half of the PA Cabinet. If an exhaust duct is used, static pressure in the duct must be neutral or slightly negative. Static pressure for air intake at the rear of the transmitter must be neutral or slightly positive. The exhaust grill opening on the top of the PA Cabinet must not be restricted. The dimension from the front edge of the transmitter to the exhaust opening is only 2.3 inches (5.84 mm). This is an important consideration when a wall will be installed along the front of the transmitter.

2.8 Electrical Installation

Refer to sheet 3 of the DX-25U Cabinet Outline Drawing, 839-7855-152, for electrical information.

Sheet 1 of the DX-25U Overall Schematic, 839-7855-151, details the interconnections between the PA Cabinet and the Step Start panel.

2.8.1 Step Start Panel

The Step Start panel is intended to be wall mounted and should be located as close as possible to the PA Cabinet. The conduit may be attached to any of the four sides or the back of the Step Start panel, however, there are no knock-out holes provided on the back of the panel. All transmitter AC power is routed through the Step Start panel to utilize the MOV surge protectors. The grounding strap 3E1, should be connected to a good station ground with 2" copper strap for optimum protection.

2.8.2 AC Power

There are two separate AC power feeds needed for the DX-25U: a three phase 105 kVA input for T1, PA Power supply transformer and a single phase 1 kVA supply for T2, Low Voltage supply transformer. The input voltage for T1 can be from 360 VAC to

Table 2-2. Transformer Tapping for T1 and Blowers

PA Supply Voltage 230 VDC			**Blower Wires #123, #124, & #125**		
Line Voltage	Line to T1 Tap	Jumper	Line Voltage	Line Frequency 60 Hz	50Hz
502 Vac	485	485 to +4%	502 Vac	-4% tap	380 tap
485 Vac	485	485 to 0	485 Vac	-4% tap	380 tap
468 Vac	485	485 to -4%	468 Vac	-4% tap	380 tap
447 Vac	430	430 to +4%	447 Vac	+4% tap	380 tap
430 Vac	430	430 to 0	430 Vac	+4% tap	380 tap
413 Vac	430	430 to -4%	413 Vac	485 tap	380 tap
397 Vac	380	380 to +4%	397 Vac	430 tap	0 tap
380 Vac	380	380 to 0	380 Vac	485 tap	0 tap
363 Vac	380	380 to -4%	363 Vac	485 tap	0 tap

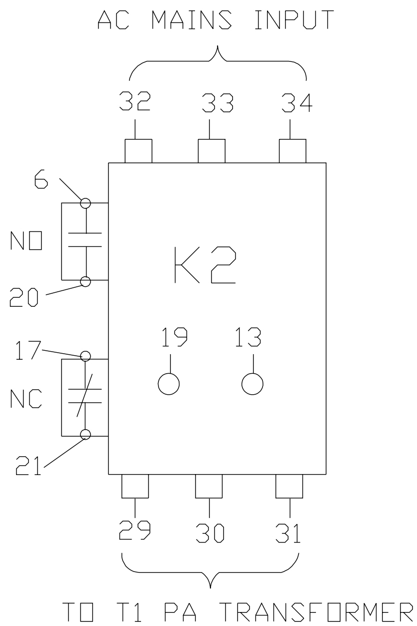

Figure 2-1
K2 in step-start panel connections.

505 VAC, 50/60 Hz. The T2 input voltage can range from 198 VAC to 280 VAC. An optional 1 kVA step-down transformer may be purchased if a separate 240 VAC source is not available.

Refer to page three of the DX-25U Cabinet Outline Drawing for recommended wire and fuse size for the three phase 105 kVA feed.

NOTE

THIS EQUIPMENT IS DESIGNED FOR CONNECTION TO A WYE OR CLOSED DELTA THREE-PHASE POWER SOURCE. EACH AC POWER FEED IS TO HAVE ITS OWN SEPARATE DISCONNECT.

2.8.3 Interconnection Wiring

Refer to Sheet 1 of the DX-25U Overall Schematic, 839-7855-151, and Table 2-3 for interconnect information between the cabinets and Step Start panel. Wires 154, 155, 156, 121, 519, 96, and 97 are part of the wiring harness in the PA Cabinet.

The Installation Kit, 992-8102-001, provides an assortment of wire and lugs to be used between 3TB1 of the Step Start panel and TB3 of the PA Cabinet. Enough wire is provided for a conduit run of approximately 60 feet (18.29 meters). See drawing 3A-10 for component lay out.

The electrical interconnection between the Step Start Panel and the PA Cabinet should be made by using conduit runs into the top of the transmitter. Access is available through the bottom of the transmitter for use of a wire trough. If conduit is used, 3 runs are needed: One for the 105 kVA 3 phase feed, one for the 1 kVA single phase feed and one for the step start control cables. The control cables should be kept separate from any AC input to the transmitter cabinet. Refer to Sheet 3 of the DX-25U Cabinet Outline drawing, 839-7855-152, for drawing details of these runs and the location of the interconnect points.

2.8.4 Transformer Tap Settings

Tapping information for T1 and the blowers will be found on Table 2-2, wire and fusing information will be found on Sheet 3 of the DX-25U Cabinet Outline drawing, 839-7855-152. Tapping information for Low Voltage Supply transformer T2 is silk screened on the center door and labeled on the transformer.

NOTE

If the line voltage falls between the 4% taps or sags when going from no load to full load, tap T1 down to the next voltage combination to avoid unnecessary tripping of the Over Voltage Overload during initial turn on.

2.9 Component Installation

Some components have been removed for shipment, and will have to be reinstalled. These components include the PA Combiner Output Bar and cover and Grounding Plate. Under some shipping conditions, Output Network capacitors may have been removed. For the following information, refer to Sheet 4 of the Overall Schematic, 839-7855-151, and Sheet 1 of the Cabinet Outline drawing, 839-7855-152.

2.9.1 PA Combiner Output Bar

Slide the PA Combiner Output Bar through the feed-through between the PA Cabinet and Output Network Cabinet. Fasten the bar between the Combiner and L1 in the Output Network using 1/4-28 hex screws and lock washers. Make sure the hardware is securely tightened.

Next, slide the Output Bar Cover over the Output Bar. Make sure no packing material is left inside the cover. Secure it using 10-32 screws, flat washers, and split washers. Install the RF Sample Assembly (T6) on top of the cover with 6-32 screws, flat washers, and split washers. Use the silkscreen on the back of the rear access panel as a guide to ensure that the assembly is installed in the correct direction. Wire #96 should be connected to T6.

After the RF Sample Assembly is installed on the Output Bar Cover, fasten the two Close-Out Panels over the feed-through openings. One is mounted on the PA Cabinet side and the other is mounted on the Output Network Compartment side.

2.10 Transmitter Grounding

The PA and Output Network Cabinets must be grounded in addition to grounding the Step Start panel. The transmitter must be grounded to the station ground system with copper strap at least two inches wide and 0.020 inch thick connected to 2E1 in the Output Network Cabinet. A two inch strap connects 2E1 in the Output Network Cabinet with E1/E2 of the PA Cabinet.

All grounding points in the transmitter have a brass block to make grounding connections. Grounding connections external to the transmitter should be brazed.

CAUTION

THE TRANSMITTER MUST BE GROUNDED WITH A LOW IMPEDANCE PATH. THE OUTER CONDUCTOR OF THE RF TRANSMISSION LINE IS NOT AN ADEQUATE GROUND.

2.11 RF Output Connection

The RF output connection is a 3-1/8 inch gas barrier EIA flange connector, (Female). A bullet and O-ring are provided and packed separately. This combination allows mating to a male or female transmission line connector. After the RF output termination is made, make sure the spark gap, E101 in the Output Network Compartment, is set to 0.125 inches.

2.11.1 Dummy Antenna Information

It is very useful to be able to switch the transmitter RF output to a dummy antenna for testing. This testing frequently includes modulating with tones. With tone modulation, 100% modulation of a 30 kW carrier produces an average power of 45 kilowatts. Sustained asymmetrical modulation of a 25 kW carrier, with -100% and +140% peaks, will produce 47 kW of average power that must be absorbed and dissipated by the load. The instantaneous peak power under these conditions will be approximately 152 kW. When selecting a dummy load, select a power rating sufficient for the type of testing to be done. The peak power should be considered when selecting a water cooled load.

2.12 Customer Interface Connections

The following paragraphs include information on customer interface connections for:

- Audio Input
- Frequency and Modulation Monitors
- External Interlocks
- External RF Input

Refer to paragraphs on Remote Control connections for a description of various interface connections.

2.12.1 Audio Input

Use a shielded pair audio cable for connection between processing equipment and Audio Input terminal TB3 on the External Interface. The External Interface is located at the top of the right side wall in the Center Control Compartment.

Audio input connections are as follows:

- TB3-1: Shield (to transmitter chassis ground).
- TB3-2: Audio (+)

Table 2-3. Interconnect Wiring Check List

WIRE #	FROM	TO	LOCATION/DESCRIPTION
PA/OUTPUT CABINET INTERCONNECT			
154	F17	2TB1-1	OUTPUT NETWORK CABINET
155	F18	2TB1-2	SAME
156	F19	2TB1-3	SAME
121	A27-J7	2J1	SAME
519	A27-J1	A26-J1	OUTPUT SAMPLE BOARD IN OUTPUT NETWORK CABINET
96	A17-J3	T6	PA CABINET, PA COMBINER OUTPUT BAR AND COVER ASSEMBLY
STEP START PANEL INTERCONNECT			
13TB1-1TB3-1SINGLE PHASE AC INPUT TO PA CABINET *			
23TB1-2TB3-2SINGLE PHASE AC INPUT TO PA CABINET *			
33TB1-3TB3-3GROUND			
8 CONDUCTOR CABLE			
SHIELD	3TB1-4TB3-4 **		
BLK	3TB1-5TB3-5 **		
BLU	3TB1-6TB3-6 **		
BRN	3TB1-7TB3-7 **		
GRN	3TB1-8TB3-8 **		
ORN	3TB1-9TB3-9 **		
RED	3TB1-10TB3-10 **		
WHT	3TB1-11TB3-11 **		
153TB1-15TB3-15K1 AND K2 COIL VOLTAGE			
163TB1-16TB3-16K1 AND K2 COIL VOLTAGE			
2 CONDUCTOR CABLE			
SHIELD	3TB1-14	TB3-14	
BLK	3TB1-17	TB3-17	
WHT	3TB1-18	TB3-18	

(Note: WHT may be clear or RED.)

*** NOTE: #1, #2, & #3 are 14 AWG. Electric code may require different wire size being used.**

**** NOTE: This is only a suggested order to follow. The color coding may vary between different wire manufactures. (e.g. BRN substituted with RED/BLK. YEL substituted with WHT/BLK. The important thing is to maintain the 1 to 1 interconnect between 3TB1 and TB3.)**
NOTE: YEL or 8th does not need to be connected.

WARNING: Disconnect primary power prior to servicing.

- TB3-3: Audio (-)
- TB3-4: Optional shield connection, capacitively coupled to transmitter chassis ground.

Audio Input TB3 is shown on sheet 2 of the DX-25U Overall Schematic, 839-7855-151. The following paragraphs include additional information which may be useful in planning and connecting the audio input.

2.12.1.1 Shield Connections

The audio input cable shield should be grounded at only one end, either at the processor or at Audio Input terminal TB3-1. Connecting the shield at both ends can result in ground loop problems and increased system noise. Audio Input terminal TB3-4 provides an AC coupled path to the transmitter cabinet. In some installations, lower noise may be obtained by connecting the audio cable shield to this terminal.

2.12.1.2 Polarity

If the audio processor has output terminals marked "+" and "-," connect one wire of the audio pair (typically red) between the processor's "+" output and the transmitter's "+" input terminal, and connect the other wire (typically black) between the "-" terminals.

2.12.1.3 Audio Source Impedance

The transmitter uses a Bessel filter at the audio input to obtain superior overshoot performance. Performance of this filter depends on the source impedance of the processing equipment. The load impedance of the processing equipment is not necessarily its source impedance; for example, modern equipment may be specified for a 600 Ohm load but have a very low source impedance, 50 Ohms or less.

2.12.1.4 Selecting Source Impedance

A white Molex connector on audio input cable number 100, from the External Interface, plugs into J1, J2, or J3 on the Analog Input Board. Source impedance for each input is silk screened on the board. For optimum performance and best high frequency response, use the jack labeled with an impedance closest to the source impedance of the processing equipment.

This connection is NOT critical; using the wrong connector may result in some overshoot or undershoot on square waves and a slight change in audio frequency response (typically less than 1 dB at 10 Khz). If the processing equipment source impedance cannot be determined, try "Rs = 600 Ohms" for older transformer equipment, and "Rs less than 50 Ohms" for newer equipment with direct coupled operational amplifier outputs.

2.12.2 Modulation Monitor Connection

If a modulation monitor is used at the transmitter site, run a 50 Ohm coaxial cable from BNC jack J5 on the Output Monitor to the modulation monitor input. The Output Monitor is located at the top of the left side wall of the Center Control Compartment. If the modulation monitor has a high input impedance rather than an internal 50 Ohm termination, a 50 Ohm, 3 to 5 Watt termination should be placed across the Modulation Monitor input terminals.

Do not connect the coaxial cable to the monitor until instructed to do so during the Initial Turn On Procedure.

2.12.3 Frequency Monitor Connection.

If a frequency monitor is used at the transmitter site, a coaxial cable should be run from BNC jack J5 on the Oscillator to the frequency monitor input. The Oscillator is located toward the bottom of the right side wall in the Center Control Compartment. The RF sample at J5 is a 5 V peak unmodulated signal, at the transmitter carrier frequency.

2.12.4 External RF Input

An external RF input from a frequency synthesizer or AM Stereo exciter is connected to J2 on the Oscillator. Jumper P3 on the Oscillator should be moved to the 1-2 position. Jumper P5 on the Oscillator should be used to select the correct impedance for the external RF source. Refer to SECTION A, Oscillator, for additional information.

2.12.5 External Interlock (Failsafe)

The External Interlock should be used for any function which should turn the transmitter OFF by turning off the high voltage supply. Examples include Failsafe connections and safety interlocks on phasor cabinets or other enclosures which could expose personnel to RF when opened.

More than one External Interlock can be used by connecting the normally closed interlock switches in series. All External Interlock switches should be closed when the interlocked enclosure or circuit is in the safe condition, and should open when in the unsafe or fault condition.

External (remote) Control interface connections are made at TB1 and TB2, at the top of the right side wall in the Center Control Compartment. Terminal information is silk screened on the back of the Driver Compartment door.

EXTERNAL INTERLOCKS should be connected between TB1-1 and TB1-2.

a. A CLOSED circuit between TB1-1 and TB1-2 allows the transmitter to turn ON.
b. An OPEN circuit between TB1-1 and TB1-2 turns the transmitter OFF by interrupting the 24 VAC coil voltage for the External Interlock relay K3. The transmitter cannot be turned on again as long as there is an OPEN circuit between the External Interlock terminals. The 24 VAC is fused at 1 Amp by F24. External interlock contacts and wiring should be rated for 1 Ampere AC current.
c. If NO External interlocks are used, a jumper must be connected between External Interlock terminals TB1-1 and TB1-2.

NOTE

Do not use the External Interlock for antenna pattern switching, which requires only a brief interruption of RF output. The EXTERNAL PA TURN OFF connection, described under Remote Control connections later in this section, should be used for that purpose.

2.13 Pre-Turn On Checks (Mechanical)

Although appropriate packaging and shipping precautions are taken before the equipment leaves the factory, hardware sometimes works loose during shipment. The transmitter should be checked for any debris, loose hardware and loose connections before applying primary power. Pre-turn on checks and inspection should include:

a. Check for debris and loose hardware, both in the transmitter and in the AC power panel.
b. Check for loose connections, in particular at the following:
   1. Filter capacitors
   2. High voltage and low voltage supply rectifier diodes
   3. Output network clips, insulators, and hardware
   4. PA Power supply transformer
   5. Low voltage supply transformer
c. Check RF drive cable connectors. Ensure that cable connectors are properly locked into their printed circuit board sockets.
d. Check ribbon cable connectors. Ensure that cable connectors are properly locked into their printed circuit board sockets.
e. Ensure that output network connections and coil taps are tight, especially at high current points. (Over tightening can strip threads or break bolts, especially where brass hardware is used).
f. Ensure that no shipping ties, blocks, or tape remain.

2.14 Pre-Turn On Checks (Electrical)

Before initial turn on, ensure that the following items have been completed:

a. A ground strap must be properly connected between the transmitter and the station earth ground.
b. AC input wiring must be properly connected and connections must be tight.
c. The transmitter RF output must be properly terminated with a suitable load capable of handling rated output power. This can be either an antenna system or a dummy load.
d. External interlocks must be satisfied.
e. Audio input must be properly connected.
f. Monitoring equipment is properly connected.
g. SECTION III, Operators Guide, in this technical manual should be read and understood.

2.15 Initial Turn On Procedure

The initial turn on procedure provides checks or adjustments in the following sequence:

a. Low Voltage Power Supply test.
b. Underdrive overload test.
c. PA Power Supply check.
d. Fan rotation check.
e. Driver operation check.
f. Raise/Lower Function check.
g. Power Amplifier turn on check.
h. Setting RF monitor levels.
i. Modulation check.
j. Setting Audio Input level.
k. Audio Input phasing check.
l. Battery Backup for controller.
m. Recording normal meter readings.

If all Installation Procedures up to this point have been completed, the transmitter is ready to be powered up by the following sequence. Each step assumes the preceding step has been successfully completed.

WARNING

IF YOU MUST ENTER ANY PART OF THE TRANSMITTER EXCEPT THE FRONT NON-INTERLOCKED COMPARTMENTS, TURN OFF THE TRANSMITTER BY DEPRESSING THE “OFF” BUTTON, SET THE REMOTE/LOCAL SWITCH ON THE STATUS PANEL TO “LOCAL,” AND REMOVE SINGLE PHASE AND THREE PHASE PRIMARY POWER AT THE MAIN DISCONNECT. BEFORE REMOVING PANELS OR OPENING DOORS, VERIFY THAT THE PA POWER SUPPLY IS DISCHARGED BY CHECKING “SUPPLY VOLTS” ON THE FRONT PANEL MULTIMETER.

CAUTION

GROUNDING STICKS ARE PROVIDED INSIDE THE TRANSMITTER AND SHOULD BE USED TO ASSURE THAT ALL HIGH VOLTAGE HAS BEEN REMOVED.

CAUTION

WHEN WORKING IN THE FRONT NON-INTERLOCKED COMPARTMENTS, BE CAREFUL NOT TO GROUND ANY CONNECTIONS WHICH ARE STILL ENERGIZED. THIS INCLUDES ALL LOW VOLTAGE CIRCUITS IF THE LOW VOLTAGE SWITCH CIRCUIT BREAKERS CB1 AND CB2 HAVE NOT BEEN SET TO THE “OFF” POSITION.

CAUTION

IF ANY ABNORMALITIES ARE ENCOUNTERED IN THE FOLLOWING STEPS, STOP THE PROCEDURE AND REFER TO THE TROUBLESHOOTING SECTION OF THIS TECHNICAL MANUAL.

Find the packet shipped with the transmitter entitled Factory Test Data. This data should be used as reference during the initial turn on procedure.

2.15.1 Power Supply Test

This test will be the first application of single phase AC power to T2, Low Voltage transformer. This will energize the control circuitry and allow Low Voltage meter readings to be taken.

WARNING

TURN OFF SINGLE PHASE AND THREE PHASE PRIMARY POWER AT THE MAIN DISCONNECT BEFORE REMOVING ANY REAR PANEL.

a. Remove the rear access panels from the RF Amp Compartment and locate the two Fuse Boards (A24/A25).
b. Remove F20 located on High Voltage Transformer T1 terminal deck; F21 and all other fuses on T1 remain.
c. Remove F1 through F8 on the A25 Fuse Board. This will minimize inrush current in case of a problem in the step start sequence or control.

NOTE

Before replacing the rear access panels, make sure nothing is shorting out the supply. With an ohmmeter, measure the resistance of the +230 VDC supply between the heavy copper buss bar on the fuse boards and ground. With the positive lead on the supply, the resistance should be approximately 500 Ohms +/-10%, which is the resistance of the PA Discharge circuit. Remember that S9, S10, and S12 short out the supply when any of the interlocked RF Amp Compartments behind the front doors are open.

d. Replace the rear access panels and apply SINGLE phase AC power to the transmitter at the main disconnect. DO NOT APPLY THREE PHASE POWER AT THIS TIME.
e. Turn the Low Voltage Power Supply circuit breakers CB1 and CB2 in the Center Control Compartment to the ON position.
f. All transmitter front panel ColorStat™ panel indicators should be either red or green (except for the Remote LED, which will not be illuminated when in the LOCAL position). Indicators are bi-color LED's (except for Local and Remote indicators, which are single color LED's).
g. Switch the front panel MULTIMETER to the -8 VDC, +8 VDC, -22 VDC, and +22 VDC positions and check the readings against the Factory Test Data. These readings should be within 10% of the Factory Test Data readings. The readings will be slightly lower when the +230 VDC PA Power Supply is energized.

NOTE

If the readings are not within 10% of the Factory Test readings, turn off CB1 and CB2, remove primary AC power at the main disconnect and review the connections to Low Voltage Transformer T2.

2.15.2 Underdrive Overload Test

The following test simulates an Underdrive fault condition by bringing the transmitter up with 3 phase primary AC OFF. The importance of this test is to assure that the RF drive sensing circuitry is functional. Proper drive level is critical to prevent failures in any of the RF amplifiers, RF1 through RF64, in the Power Amplifier stage. There are other fault conditions that will be detected by the Underdrive Overload circuit that are not RF related failures: i.e. a short across the PA Power Supply during the step start sequence. Refer to Section IV, Overall System Theory, and Section VI, Troubleshooting, for a more detailed understanding of Underdrive overload.

a. Single phase AC power ON, three phase AC power OFF.
b. Depress the LOW power button. Observe the following:
   1. K1 step start contactor should energize, quickly drop out, energize, then drop out a second time.
   2. The Underdrive LED on the ColorStat™ panel should change to AMBER on the first drop out, RED on the second drop out and remain RED until the display is reset.
   3. K2 in the Step Start Panel should not energize.
   4. These events should all occur within two seconds.

2.15.3 PA Power Supply Check

This test will be the first application of three phase AC power to T1 and will energize the +230 VDC, +115 VDC, and +60 VDC supplies. It will also determine that the step start sequence is operating properly.

a. Single phase AC power ON, three phase AC power ON.
b. Place the PA OFF switch, S2, located on the Controller, in the OFF (up) position.
c. Rotate the front panel Multimeter switch to the PA SUPPLY +VDC position.
d. Depress the LOW power button and observe one of the following:
   1. Step start sequence completes, PA supply voltage comes up to +255 VDC +/-5%.

      or
   2. Step start sequence drops out due to an Underdrive fault. or
   3. Step start sequence drops out due to an Overdrive and/or Overvoltage fault.
e. If step d1. was observed, proceed to the Fan Rotation check
f. If step d2. was observed, temporarily disable the Underdrive overload by placing a clip lead on the LED Board between TP8 and GND (ground), and then repeat the test.
g. If step d3. was observed, retap T1 to lower the supply voltage and then repeat the test.
h. Depress the OFF button and observe the PA SUPPLY +VDC on the Multimeter. The voltage should drop to zero very quickly. If the voltage bleeds off slowly, troubleshoot the PA Supply Discharge Circuit (Crowbar). Refer to Sheet 1 of the DX-25U Overall Schematic, 839-7855-151, in the Drawing Package for details of the PA Supply Discharge circuit.
i. Repeat the procedure to verify the step start sequence is functioning properly. The sound of K1 and K2 is proportional to their size.

2.15.4 Fan Rotation Check

The fan motors are three phase and correct rotation must be verified. If necessary, two of three AC input wires must be interchanged at 2TB1 in the Output Network Cabinet. Use the following procedure:

a. Single phase ON, three phase ON, CB1 and CB2 ON, PA Off switch S2 OFF.
b. Depress the LOW power button and hold a piece of paper against one of the air filters at the rear of the Output Network Cabinet. Correct fan rotation will pull air in and hold the paper in place.
c. If there is incorrect air flow, the transmitter may turn off again after 20 seconds, and the AIR INTERLOCK indicator on the ColorStat™ panel will indicate RED.
d. Depress the OFF button.
e. Remove the left upper air filter on the back of the Output Network Cabinet and observe the rotation of the coasting fans. (The fans are located at the left side of the Output Network Compartment as viewed from the back of the transmitter). All four fans should be rotating CCW (counterclockwise).
f. If the rotation is correct, reinstall the air filter.
g. IF ROTATION IS NOT CORRECT:

WARNING

DISCONNECT SINGLE PHASE AND 3 PHASE PRIMARY POWER AT THE MAIN DISCONNECT BEFORE REMOVING ANY REAR PANEL.

1. Remove the left rear access panel from the Output Network Compartment.
2. Disconnect and interchange ANY TWO of the three wires 1, 2 or 3 connecting the fans to 2TB1. (Interchanging any two of three wires to a three phase motor will reverse its direction of rotation).
3. Reinstall the access panel on the Output Network Compartment. Reapply single phase and three phase primary AC power to the transmitter.

h. Ensure that all rear panels are in place. Turn the transmitter ON by depressing the LOW power button.
i. When the transmitter is turned ON, the AIR interlock LED on the ColorStat™ panel will extinguish. It will then come back on after 20 seconds, as follows:
   1. GREEN: Air pressure is okay.
   2. AMBER: Air pressure reduced.
   3. RED: Air pressure FAULT. The fault will also turn the transmitter OFF.

An Air Pressure Fault indicates insufficient air. Likely causes include a back panel not installed or fastened at all points, incorrect blower tap connections on the primary of T1 or incorrectly adjusted circuit on the Driver Encoder/Temp Sense Board. Correct taps for blower wires 123, 124 and 125 are listed on Table 2-2. The adjustment procedure for the airflow switch is in SECTION V, Maintenance.

2.15.5 Driver Operation Check

If a stereo generator, frequency synthesizer, or other external RF source equipment is used, it must already be installed and operational.

a. Remove the clip lead between TP8 and GND on the LED Board if used in checking out the PA Power Supply.
b. The PA OFF switch S2 on the Controller should be OFF (up).
c. Apply single phase and three phase primary power at the main disconnect.
d. Low voltage circuit breakers CB1 and CB2 in the transmitter should be ON.
e. Depress the LOW power button.
f. Rotate the front panel Multimeter switch to the RELATIVE RF DRIVE position and compare the reading with the Factory Test Data.
g. Using the RF MULTIMETER on the inside of the Driver Compartment door, compare all readings with the Factory Test Data. Voltage readings D8A and D8B may differ from Factory Test Data, depending on the AC line voltage. If the D8A reading is low, check to see if the AUTO circuit on the Driver Encoder/Temp Sense Board has turned on Driver Module D7. This will be indicated by the AUTO LED on the Driver Encoder/Temp Sense Board in the Driver Compartment. This is a normal function of this circuit and does not affect transmitter operation adversely. If the Underdrive or Overdrive circuits on the transmitter do not turn the transmitter OFF, the drive level is correct. NO TUNING OF THE DRIVER STAGE SHOULD BE NECESSARY.

2.15.6 Raise/Lower Function Check

The normal time interval for running the power level from zero to 30 kW is approximately 25 seconds. With the +230 VDC PA Power Supply energized, lower the power level to zero on all 3 positions, LOW, MED, and HIGH, by holding the LOWER push button for 10 seconds in each position, while simultaneously depressing S1 on the Controller. Switch S1 speeds up the RAISE/LOWER command by more than 5:1. After all three positions have been LOWERED, turn the transmitter OFF by pressing the OFF button.

2.15.7 Power Amplifier stage Turn On Check

If a 50 Ohm resistive dummy load is used for initial check of the Power Amplifier stage, only minimum adjustment of the TUNING and LOADING controls will be necessary. When the transmitter is then connected to the antenna or if the antenna is used for the initial Power Amplifier stage check, additional adjustments to the DETECTOR NULL (ANTENNA) circuitry may be required.

WARNING

DISCONNECT SINGLE PHASE AND THREE PHASE PRIMARY POWER AT THE MAIN DISCONNECT BEFORE REMOVING ANY REAR PANEL.

a. Remove the rear access panels from the RF Amp Compartment and replace fuse F20 on T1 and all fuses removed from the A24 and A25 Fuse Boards.

b. Replace all rear panels and apply single phase and three phase AC power to the transmitter. The Low Voltage circuit breakers CB1 and CB2 should be ON and the PA OFF switch S2 on the Controller should be OFF (up).

c. Depress the LOW power button. The +230 VDC PA Power Supply should come up as in the RF drive checkout. Compare all meter readings with Factory Test Data.

d. Turn the PA OFF switch S2 on the Controller to the ON (down) position.

e. Change the front panel Multimeter switch from the PA +VDC to the DETECTOR NULL (ANTENNA) position. The power meter selector switch should be in FWD.

f. Raise the output power by depressing the RAISE button. Observe the following while raising the power:

   1. Power and Current should increase.
   2. DETECTOR NULL (ANTENNA) indication may begin to rise depending upon the degree of mismatch between the station load and the factory test load, especially if the transmitter is loading into the antenna. This may cause ANT VSWR trips and prevent full power operation until this circuit is adjusted.
   3. If ANT VSWR trips occur, the Antenna VSWR Phase Angle Detector on the Output Monitor will have to be adjusted. The Bandpass Filter VSWR Phase Angle Detector may also require adjusting, but should be done after the TUNE and LOAD controls are adjusted for the proper PA voltage/current ratio.

In brief, adjust C15 and L12 on the Output Monitor for minimum reading on the multimeter DETECTOR NULL (ANTENNA) position. Adjust C16 and any of the coils (L5, L6, L7, or L8) switched in by S7 on the Output Monitor for a minimum reading on the DETECTOR NULL (FILTER) position. Refer to SECTION V, Maintenance, for the Output Monitor adjustment procedures.

2.15.7.1 Tuning for Voltage/Current Ratio

a. At 25 kW power output, the PA Supply Current should be between 105A and 123A depending on the AC line voltage. Refer to the Factory Test Data and use the following information to help tune the transmitter for the correct PA Supply Voltage/Current ratio.

   1. Power Output (meter)
   2. PA Voltage
   3. PA Current
   4. PA Efficiency
   5. # of Steps turned on

b. The RAISE control determines the number of steps (PA Modules) turned on. When a PA Module is ON, the green LED on the module is illuminated. With a PA Power Supply voltage of +230 VDC, there should be 23 PA Modules on for 25 kW output.

c. The LOADING control adjusts the PA Supply Current and power output. With a PA Power Supply voltage of +230 VDC, PA Supply Current should be between 110 and 115 Amps.

d. The TUNE control is adjusted for a PEAK in power output. This control is rather broad, especially at the low end of the medium wave band.

2.15.8 Setting Modulation Monitor Sample Levels

An adjustable 1 to 10 Volt RMS signal is available at the Output Monitor. The RF sample is set for the proper level at the LOWEST operating power by adjusting 2L7 in the Output Network Compartment. When the LOW Power sample level has been set, MEDIUM and HIGH power levels are adjusted by R7 and R8 on the Output Monitor.

a. Set the LOW power output of the transmitter to the lowest power that will be required for normal operation.

b. Measure the RF voltage level at the monitor. If the level must be increased or decreased to meet modulation monitor input voltage requirements, the tap on 2L7 must be adjusted.

WARNING

TURN OFF ALL SINGLE PHASE AND THREE PHASE PRIMARY POWER AT THE MAIN DISCONNECT BEFORE REMOVING ANY REAR PANEL.

c. Remove the rear right panel from the Output Network Compartment.

d. Locate Modulation Monitor sample coil 2L7 connected to the RF output flange. To DECREASE the sample voltage, move the tap closer to the grounded end of the coil. To INCREASE the sample voltage, move the tap away from the grounded end of the coil. Move the tap 1/4 turn in the desired direction. Be careful not to short adjacent turns when positioning the clip.

e. Replace the Output Network Compartment rear panel. Reapply single phase and three phase AC primary power at the disconnect switch. Depress the LOW power switch.

f. Measure the RF sample voltage. Repeat the coil adjustment procedure until the desired sample voltage for the LOW power setting is obtained.

When the LOW power sample level is satisfactory, continue with the following steps:

g. Turn R7, MEDIUM power modulation monitor sample adjustment, on the Output Monitor fully CCW (counterclockwise).

h. Turn the transmitter on at MEDIUM power, or, if the transmitter is already on at another power level, depress the MEDIUM power switch. Use the RAISE and LOWER buttons to set the MEDIUM power output.

i. Adjust R7 on Output Monitor until the sample voltage at the modulation monitor is the SAME as it was in the LOW power position. This adjustment can be made while the transmitter is operating.

Table 2-4. Minimum Recommended Control and Status Functions for Remote Control

CONNECTION	FUNCTION
CONTROLS:	
1. TB1-22, TB1-24	HIGH power control
2. TB1-26, TB1-28	MEDIUM power control
3. TB1-30, TB1-32	LOW power control
4. TB1-25, TB1-27	LOWER control
5. TB1-29, TB1-31	RAISE control
6. TB1-33, TB1-35	OFF control
7. TB1-38, TB1-40	OVERLOAD RESET
METERED PARAMETERS:	
1. TB1-3	FORWARD POWER
2. TB1-4	REFLECTED POWER
3. TB1-5	SUPPLY CURRENT
4. TB1-6	SUPPLY VOLTAGE
(Use TB1-19 for ground return for remote metering outputs).	
OVERLOAD AND FAULT INDICATIONS:	
1. TB2-9	LOAD VSWR occurred
2. TB2-24	SUPPLY VOLTAGE overload
3. TB2-25	SUPPLY CURRENT overload
4. TB2-33	Type 3 FAULT
(Use TB2-19 or TB2-20 for ground return).	
STATUS INDICATIONS:	
1. TB1-15	LOWER indication
2. TB1-16	HIGH POWER indication
3. TB1-17	RAISE indication
4. TB1-18	MEDIUM POWER indication
5. TB1-20	LOW POWER indication
(Use TB1-13 or TB1-14 for ground return).	
ADDITIONAL DESIRABLE STATUS INDICATIONS:	
10. TB2-22	EXTERNAL INTERLOCK OPEN indication
11. TB2-26	UNDER-DRIVE fault
12. TB2-27	OVER-DRIVE fault
13. TB2-28	AIR OVERLOAD
14. TB2-29	HIGH VOLTAGE SUPPLY FAILURE
15. TB2-30	CURRENTLY UNDER LOCAL CONTROL
16. TB1-21,23	PA OFF

The "PA OFF" control input is normally connected to the Phasor or Antenna Switching control unit for antenna pattern switching.

WARNING: Disconnect primary power prior to servicing.

j. Turn R8, HIGH power modulation monitor sample adjustment, on Output Monitor fully CCW.

k. Turn the transmitter on at HIGH power, or, if the transmitter is already on at another power level, depress the HIGH power switch. Use the RAISE and LOWER buttons to set the HIGH power output.

l. Adjust R8, on Output Monitor, until the sample voltage at the modulation monitor is the SAME as it was in the LOW and MEDIUM position.

m. Switch between LOW, MEDIUM, and HIGH power to verify that the Modulation Monitor sample is the same for all three power levels. If necessary, readjust R7 or R8 so that all sample voltages are the same.

2.15.9 Modulation Check

During the modulation check, it is helpful to monitor the RF envelope on an oscilloscope connected in parallel with the Modulation Monitor RF sample. Check for proper modulation at various power levels, as follows:

a. Connect an audio generator to the audio input.

b. Turn the transmitter on at LOW power. Apply a low level audio sine wave at 1 kHz. Increase the generator output until modulation level is approximately 50%.

c. Observe the modulated RF signal on the oscilloscope. The modulation envelope should be a smooth sinewave, with no steps, notches, or other distortion. (If a distorted envelope is observed, check the audio generator output with the oscilloscope before assuming there is a transmitter problem. Sometimes, defective test equipment is the problem rather than the equipment being tested).

d. Switch to MEDIUM and then to HIGH power. The transmitter will maintain the same modulation level. Again, observe the modulated RF signal on the oscilloscope. The modulation envelope should still be a smooth sinewave.

e. Increase the modulation to 95% negative peak modulation. Observe the waveform again at all power levels.

f. Check all meter readings against the Factory Test Data sheets for meter readings with modulation. Meter readings should be close to factory readings.

g. Note that the front panel CURRENT meter reading depends on power output AND modulation level. The meter reads the average current returning to the PA Power supply. Because PA voltage is fixed, PA current depends on transmitter output power, which varies with modulation.

2.15.10 Setting Audio Input Level

The Audio Input sensitivity of the transmitter is adjusted with the AUDIO GAIN ADJ control, R15, on the Analog Input Board. The Analog Input Board is located below the Output Monitor on the left wall of the Center Control Compartment. Use the following procedure for this adjustment:

a. Determine the stations's reference audio level for 100% modulation. (Typical levels are 0 Dbm or +8 Dbm, but the transmitter can accommodate reference levels from -10 dBm to +10 dBm at 600 Ohms.)

b. Switch the transmitter to MEDIUM power. Set the output level from the audio generator to the station's reference value for 100% modulation. (If you are using an output level meter on the audio signal generator, be sure that the generator is operating into the proper impedance. Some audio signal generator meters are accurate only with the correct load.)

c. Using R15, Audio Gain Adjust on the Analog Input Board, adjust for a modulation level of 100%, as read on the modulation monitor. This completes audio input level adjustment.

2.15.11 Audio Input Phasing Check (Optional).

This is not a transmitter check, rather, it is a system check. The 50kW transmitter version is capable of positive peak modulation of +125% or greater at 55 kW carrier power, and even higher positive peak modulation at 25 kW or less. An audio phasing check may also be included in the manuals for the audio processing equipment.

In the United States and many other countries, positive peak modulation up to +125% is permitted. If regulations at your location permit, and you have audio processing equipment with asymmetrical output, you may wish to verify that your audio input is phased correctly. Proceed as follows:

a. You will need a program source or audio frequency generator with asymmetrical output, audio processing equipment capable of providing positive peaks over +100%, and a modulation monitor with a negative 100% peak flasher and an adjustable positive peak flasher. (An audio generator with an asymmetrical audio frequency output is ideal for this check, but is not available at most stations).

b. Turn the transmitter on, at any power level, and modulate with asymmetrical audio or with program. Adjust the program level so that negative peaks just reach -100%.

c. Observe positive peak modulation levels.

- If positive peaks are approximately 100%, you don't have a program source with higher positive peaks than negative peaks, or possibly your processing equipment is not adjusted properly.
- If positive peaks are LESS than 100%, try reversing the two audio signal leads, either at the audio output supplying the transmitter or at the transmitter audio input terminals.
- If positive peaks are GREATER than 100%, your audio input phasing is correct.

2.15.12 Controller Battery Backup

A 1 Farad capacitor supplies backup for AC power failures shorter than 2 hours.

Three AA alkaline batteries are used for Controller power mode and power level memory backup. These will enable the transmitter to return to operation at the correct power level after an AC power failure longer than two hours at 72 degrees F (25 degrees C). The batteries should be installed AFTER the Low Voltage circuits have been energized to prevent battery drain by the 1 Farad capacitor. The batteries can be installed while the transmitter is ON. (Do NOT use rechargeable batteries, such as NiCad cells. The cell voltage is not high enough for reliable operation).

2.15.13 Recording Normal Meter Readings

We strongly recommend that a permanent record of ALL meter readings be made, with carrier only (no modulation) and with modulation at one or more levels (-95% should be one level). The form at the end of this section provides an outline. Data should be taken using the primary or main antenna system and a dummy antenna (dummy load) if one is available, because a dummy load will provide the most repeatable set of conditions.

2.16 AM Stereo Installation and Tuning Hints

The transmitter is stereo ready in terms of interfacing with the stereo exciter. The most difficult part of making a transmitter stereo ready is minimizing the IQM, increasing RF bandwidth, and reducing L-R noise. All these were taken into consideration in the design of the transmitter. This results in a transmitter which essentially requires NO compromise of efficiency, tuning, or mono performance to obtain the best stereo performance. When most controls are set for best stereo performance, the other performance areas are also optimized.

2.16.1 Interfacing For Stereo

Connect the RF output of the stereo exciter through a BNC cable to J2 on the Oscillator. Move Jumper P3 to position 1-2. This enables the external drive input. Move P5 to position 1-2 for most TTL exciter RF outputs. This is a 20k Ohm termination. Move P5 to 1-3 for a 50 Ohm termination needed for higher level exciter RF outputs.

2.16.2 Bandpass Tuning 2C1

The Bandpass tuning is the only control that will affect the Incidental Phase Modulation (IPM) of the transmitter. Normally, the Bandpass tuning is adjusted for peak power output on the power meter, and then turned approximately one turn counterclockwise off the peak on the inductive side of resonance. This typically optimizes efficiency, IPM and mono THD and IMD. The bandpass tuning can be adjusted while the transmitter is ON and modulating.

NOTE

THE TUNING CONTROL SHOULD NOT BE ADJUSTED MORE THAN 2000W OFF OF THE POWER PEAK. MOST EFFICIENT OPERATION OCCURS AT OR NEAR THE POWER PEAK. TUNING OFF THE PEAK IN THE CAPACITIVE (CLOCKWISE) DIRECTION CAN REDUCE EFFICIENCY AND CAUSE EXCESSIVE HEATING OF THE RF AMPLIFIER MODULES.

2.17 Remote Control Connections

The following paragraphs include basic information on remote control interfacing. Remote Control connections (including connection to extended control panels, if used) can be different for each installation.

The Customer Interface for remote control, metering, and status monitoring is compatible with nearly all remote control systems.

If the remote control system does not have enough channels available for all control and status functions, Table 2-4 lists the minimum recommended control and monitor functions.

All connections are made on TB1 and TB2 in the Center Control Compartment. Sheet 3 of the External Interface schematic, 839-7855-090, in the Drawing Package shows the list of remote control functions with a letter (A through E) placed next to each terminal number. This letter refers to the Characteristic Key on the diagram. Each Characteristic Key provides schematics and information which will be useful when planning interfaces to a remote control unit or to an extended control panel. For detailed information, including typical interfaces, refer to SECTION N, External Interface.

2.17.1 Control Inputs

Control Inputs are isolated by optoisolators on the External Interface. This permits maximum flexibility, allowing use of voltage sources provided on the External Interface or external voltage sources. Control inputs can be a relay contact closure, switch closure, or transistor switch. Control inputs may be isolated from ground, or can be switched to ground by a positive or negative voltage. Each remote control input uses a “+” and “-” terminal on TB1 or TB2. Applying a voltage between the terminals is the same as depressing the corresponding button or operating the corresponding switch on the transmitter. Voltage applied to these terminals should be between 15 and 29 Volts; corresponding currents are 40 to 70 milliamperes. For convenience, +15 VDC and -15 VDC sources (at 175 mA maximum current) are provided at TB1-11 and TB1-12, respectively.

2.17.2 Analog Monitoring Outputs

These remote meter readings monitor voltages, currents, power levels, and other analog parameters. When a high impedance remote control system input is connected to a Monitor Output terminal, the nominal output will be +3.4 Volts (or -3.4 Volts to monitor -22 V and -8 V supplies) when the transmitter is operating at 25 kW. This allows for some increase in readings while still remaining within the 4 Volt input limit of remote control systems such as the Harris Sentinel. If the remote control system input is not high impedance, the loading on the monitor output will reduce the output voltage.

2.17.3 Status Monitoring Outputs

These are open-collector outputs to ground. When the corresponding status indicator is illuminated at the transmitter (or when a ColorStat™ panel LED is RED), the transistor turns ON and provides a current sink from the status output to ground. These status outputs can switch a 6 or 12 VDC low-current relay, or can provide a logic LOW output when a pull-up resistor to +5 to +15 VDC is used. Maximum safe voltage at a status output terminal is +15 VDC and maximum safe current into a status output is 100 mA.

2.17.3.1 Explanation Of Selected Remote Control Functions
Most remote control functions and monitor outputs are the same as the corresponding functions or indications in the transmitter. Some indications and functions will, however, be explained here to aid in planning and installing a remote control system.

a. OFF Control: Use for normal transmitter turn-off, for example, at the end of the operating day. The external OFF control operates the same as the front panel OFF button and turns off the PA Power supply.

b. EXTERNAL PA TURN OFF: Use to remove RF output during antenna pattern switching or for other RF switching operations. Because the transmitter RF output returns as soon as the PA Turn Off control input voltage is removed, PA Turn Off MUST NOT be used for failsafe or safety interlock purposes. A PA Turn Off input turns all PA Modules OFF through modulator section action, causing RF output to go to zero. The PA is held OFF as long as the External PA Turn Off input is active. As soon as the External PA Turn-Off signal is removed, the transmitter immediately comes back up to its pre-set operating power. The External PA Turn-Off command does NOT turn off the PA Power supply and will NOT result in any red LED indication on the ColorStat™ panel. However, segment nine of DS1 on the Modulation Encoder (A37) will illuminate RED whenever there is an active PA Off command. The External PA Turn-Off provides the same function as the PA OFF switch S2 on the Controller.

NOTE

PA TURN OFF should NOT be used for FAILSAFE purposes, for interlocks, or for routine transmitter turn off. It is intended to remove RF output during antenna switching operations.

c. EXTERNAL INTERLOCK is used for Failsafe and for safety interlocks on any enclosure which would permit contact with RF output, such as phasors or antenna switching equipment.

d. TRANSMITTER ON does not use a separate ON switch. The transmitter comes ON at the desired power level when a momentary remote control input (at least 100 mS long) is provided at the LOW, MEDIUM, or HIGH terminals on TB1. If the transmitter is already ON, providing another of these inputs will change power level without interrupting RF output.

e. RAISE/LOWER inputs change the RF power. A RAISE input will cause transmitter power output to INCREASE for as long as the control input is provided, or until the transmitter power output reaches the maximum power limit. A LOWER input will cause transmitter power output to DECREASE for as long as the control input is provided, or until the power output reaches zero.

NOTE

When remote control and monitoring is used, delays in data transmission can delay the remote output power reading while the RAISE or LOWER controls are being operated. This can cause the remote output power reading to continue to change for a short time after the RAISE or LOWER command is stopped.

f. FORWARD and REFLECTED POWER (Remote Meter Reading) outputs correspond to the transmitter FORWARD and REFLECTED power meter indications. Note that the transmitter power meter scale is not linear. The voltage outputs at Forward remote output TB1-3 and Reflected remote output TB1-4 are proportional to the RF output voltage which is proportional to the square root of the RF power.

g. BANDPASS FILTER VSWR and ANTENNA VSWR (Remote Meter Reading) outputs are uncalibrated, relative readings from the VSWR phase detectors on Output Monitor.

   1. BANDPASS FILTER VSWR corresponds to the DETECTOR NULL (FILTER) reading on the transmitter front panel multimeter. A change in the Bandpass Filter/Output Network of the transmitter will cause the reading to increase.

   2. ANTENNA VSWR corresponds to the DETECTOR NULL (ANTENNA) reading on the front panel multimeter. A mismatch in the antenna system will cause the Antenna VSWR reading to increase. Antenna VSWR is an uncalibrated, relative reading, but is more sensitive than Reflected Power.

h. RF DRIVE ESTIMATE (Remote Meter Reading) is an UNCALIBRATED sample of the RF drive to the PA Modules and corresponds to the RELATIVE RF DRIVE position on the front panel Multimeter.

i. MONITOR SIGNALS: +22 VDC, -22 VDC, +8 VDC, And -8 VDC (Remote Meter Readings) are samples of unregulated voltages from the low voltage power supply, and will indicate +3.4 VDC for positive supplies and -3.4 VDC for negative supplies during typical operation.

Table 2-5. Initial Turn-On Meter Readings

FREQ. ______________

DATE ______________

	PA SUPPLY ON 0KW NO CARRIER	LOW	MED	HIGH	LOW	MED	HIGH	LOW	MED	HIGH
AUDIO MODULATING FREQUENCY		UNMODULATED CARRIER ONLY								
MODULATION %		0	0	0						
CARRIER POWER										
PA CURRENT										
FRONT PANEL MULTIMETER:										
-8V										
+8V										
-22V										
+22V										
RELATIVE RF DRIVE										
DET. NULL (ANTENNA)										
DET NULL (FILTER)										
PA SUPPLY +VDC										
RF MULTIMETER:										
PREDRIVER IDC										
PREDRIVER +VDC										
DRIVER +VDC										
DRIVER IDC										
DRIVER SECT D8A +VDC										
DRIVER SECT D8B +VDC										
NUMBER OF STEPS										

	PA OFF	PA ON		
DC REGULATOR	P1 IN TEST POSITION	0KW	25KW 0% MODULATION	25KW 100% MODULATION
B- "A"				
B- "B"				
ANALOG INPUT				
POWER CONTROL V	VOLTMETER	VOLTMETER	VOLTMETER	SCOPE
DC + AUDIO TP7				

2290-025

3.1 Introduction

This section contains information on day-to-day operation for the non-technical operator.

3.2 Operating Procedures

These procedures describe normal daily operation of the DX-25U AM TRANSMITTER, including:

a. Daily pre-operational checkout
b. Transmitter turn-on procedure.
c. Transmitter turn-off procedure.
d. Transmitter operations.

It is important that the operator be aware of normal transmitter operation and performance, and note any changes or fault indications. Changes in operation may indicate a need for maintenance or corrective action before more serious problems develop.

WARNING

ALL SERVICE SHOULD ONLY BE PERFORMED BY QUALIFIED PERSONNEL. DANGEROUS VOLTAGES OR CURRENTS MAY BE PRESENT INSIDE WHEN DOORS ARE OPEN.

Normal operation and monitoring of the transmitter is accomplished through front panel controls, meters, and indicator (see SECTION IIIA: Controls and Indicators).

NOTE

If remote/extended control of the transmitter is used, the station chief engineer or qualified technical staff member should provide instructions for operator use.

3.3 Daily Preoperational Checkout

The following paragraphs describe checks to be made before normal daily turn-on.

a. Check the transmitter maintenance log to make sure that maintenance performed on the transmitter, or other abnormal conditions, do not place any restrictions on transmitter operation. An example is a requirement to operate at reduced power.

b. Ensure that the transmitter RF output is properly terminated into the antenna. This may include determining that antenna pattern switching is correct.

c. Check the ColorStat™ panel on the center front of the transmitter. If the transmitter is ready for operation, all the status, interlock, and overload LEDs will be green. If any LEDs are red, note which indicators are red so that information may be entered into the station maintenance log, then press the RESET button. All indicators should change to green when the RESET button is pushed and released.

If any indicators are still red after operating the RESET, do not attempt to turn on the transmitter and contact qualified maintenance personnel.

3.4 Transmitter Turn-On Procedure

When the Preoperational Checkout has been completed and no problems are present, the transmitter is ready to turn on.

a. Set the selector switch below the POWER meter on the meter panel to FORWARD, if it is not already in that position.

b. Depress the LOW, the MEDIUM, or the HIGH button, depending on power level desired. Each of these buttons will turn the transmitter on at the power level which has been preset.

c. The button operated should illuminate green, and power will come up to the preset level. (You should also hear three ‘clicks’ as contactors operate, then the blowers should start, then power will come up.)

NOTE

During the Step Start sequence, you should see the power meter go to 1/2 of the power selected, then reach the desired power level.

d. Should FORWARD POWER not be correct, verify that you have selected the correct power level (LOW, MEDIUM, or HIGH). If not, press the proper power level button, and check forward power again.

e. When the correct power level has been selected, but an adjustment in power is still needed, press the RAISE button to INCREASE power, or the LOWER button to DECREASE power. When you press the button and watch the FORWARD POWER indication, the power will change slowly. Hold the button in until the power is correct.

NOTE

RAISE and LOWER buttons will only change power level if the transmitter is operating in the HIGH, MEDIUM, or LOW function. This new power level will become the preset power until it is changed again. The Raise and Lower buttons will adjust power from zero to 30 kW on each selected power level.

f. Check transmitter panel meter readings for normal values. If an abnormal meter reading is obtained, qualified maintenance personnel should be contacted.

3.5 Transmitter Turn-Off Procedure

a. To turn off (de-energize) the transmitter, depress the OFF button.

b. The HIGH, MEDIUM or LOW lamp will go out, you should hear the contactor as it de-energizes, and the blowers will stop.

c. With the POWER switch in the FORWARD position, the Power meter should indicate zero power. Supply voltage and supply current meters should both indicate zero readings.

3.6 Transmitter Operations

The following is intended to make the operator aware of some basic operational characteristics of the transmitter.

3.6.1 Routine Meter Readings

A sample log sheet is provided in Section II, Installation/Initial Turn On. Copies can be made of the log sheet for station records. Readings should be taken monthly, at a minimum. However, more frequent logs can be an important tool in assisting maintenance personnel.

3.6.2 Fault Conditions

The following describes normal transmitter actions for certain possible fault conditions. It is very important that operators log all abnormal operation, such as incorrect meter readings, overloads, fault indications, and transmitter shut-downs. A log or record of abnormal operating conditions will be useful to technical personnel in locating and correcting transmitter or other system problems.

3.6.2.1 Transmitter Shuts Off

The operator should first check for overload or fault indications that are RED and log any fault indications that are found. Press the RESET button on the ColorStat™ panel to clear fault indications. ColorStat™ panel indicators should change from RED to GREEN.

If any LEDs are still RED, contact qualified maintenance personnel.

When the fault indicators are GREEN, follow the normal turn-on procedure.

If the transmitter shuts OFF again, and the same overload or fault indication comes on, try turning the transmitter ON by using the LOW power button. Under some conditions, a transmitter may operate satisfactorily at reduced power. If it will not come on at LOW power, contact qualified maintenance personal.

3.6.2.2 AC Power Failure

If Battery Backup has been installed in the transmitter, no operator action is required for AC power failures less than approximately 96 hours. The transmitter will automatically return to an on-air condition, at the same power level as before the power failure.

If Battery Backup has not been installed in the transmitter, no operator action is required for AC power failures less than approximately 2 hours. The backup capacitor will hold transmitter memory for this time and the transmitter will automatically return to an on-air condition, at the same power level as before the power failure.

If AC power failures greater than approximately 2 hours occur and no Battery Backup has been installed, the transmitter will remain OFF after AC power returns, and operator action will be required to turn the transmitter ON and to reset power levels on the LOW, MEDIUM and HIGH positions.

3.6.2.3 Power Supply Current Fault

During a Current Fault condition the transmitter will shut off and the indicator will change to RED. The transmitter will attempt to restart once by itself. If the fault is no longer present, the transmitter will remain ON. If the fault is still present when the transmitter attempts to restart, the transmitter will turn OFF and operator action will be required to restart the transmitter and possibly correct the problem.

a. If the transmitter turns back on and stays on, check program modulation level. If overmodulating on positive peaks, reduce audio level to reduce modulation.

b. If the transmitter shuts off again and no longer automatically restarts. Log or record the fault, RESET the fault indicator, and try turning the transmitter on.

c. If the fault occurs again, try operating at LOW power. If the transmitter will operate at LOW power, operation may continue on a temporary, emergency basis.

3.6.2.4 Power Reduction

The transmitter will reduce the power output during certain fault conditions.

If the power output has been reduced, the transmitter has responded to one of the following faults.

3.6.2.5 VSWR Faults

If the BANDPASS VSWR, ANTENNA VSWR, OR VSWR TEST indicators are RED, the following may be the cause:

a. This may be a normal occurrence during a thunderstorm, rain storm, blowing sand, or under conditions of ice on the antenna and will stop when the weather conditions improve.

b. The indicators may flash RED when overmodulation occurs. Reducing modulation to normal levels may correct the condition.

c. If the indicators remain RED and weather conditions or overmodulation are not the cause, transmitter and/or antenna problems are indicated.

3.6.2.6 Temperature Faults

If the TEMP FAULT LED on the Driver Encoder/Temp Sense Board, inside the Driver Compartment door, is RED, the following may be the cause:

a. Failure of the building cooling system (high ambient temperatures).

b. Possible transmitter mistuning

3.6.2.7 Air Flow Faults

If the AIR FLOW indicator on the ColorStat™ panel is AMBER, the following may be the cause:

a. Obstruction of air flow at the air intake on the transmitter rear doors or at the air outlet on the transmitter top.

b. Dirty or clogged air filters.

3.6.2.8 RF Amp Fuse

The transmitter will continue to operate safely, although power output will be slightly reduced. The fault indication can not be RESET. The fault must be corrected to clear the fault indication. Continue normal operation and contact qualified maintenance personnel.

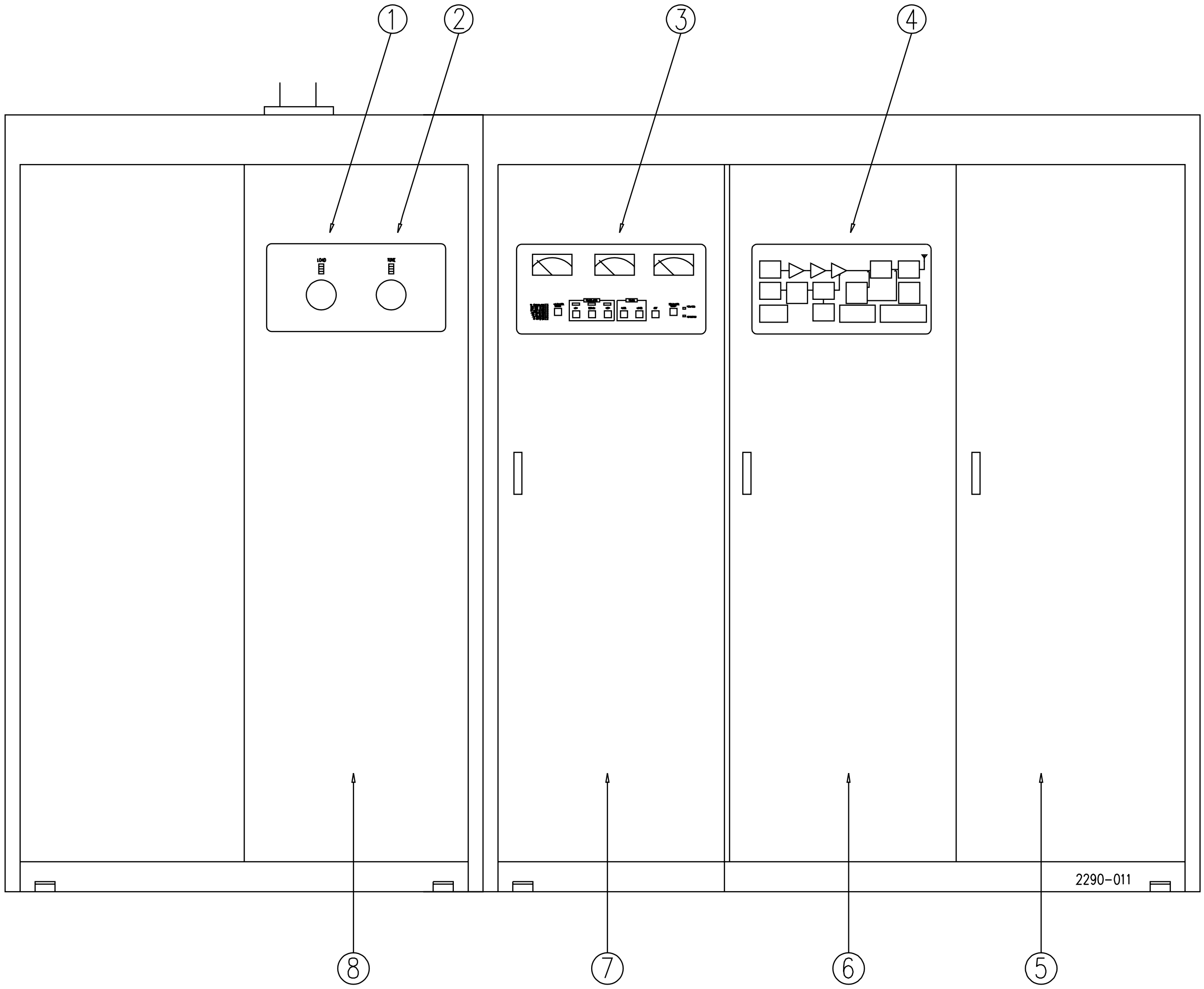

Figure 3A-1. DX 25 Front View, Controls and Indicators

Table 3A-1. DX 25U Transmitter, Controls and Indicators

REF.	CONTROL/INDICATOR	FUNCTION
1	LOAD Control	Control for matching load to 50 Ohm transmitter impedance.
2	TUNE Control	Control for matching load to 50 Ohm transmitter impedance.
3	Switch Board/ Meter Panel	See Table 3A-2 and Figure 3A-2.
4	ColorStat™ Panel	See Table 3A-3 and Figure 3A-3.
5	Driver Control Compartment	
6	Center Control Compartment	
7	Left Control Compartment	
8	Output Network Compartment	

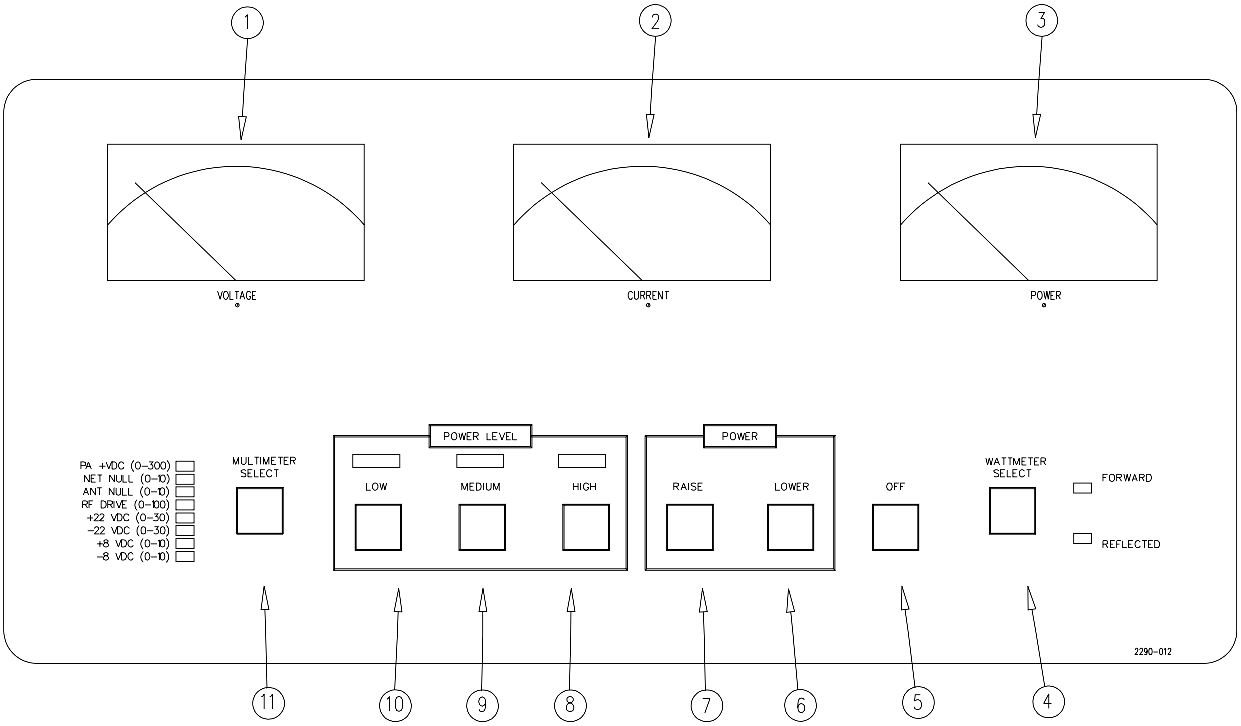

Figure 3A-2. Switchboard/Meter Panel Controls and Indicators

Table 3A-2. Switchboard/Meter Panel Controls and Indicators

REF.	CONTROL/INDICATOR	FUNCTION
1	VOLTAGE multimeter	Indicates voltages at points selected by the Multimeter Switch (Ref. 11).
2	SUPPLY CURRENT meter	Indicates the 230V supply current being supplied to the Power Amplifier.
3	POWER meter	Indicates either FORWARD or REFLECTED power at the transmitter output, whichever is selected by the POWER METER selector switch (Ref. 4).
4	POWER, selector	Selects Forward power output or Reflected power, to be read on the POWER meter.
5	OFF, pushbutton	Used to turn the transmitter off. (Low voltage supplies remain on as long as AC primary power is applied).
6	LOWER, pushbutton	Used to adjust power level. When the transmitter is in the LOW, MEDIUM, or HIGH power mode, depress to LOWER power output and hold until desired power is reached. INDICATOR illuminates while power is being lowered.
7	RAISE, pushbutton	Used to adjust power level. When the transmitter is in the LOW, MEDIUM, or HIGH power mode, depress to RAISE power output and hold until desired power is reached. INDICATOR illuminates while power is being raised.
8	HIGH, pushbutton	Used to turn the transmitter on at the preset HIGH power level, or to change power to the preset HIGH power level. INDICATOR: The pushbutton will illuminate when in the HIGH power mode.
9	MEDIUM, pushbutton	Used to turn the transmitter on at the preset MEDIUM power level, or to change power to the preset MEDIUM power level. INDICATOR: The pushbutton will illuminate when in the MEDIUM power mode.
10	LOW, pushbutton	Used to turn the transmitter on at the preset LOW power level, or to change power to the preset LOW power level. The pushbutton will illuminate when in the LOW power mode.
11	MULTIMETER switch	Selects the desired point to be monitored by the VOLTAGE multimeter.

WARNING: Disconnect primary power prior to servicing.

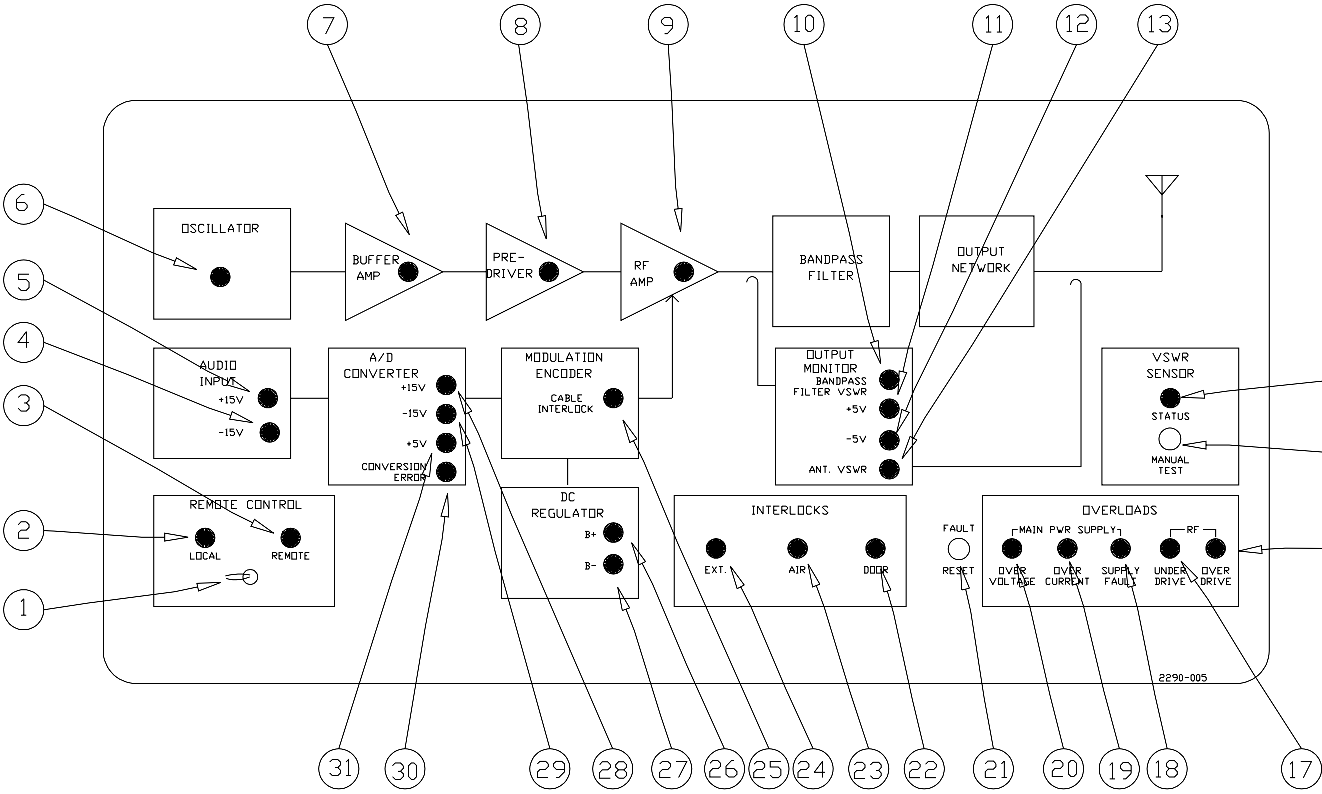

Figure 3A-3. ColorStat™ Panel Controls & Indicators

Table 3A-3. ColorStat™ Panel Controls & Indicators

REF.	CONTROL/INDICATOR	FUNCTION
1	LOCAL/REMOTE, switch	Selects LOCAL or REMOTE control of the transmitter. (Remote monitoring is operational in either the LOCAL or REMOTE switch position.)
2	LOCAL, status indicator	Indicates that the remote control inputs to the transmitter are disabled, and only local control is possible.
3	REMOTE, status indicator	Indicates that the transmitter remote control inputs are active. (The transmitter may still be controlled with the panel pushbuttons as well.)
4	AUDIO INPUT board, -15V supply status indicator.	Bicolor LED indicator. Indicates status of -15 Volt supply on the audio input board. GREEN indicates normal operation; RED indicates -15 Volt supply fault.
5	AUDIO INPUT board, +15 V supply status indicator.	Bicolor LED indicator. Indicates status of +15 Volt supply on the audio input board. GREEN indicates normal operation; RED indicates +15 Volt supply fault.
6	OSCILLATOR, RF output status indicator	Bicolor LED indicator. Indicates oscillator board RF output status. GREEN indicates normal RF output; RED indicates low or no RF output. (Note 1)
7	BUFFER AMP, RF output status indicator	Bicolor LED indicator. Indicates buffer amplifier RF output status. GREEN indicates normal RF output; RED indicates low or no RF output. (Note 1)
8	PREDRIVER, RF output status indicator	Bicolor LED indicator. Indicates predriver RF output status. GREEN indicates normal RF output; RED indicates low or no RF output. (Note 1)
9	RF AMP, indicator	Bicolor LED indicator. Red indicates a failure of an RF Amplifier. Green indicates a normal, no fault condition. (Note 2)

WARNING: Disconnect primary power prior to servicing.

Table 3A-3. Status Panel, Controls and Indicators (Cont.)

REF.	CONTROL/INDICATOR	FUNCTION
10	OUTPUT MONITOR, BANDPASS FILTER VSWR indicator	Bicolor LED indicator. GREEN indicates that there is low reflected power at the input of the bandpass filter; RED indicates that reflected power at the filter input is above the level set by the VSWR trip adjust control.
11	OUTPUT MONITOR, +5 V supply status indicator	Bicolor LED indicator. Indicates status of +5 Volt supply on the Output Monitor board. GREEN indicates +5 Volts present; RED indicates +5 Volt supply fault.
12	OUTPUT MONITOR, -5V supply status indicator	Bicolor LED indicator. Indicates status of -5 Volt supply on the Output Monitor board. GREEN indicates -5 Volts present; RED indicates -5 Volt supply fault.
13	OUTPUT MONITOR, ANT. VSWR, status indicator	Bicolor LED indicator. Indicates VSWR status. RED indicates that VSWR at the transmitter's 50 Ohm point is above the threshold set by "VSWR Trip Adjust" control. GREEN indicates low VSWR.
14	VSWR SENSOR, "STATUS" indicator (VSWR Self-Test result)	Bicolor LED indicator.Indicates result of "VSWR Self-Test." RED indicates VSWR logic fault, GREEN indicates VSWR protection logic is functioning normally. ("VSWR self-test" can be initiated manually with "VSWR SENSOR, Manual Test," and is performed automatically whenever AC power is restored.
15	VSWR SENSOR, MANUAL TEST, pushbutton	Used to test operation of VSWR logic, result of test is displayed on VSWR SENSOR, STATUS indicator (Ref. 14, above). When the pushbutton is depressed, both the Bandpass Filter and Antenna VSWR status indicators will momentarily go red, then Sensor Status Indicator will indicate green if VSWR logic is functioning properly. DO NOT TEST WHILE TRANSMITTER IS ON AIR.
16	OVER DRIVE, status indicator	RED indicates excessive RF drive level to the Power Amplifier. GREEN indicates drive level is below the Overdrive threshold.
17	UNDER DRIVE, status indicator	RED indicates low RF drive level to the Power Amplifier. GREEN indicates drive level above the preset threshold. Red can also indicate a short in the PA power supply.
18	SUPPLY FAULT, overload indicator	RED indicates that the Power Supply Protection circuit has detected a PA Power Supply fault (an imbalance in three phase voltages from transformer T1, caused by loss of one phase or phase imbalance on incoming primary power. GREEN indicates no fault.
19	OVER CURRENT, overload indicator	GREEN status indicates normal status; RED indicates that either average or peak supply current has exceeded preset levels.
20	OVER VOLTAGE, overload indicator	Bicolor LED indicator. GREEN indicates normal status; RED indicates main power supply voltage has exceeded 260 Volts DC.
21	RESET pushbutton	Resets the overload indicators; when depressed, overload indicators will change from RED to GREEN if the cause of the overload has been cleared. Depressing the RESET button will also reset the Bandpass and Antenna VSWR fault indicators.
22	DOOR INTERLOCKS, status indicator	Bicolor LED indicator. GREEN indicates all doors are closed; RED indicates that a door is open, or not fully closed.
23	AIR INTERLOCKS, status indicator	Bicolor LED indicator. GREEN indicates proper air flow, RED indicates "air flow fault."
24	EXT. INTERLOCKS, status indicator	Bicolor LED indicator. Indicates status of external interlocks. GREEN indicates a completed circuit; RED indicates an open circuit.
25	MODULATION ENCODER, CABLE INTERLOCK, status indicator	Bicolor LED indicator. Indicates status of cables between the MODULATION ENCODER board and the Combiner/Motherboards. It also indicates when any RF Amplifier module is not properly inserted into the motherboard. GREEN indicates all cables and modules are properly installed; RED indicates that a cable or module is not installed or connected.

Table 3A-3. Status Panel, Controls and Indicators (Cont.)

REF.	CONTROL/INDICATOR	FUNCTION
26	DC REGULATOR, B+ supply status indicator	Bicolor LED indicator. Indicates status of +5 Volt supply on the DC Regulator board. GREEN indicates normal operation; RED indicates +5 Volt supply fault.
27	DC REGULATOR, B- supply status indicator	Bicolor LED indicator. Indicates status of B- supply on the DC Regulator board. GREEN indicates normal operation; RED indicates B- Volt supply fault.
28	A/D CONVERTER, +15 V supply status indicator	Bicolor LED indicator. Indicates status of +15 Volt supply on the A/D Converter board. GREEN indicates normal operation; RED indicates +15 Volt supply fault.
29	A/D CONVERTER, -15 V supply status indicator	Bicolor LED indicator. Indicates status of -15 Volt supply on the A/D Converter board. GREEN indicates normal operation; RED indicates -15 Volt supply fault.
30	A/D CONVERTER, CONVERSION ERROR, status indicator	Bicolor LED indicator. GREEN indicates normal operation of analog to digital (A/D) converter. RED indicates conversion error in A/D converter.
31	A/D CONVERTER, +5V supply status indicator	Bicolor LED indicator. Indicates status of +5 Volt supply on the A/D Converter board. GREEN indicates normal operation; RED indicates +5 Volt supply fault.

Note 1

Use S4 on the LED board to display current RF status when PA supplies are off.

Note 2

This indicator is tied to red (blown fuse) indicators on the RF Amplifiers in the PA section. Refer to Section C.

WARNING: Disconnect primary power prior to servicing.

Table 3A-4. Boards Listed in Alphabetical Order

Analog Input Board	A35
A/D Converter Board	A34
Buffer Amplifier	A16
Combiner Motherboard Binary	A8
Combiner Motherboard Main	A5 thru A7
Combiner Motherboard Driver	A14
Controller	A38
DC Regulator	A30
RF Drive Splitter	A15
Driver Encoder/Temperature Sensor	A19
Driver Supply Regulator	A22
RF Multimeter	A23
External Interface	A28
Fuse Board #1	A24
Fuse Board #2	A25
IPA Splitter	A18
LED Board	A32
Modulation Encoder/Binary	A37
Neutralization Board	A40
Oscillator	A17
Output Monitor	A27
Output Sample Board	A26
Power Distribution	A39
Switch Board/Meter Panel	A31
T6/T7 RF Sample Assembly	A41

Table 3A-5. Boards Listed in Numerical Order

A5 thru A7	Main Combiner Motherboard
A8	Binary Combiner Motherboard
A14	Driver Combiner Motherboard
A15	RF Drive Splitter
A16	Buffer Amplifier
A17	Oscillator
A18	IPA Splitter
A19	Driver Encoder/Temperature Sensor
A22	Driver Supply Regulator
A23	RF Multimeter
A24	Fuse Board Assembly 001
A25	Fuse Board Assembly 002
A26	Output Sample Board
A27	Output Monitor Board
A28	External Interface
A30	DC Regulator
A31	Switch Board/Meter Panel
A32	LED Board
A34	A/D Converter Board
A35	Analog Input
A37	Modulation Encoder/Binary
A38	Controller
A39	Power Distribution Board
A40	Neutralization Board
A41	T6\T7 RF Sample Assembly

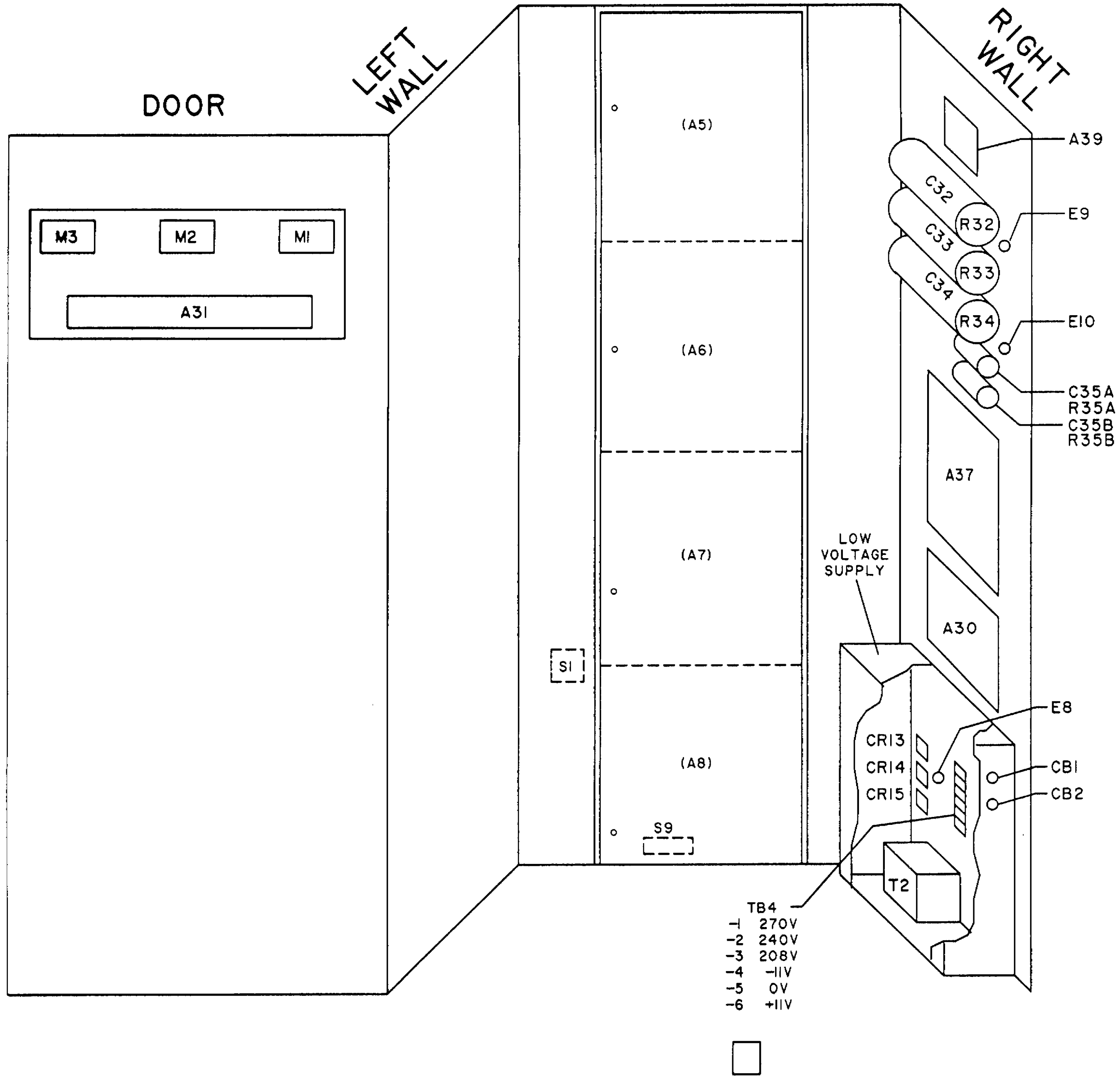

Figure 3A-4
Left Control Compartment - Front View
839 7855 117

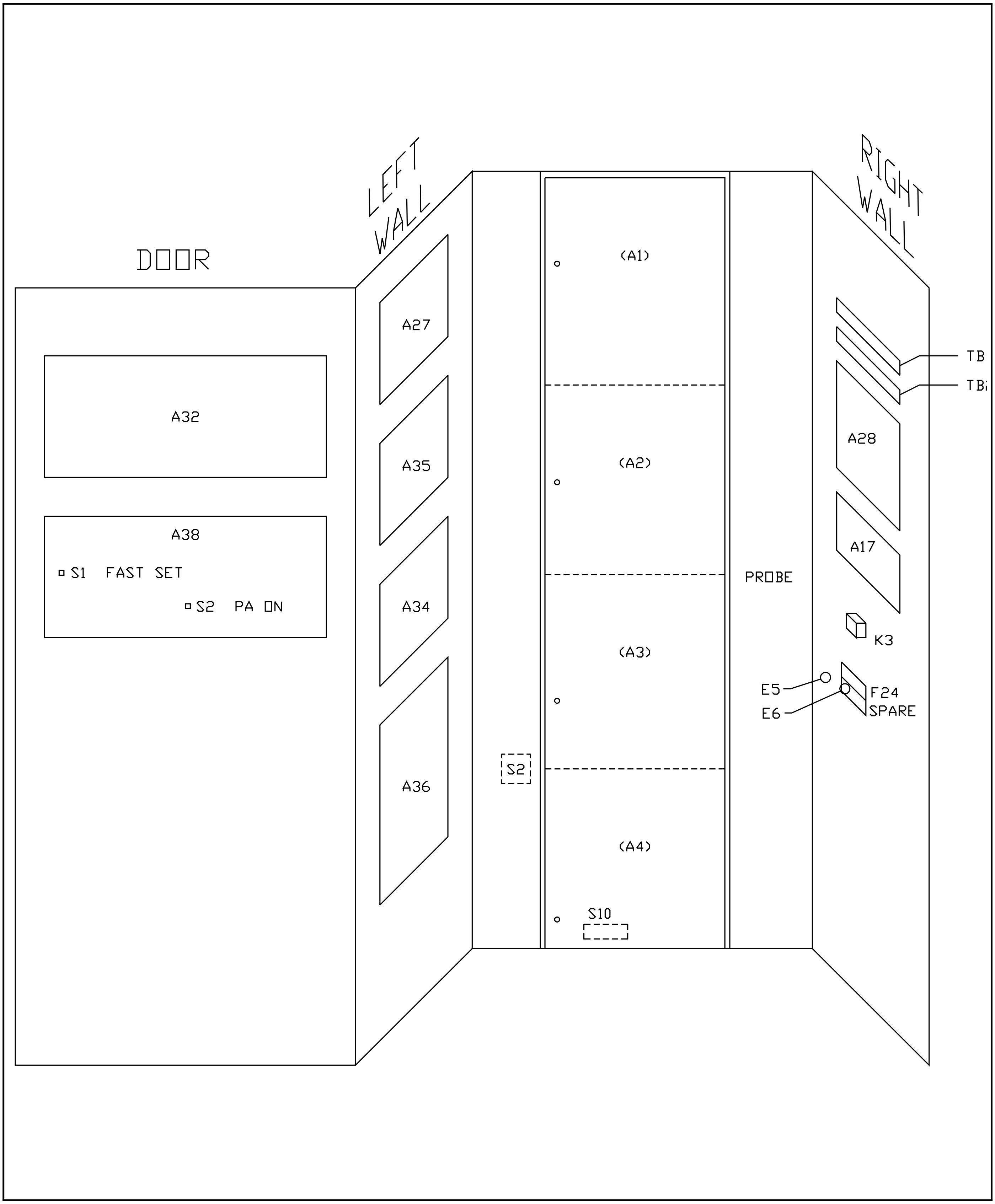

Figure 3A-5
Center Control Compartment - Front View
839 7855 118

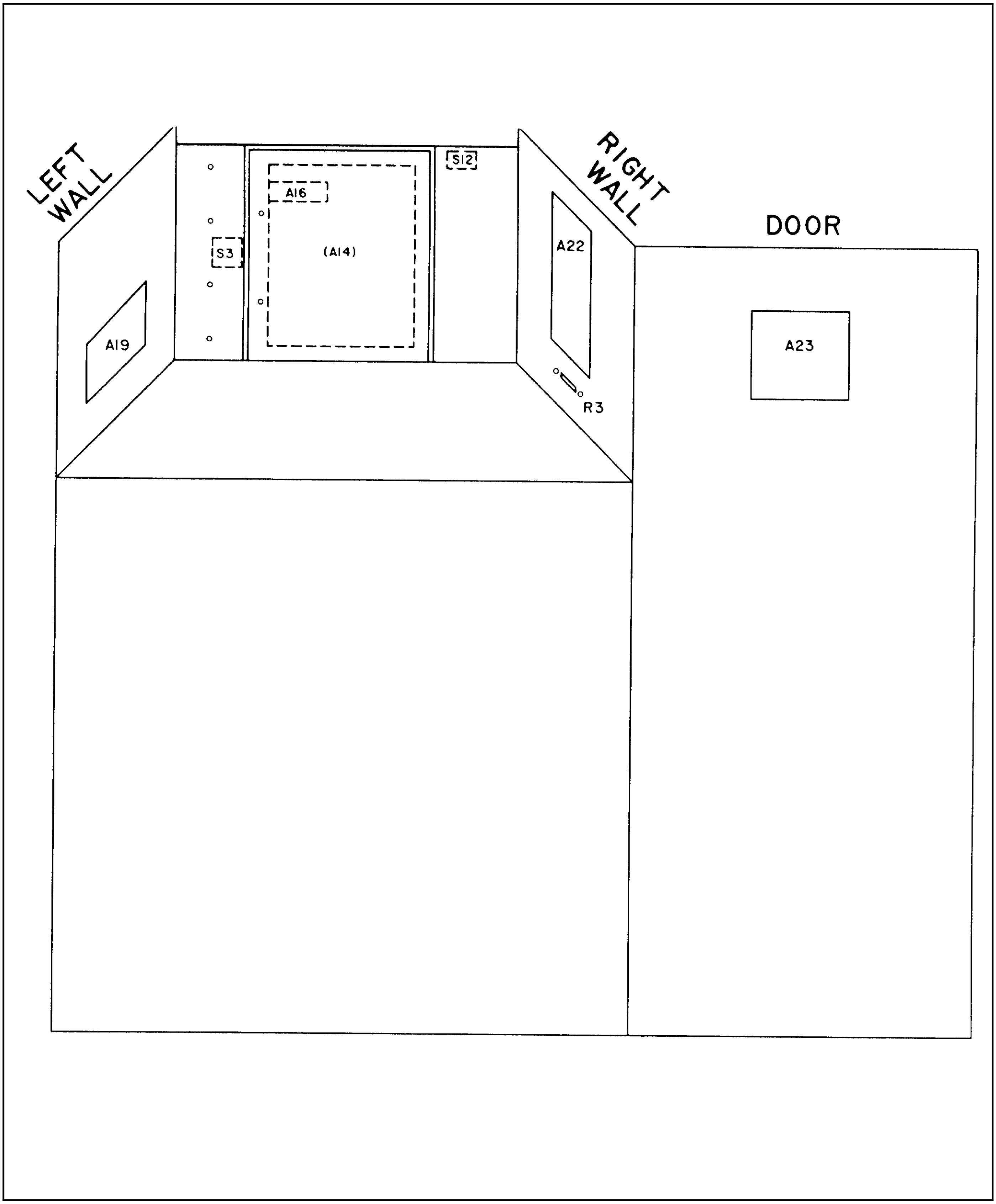

Figure 3A-6
Driver Compartment - Front View
839 7855 119

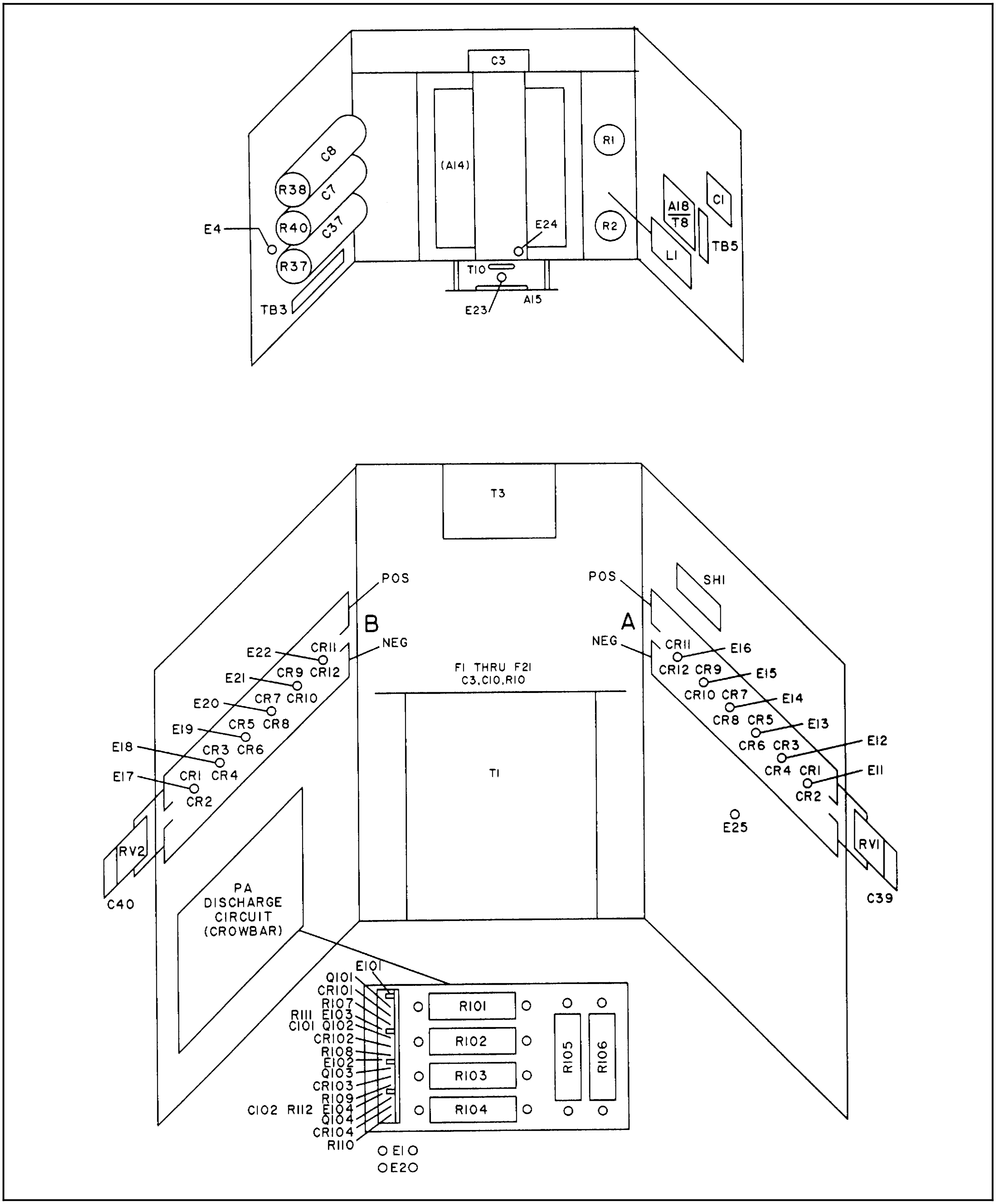

Figure 3A-7
Driver Compartment - Rear View
839 7855 126

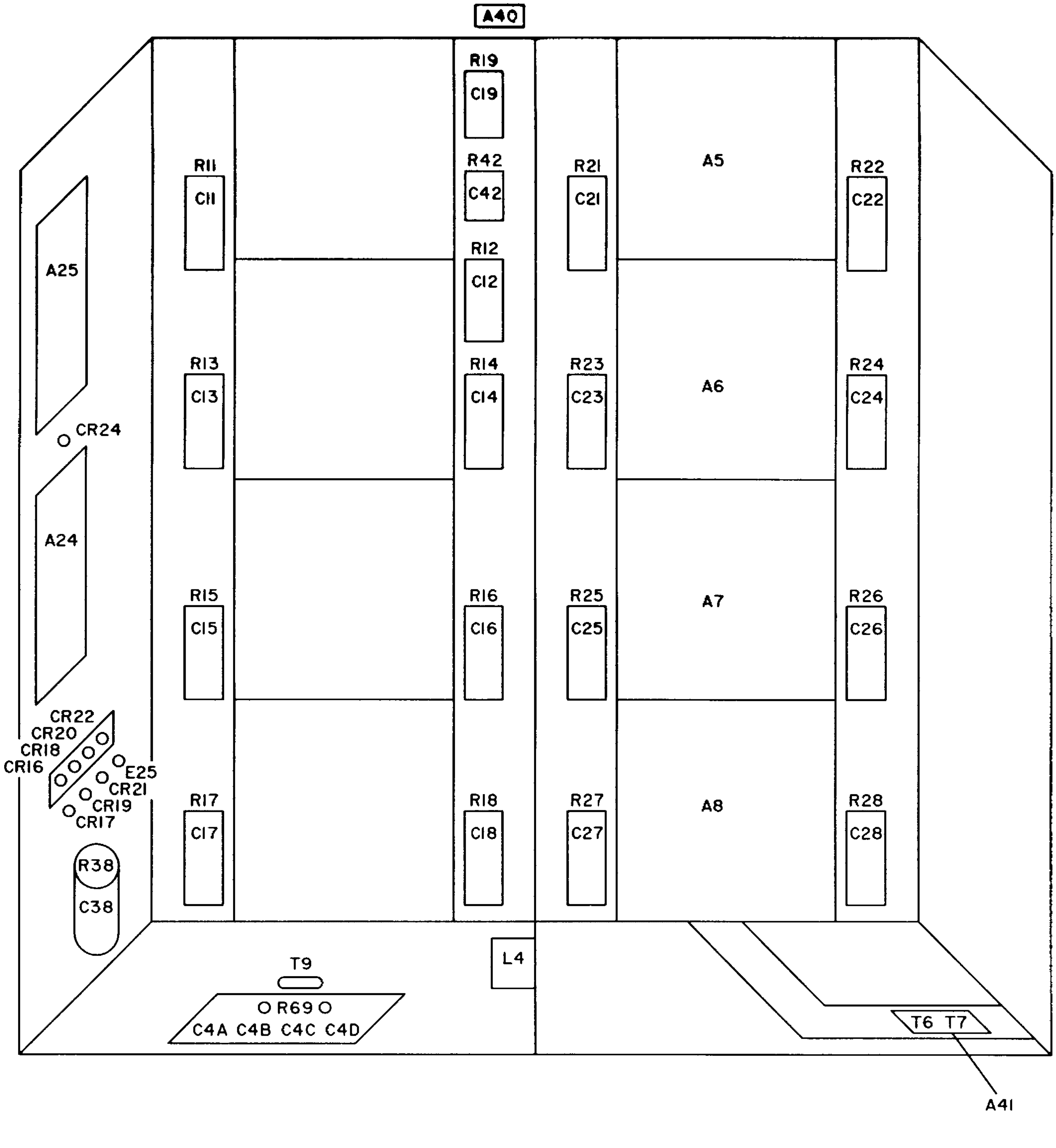

Figure 3A-8
Left & Center Control Compartments - Rear View
839 7855 121-modified

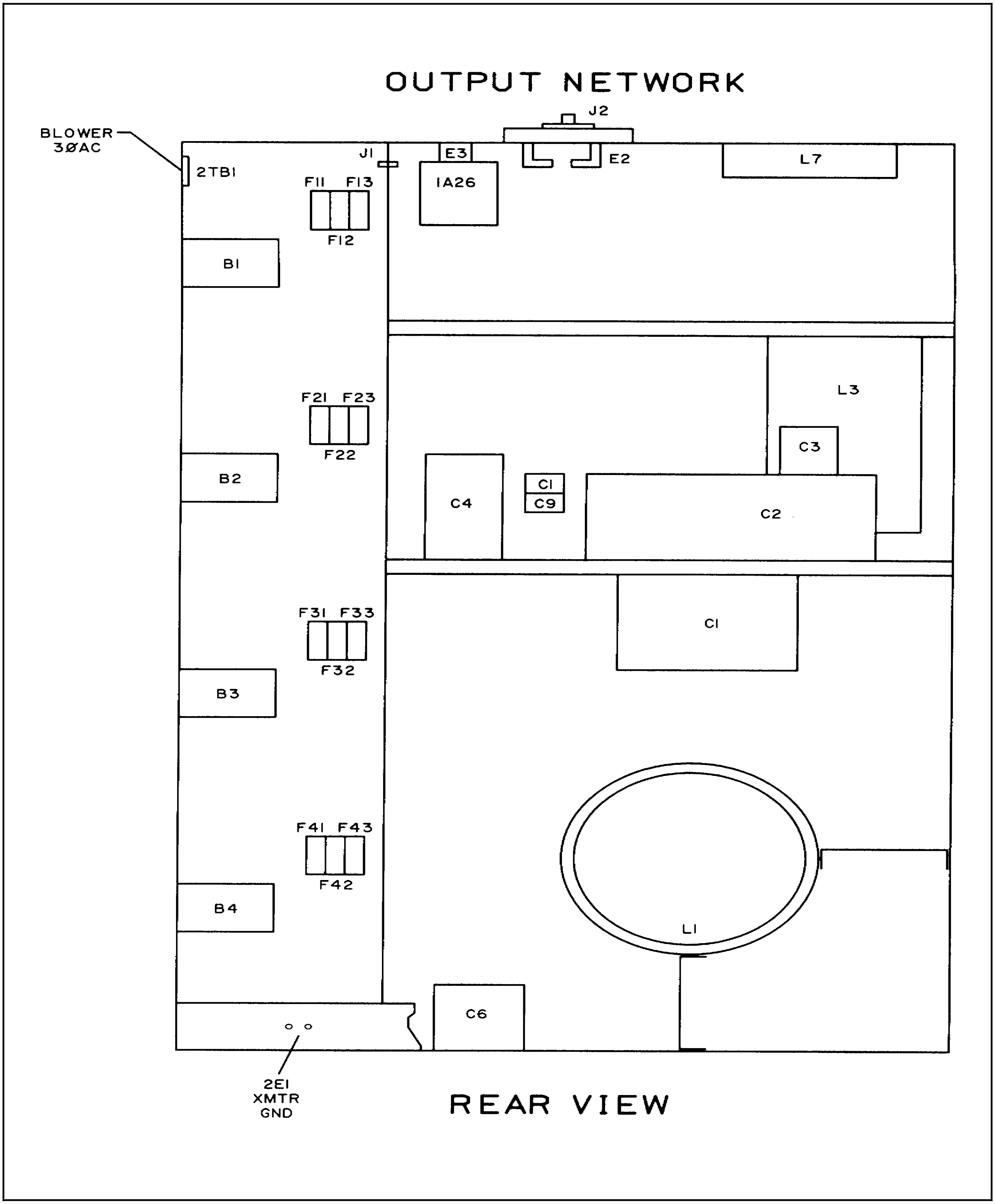

Figure 3A-9
Output Network Compartment - Rear View
839 7855 120

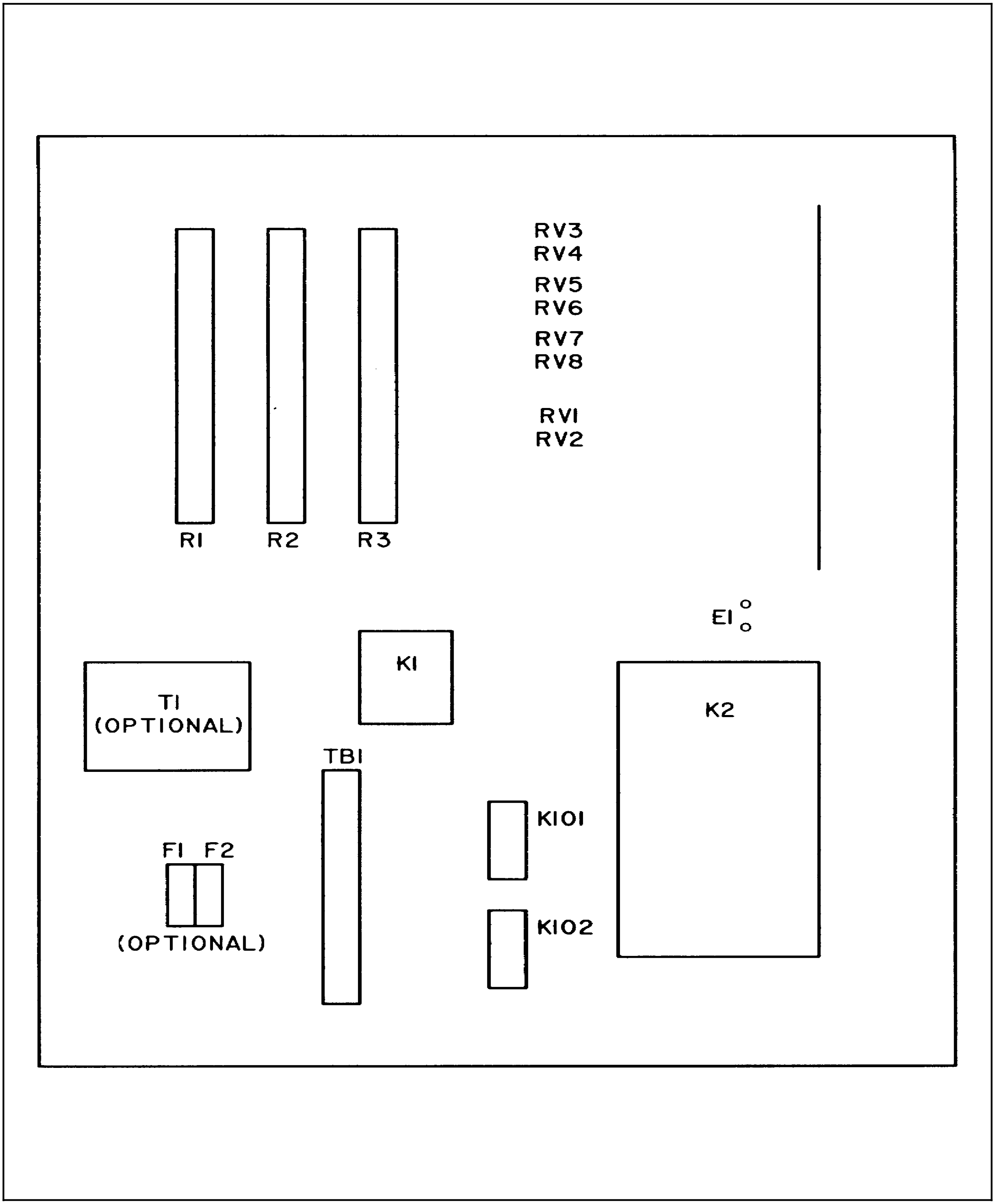

Figure 3A-10
Step Start Panel, Unit 3
839 7855 139

WARNING: Disconnect primary power prior to servicing.

4.1 Introduction

This section presents the overall principles of operation for the DX-25U AM TRANSMITTER, including a review of Digital Modulation, and circuits not described in SECTIONS A through S.

4.2 Block Diagram Description

Refer to Figure 4-1, DX-25U Block Diagram. Most of the blocks on the diagram represent printed circuit boards in the transmitter. The Overall Schematic Diagram, 839-7855-151, in the Drawing Package, includes many of the same blocks identified as printed circuit boards.

The Block Diagram description is divided into four sections:

a. RF Section
b. Audio and Modulation Section
c. Controller Section
d. Power Supplies

4.2.1 RF Section

The RF Section includes the Oscillator through the Power Amplifiers, Bandpass Filter, and Pi Matching Network.

The RF Section generates an RF signal, then amplifies the signal to a level high enough to drive the Power Amplifier stage. In the Power Amplifier stage, the RF amplifier outputs are combined, and fed to a Bandpass Filter/Output Network and then to a 50 Ohm RF output point. The Pi Matching Network allows convenient matching to loads that are not exactly 50 Ohms.

4.2.1.1 Oscillator

The RF signal path begins at the Oscillator from a crystal oscillator or from an external source, such as an AM Stereo Exciter or Frequency Synthesizer. The Oscillator output is fed to the Buffer Amplifier.

4.2.1.2 Buffer Amplifier

The Buffer Amplifier amplifies the Oscillator output and provides a stable input signal to drive the Predriver stage.

4.2.1.3 Predriver

The Predriver stage uses one of the 79 identical and interchangeable RF amplifiers used in the DX-25U. The Predriver amplifies the Buffer Amplifier signal to a high enough level to operate the 14 RF amplifiers used in the Driver stage.

4.2.1.4 Driver Stage

The Driver stage consists of the combined output of up to 14 RF amplifier modules. One of the RF amplifier modules is utilized as a spare and two operate in a reserve capacity to compensate for AC line variations. One of these two Driver Modules operates as a “coarse” adjustment, “ON” or “OFF,” while the other provides “fine” adjustment for the Power Amplifier stage drive level. The Driver Supply Regulator provides a variable DC supply for this module.

4.2.1.5 Driver Supply Regulator

The Driver Supply Regulator is part of a loop which controls RF drive level to the power amplifier. An “RF Sense” feedback signal from the RF splitter controls the regulator output voltage to control the Driver stage output.

4.2.1.6 Driver Encoder/Temp Sense Board

The Driver Encoder/Temp Sense Board provides the turn-on signals for the 14 Driver Modules. The “RF Sense” feedback signal from the RF splitter is also fed to this board for automatic control of one module. Other circuits on the board monitor heat sink temperature of PA Modules RF1 and RF2 and air flow from the four cooling fans.

4.2.1.7 RF Status Indications: RF Sense Data Lines

Three RF status indicators on the transmitter ColorStat™ panel indicate Oscillator, Buffer Amplifier, or Predriver output. A Fault in any section will cause that LED indicator on the ColorStat™ panel to turn RED.

The ColorStat™ panel indicators are normally GREEN. Some indicators will turn AMBER under certain temporary overload conditions. If a Fault or abnormal condition exists, the indicator will turn RED.

Additional indicators are located on the RF amplifiers. Each RF amplifier is fused, and if an amplifier fault causes a fuse to open, a red LED will illuminate to indicate the location of the open fuse.

4.2.1.8 Driver Combiner and RF Splitter

The outputs of the 14 RF amplifiers in the Driver stage are combined by the Driver Combiner and fed to the RF Splitter. The RF Splitter provides separate RF drive signals to the individual RF amplifiers in the Power Amplifier.

4.2.1.9 Power Amplifier (64 RF amplifiers)

The Power Amplifier consists of 64 identical RF amplifier modules. For “Digital Amplitude Modulation,” encoded audio signals turn on only as many RF amplifiers as required at any instant to generate the carrier and the modulating signal. The 64 RF amplifiers are referred to as “Steps.”

The physical location of the RF amplifier modules in the Power Amplifier stage creates a combination of 58 equal RF voltage “Big Steps” and 6 fractional RF voltage “Binary Steps”.

4.2.1.10 PA Combiner

The 64 RF amplifier modules plug into three Main Combiner motherboards and one Binary Combiner motherboard to make up the PA Combiner. The module outputs are series combined by a torroidal transformer to develop the total RF voltage. The RF signal is then fed to the Output Network.

4.2.1.11 Output Network

The Output Network transforms the low impedance of the PA Combiner output to a 50 Ohms output impedance. The impedance transformation is accomplished in two sections: the Bandpass Filter stage and the Pi Matching stage.

The Bandpass Filter stage completes the digital to analog conversion by filtering out the individual “step” voltages generated by the RF amplifiers.

The Pi Network provides for impedance matching into antenna systems that are not perfect 50 Ohm loads.

The Output Network also includes RF sample circuits for the Output Monitor circuitry to provide power monitoring, and protection against high VSWR conditions.

4.2.2 Audio and Modulation Section

The Modulation Section of the transmitter accepts an analog audio input signal and converts it to a digital signal. The digital signal is then processed, or “encoded”, to control the RF amplifiers which produce the “Digital Amplitude Modulation”. Circuit boards in the Modulation section include the Analog Input Board, Analog to Digital Converter, Modulation Encoder, and DC Regulator.

4.2.2.1 Audio Input

Audio is fed into the Analog Input Board where it is processed. This processing includes attenuating the high audio frequencies for Medium Wave Band channel spacing, and adding a DC component to determine the carrier power. This (Audio + DC) signal is sent to the Analog to Digital Converter. A second (Audio + DC) signal is sent to the DC Regulator.

4.2.2.2 Analog to Digital Converter

The (Audio + DC) signal is sampled at a 400 to 800 kilohertz rate, depending on the transmitter operating frequency, by the Analog to Digital Converter circuits. The Analog to Digital Converter converts the (Audio + DC) signal into a 12 bit digital signal.

4.2.2.3 Modulation Encoder

The Modulation Encoder converts the 12-bit digital audio information into control signals which turn the RF amplifier modules in the Power Amplifier stage ON and OFF, to generate the transmitter carrier and the instantaneous modulation level.

Other inputs to the Modulation Encoder include a PA OFF signal from the Output Monitor. Supply voltages for the Modulation Encoder are supplied by the DC Regulator.

The PA OFF signal immediately turns the Power Amplifier control signals OFF, if a VSWR condition is detected, to protect the RF amplifier modules. The OFF signal only lasts as long as the VSWR condition is present, and the transmitter will immediately return to normal operation.

4.2.2.4 DC Regulator

The DC Regulator produces the B+ (+5 VDC) and B- voltages used by the Modulation Encoder. The (Audio + DC) sample from the Analog Input Board “modulates” the DC Regulator “B-” output voltage. The Modulated B- is a bias voltage for the RF amplifier modules in the Power Amplifier stage which varies the turn on/turn off times of the modules to optimize distortion and noise performance.

4.2.3 Controller Section

The Controller section consists of the Controller, LED Board, External Interface, and the Switch Board/Meter Panel.

4.2.3.1 Controller

The PA Turn-On/Turn-Off command is recognized by the Controller from any of the LOW, MED, HIGH, or OFF buttons on the Switch board or from external inputs. Circuits on the Controller energize the main contactors for the PA Power Supply and provide carrier power control.

4.2.3.2 LED Board

The LED Board contains fault and overload sensing and logic. It provides 26 LED ColorStat™ panel indications to monitor transmitter operation. These status indications are also available as remote status outputs from the External Interface. Many status indications are “latched” to provide fault indications until they are “reset,” even if the transmitter is turned OFF. A battery backup supply holds status indications in memory if AC power fails or is turned off. The backup supply also enables the transmitter to automatically restart when AC power is restored.

4.2.3.3 External Interface (Remote Control)

The External Interface provides “remote control” inputs, status outputs, and selected metering outputs. The External Interface isolates transmitter circuits from remote control inputs to minimize the possibility of damage if improper voltages are accidentally applied to the terminal boards.

4.2.4 Power Supplies

Power Supplies are derived from two transformers: T1 provides the PA Power Supply voltage and T2 provides the Low Voltage supply.

4.2.4.1 Low Voltage Supplies

The Low Voltage supply includes +30 VDC, +22 VDC, -22 VDC, +8 VDC and -8 VDC unregulated supplies. These supplies are regulated on individual modules for circuit supply voltages.

4.2.4.2 PA Power Supply

The PA Power Supply includes +230 VDC, +115 VDC and +60 VDC supplies for the 58 “Big Step” and 6 “Binary Step” amplifiers.

4.3 Low Voltage Power Supply: Circuit Description

Refer to Sheet 1 of the DX-25U Overall Schematic, 839-7855-151, in the Drawing Package.

A 208 to 270 VAC input is protected by Metal Oxide Varistors RV1 and RV2 in the Step-Start panel, fed to Low Voltage circuit breakers CB1 and CB2 and then to transformer T2 in the transmitter cabinet.

Low Voltage Supply transformer T2 has two secondary windings. One winding provides 24 Volts AC to bridge rectifier CR15. The bridge rectifier positive output is +30 VDC and filtered by C37. The +30 VDC output is used for contactor status and

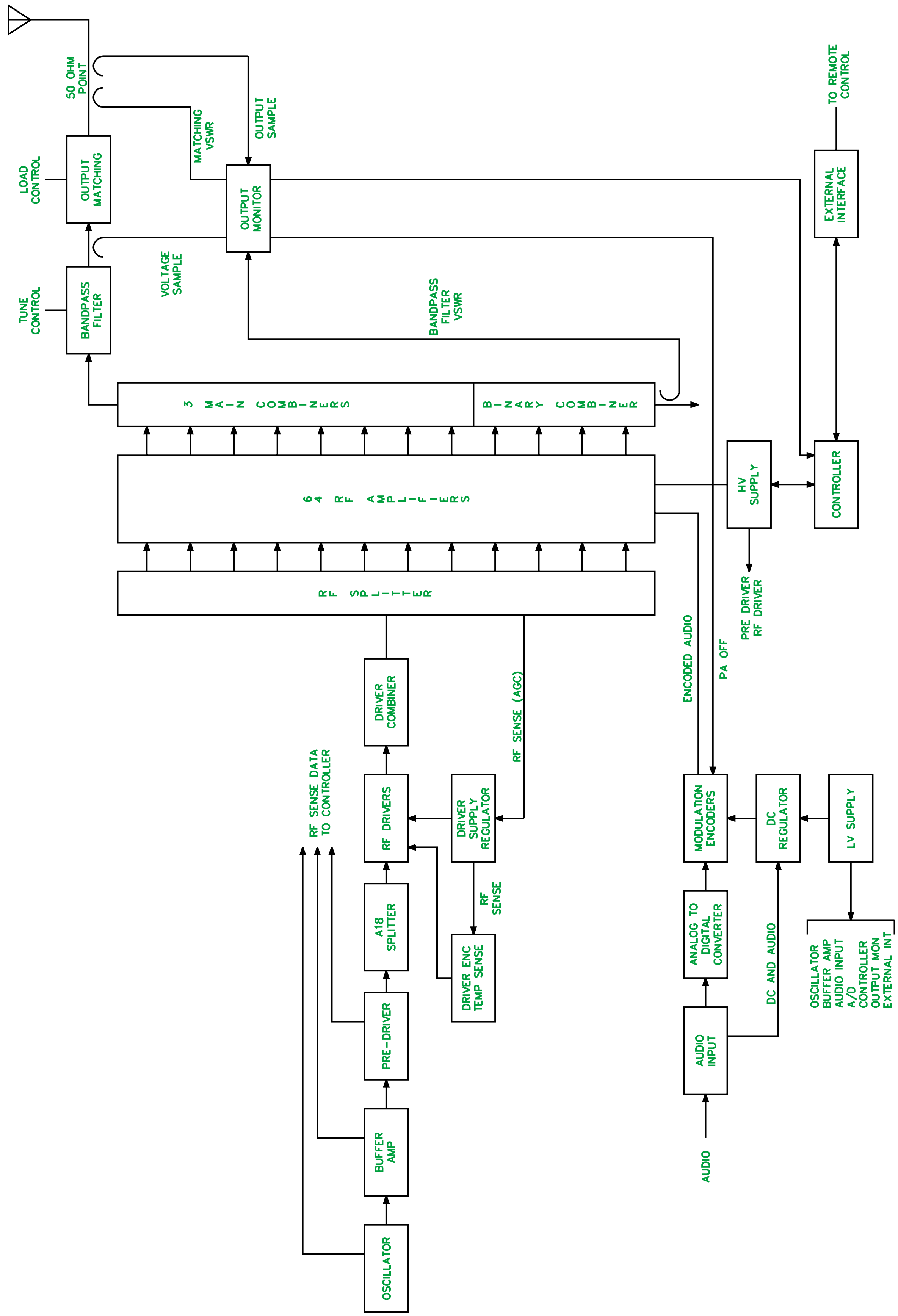

Figure 4-1. DX 25U Block Diagram

supplies the Buffer Amplifier. The winding also supplies 24 Volts AC for the interlock circuit relays.

The other secondary winding is tapped to provide two different output voltages for bridge rectifiers, CR13 and CR14. The center tap is grounded, so that each rectifier provides a positive and negative output voltage. Rectifier CR13 provides +8 VDC and -8 VDC and CR14 provides +22 VDC and -22 VDC. Large electrolytic filter capacitors are used for all Low Voltage supplies. Each capacitor has a bleeder resistor connected across its terminals to discharge the capacitor when the supply is turned off. All transmitter circuits, except Power Amplifier and Driver Modules, operate from the Low Voltage supply.

4.3.1 Power Distribution Board, A39

The Power Distribution Board distributes the +8 VDC and +22 VDC outputs to individual printed circuit boards, where +5 VDC and +15 VDC regulators and zener diodes provide required voltages for circuits on the boards. The -8 VDC and -22 VDC outputs are also distributed to individual boards where they are regulated to -5 VDC and -15 VDC.

4.4 PA Power Supply: Circuit Description

The PA Power Supply contactors K1 and K2 in the Step Start panel are driven by transmitter logic circuits to provide a step-start function on turn-on. Auxiliary contacts on K1 and K2 operate the PA Supply Discharge Circuit (Crowbar) to discharge the supply when it is turned off. The PA Power Supply transformer T1 supplies +230 VDC, +115 VDC and +60 VDC for the Power Amplifier and Driver stages. Refer to Sheet 1 of the DX-25U Overall Schematic, 839-7855-151, in the Drawing Package, for the following description.

4.4.1 Step Start Panel

Eight identical MOVs (metal oxide varistors) are mounted in the Step Start panel to absorb transient voltages on the incoming AC lines. Two are used on the single phase 1 KVA feed, and the remaining 6 are paired up and placed across the 3-phase lines.

When the PA Power Supply is energized by turn-on/turn-off logic on the Controller, the single phase AC input voltage energizes step-start contactor K1 through K101. AC power is supplied to transformer T1 through three low-resistance high wattage resistors (R1, R2 and R3). The series resistance limits surge current as power supply capacitors charge.

When K1 energizes, an auxiliary contact also closes and provides a +30 Volt “K1 has closed” logic signal back to the turn-on/turn-off logic on the Controller.

After approximately one second, the turn-on/turn-off logic energizes contactor K2 and applies primary power directly to transformer T1, completing the step-start sequence. An auxiliary contact provides a +30 Volt “K2 has closed” logic signal to the turn-on/turn-off logic. Approximately one-half second later, step-start contactor K1 de-energizes.

4.4.2 PA Supply Discharge Circuit (Crowbar)

This circuit is comprised of four power MOSFETs operating in parallel to discharge the PA Power Supply anytime K1 and K2 are deenergized.

When the PA Power Supply is energized, transistors Q101, Q102, Q103, and Q104 function as open switches. In this condition, K1 is deenergized and K2 is energized. The AUX contact of K1 is closed and the AUX contact of K2 is open. When K2 deenergizes, the AUX contact closes and applies a control voltage from the +230 VDC supply to the gate of each MOSFET. This voltage switches the MOSFETs ON and discharges the supply through resistors R101, R102, R103, and R104. Each MOSFET has a zener diode from gate to source to limit the gate voltage to 10V.

Resistors R105 and R106 provide a secondary discharge path with a faster time constant than the combination of the individual bleeder resistors mounted across each filter capacitor. The +115 VDC supply is also discharged through the PA Supply Discharge Circuit through CR24.

4.4.3 Power Supply Shorting Switches

Switches S9, S10 and S12 short the +230 VDC supply bus to ground if any Power Amplifier or Driver Compartment interlocked door is open.

4.4.4 PA Power Supply Transformer T1

Transformer T1 is a three-phase, open frame power transformer with multiple windings in the primary to allow an input voltage range from 360 VAC to 505 VAC. Three sets of secondary windings provide AC for the +230 VDC and +115 VDC rectifier assemblies.

4.4.5 Interphase Transformer T3

The +230 VDC, six-phase rectified outputs are combined through interphase transformer T3. The use of an interphase transformer reduces the losses in the supply transformer and rectifiers.

4.4.6 +230 VDC Supply

The +230 VDC 12-phase output of T3 is fed to the distribution bus on Fuse Boards A24 and A25. A 12-phase rectifier assembly provides a DC output with a small ripple component at 12 times the power line frequency and reduces the supply filtering required. A parallel supply reduces the peak current requirements of the rectifiers. To further improve overall efficiency, the total number of rectifiers in each assembly is doubled. Each rectifier is fused separately to provide built in redundancy.

4.4.7 +115 VDC and +60 VDC Supplies

The third secondary of T1 is wired in a WYE configuration to provide the +115 VDC supply and the neutral of this winding supplies +60 VDC. The third secondary of T1 feeds the rectifier assembly CR16 thru CR21. The +115 VDC output of CR16, CR18, and CR20 is sent to the A24 Fuse Board for the Driver and Binary Modules and filtered by C19 and C7. The neutral provides +60 VDC for the Predriver and Binary Amplifiers and is filtered by 10 mH choke L3 and capacitors C10 and C42.

4.4.8 Supply Current Meter, M2

The negative sides of the rectifier assemblies are tied to the PA Power Supply current meter shunt SH1 in the Driver Compartment. The total +230 VDC supply current returns to ground at this point. The Supply Current meter (M2) on the transmitter front panel is connected across the shunt.

The voltage across the shunt is proportional to supply current and also goes to the supply current overload circuit on the LED Board from the Switch Board/Meter Panel. The current overload circuit also provides a remote supply current metering output. Refer to SECTION Q, LED Board, for a description of the supply current overload circuit.

4.4.9 Secondary Winding Fuses

The secondary winding of the PA Power Supply is protected by fuses mounted on the top of transformer T1: 250 Amp fuses F1 through F12 protect the secondary windings from a short circuit in the +230 VDC rectifier assemblies or output bus and 35 Amp fuses F13, F14, and F15, protect the secondary windings for the +115 VDC and +60 VDC supplies.

4.4.10 Supply Fuses

Two 25 Amp fuses, F20 and F21 mounted on top of transformer T1, protect the +60 VDC supply to the Predriver and the Binary RF amplifiers.

The +230 VDC supply is fed to the A24 and A25 Fuse Boards where 16 individual 50 Amp fuses feed 5,100 uF filter capacitors mounted near the Combiner Motherboards. Each capacitor supplies filtering for eight RF amplifier modules.

The +115 VDC supply for the Driver and Binary RF amplifiers is fed to the A25 Fuse Board. The +115 VDC Binary supply is fused by 25 Amp fuse F9 and the +115 VDC Driver supply is fused by 30 Amp fuse F10.

On each Fuse Board, a series diode and parallel resistor provide a fast discharge path for the capacitor if a fuse opens.

4.4.11 Fan Motor Fuses

The fan motors B1 through B4 are fused separately by 1 Amp cartridge fuses F11 through F13, F21 through F23, F31 through F33 and F41 through F43. Fuses F17, F18, and F19 are 15 Amp cartridge fuses and protect the wiring between the primary of T1 and the fan motor fuses.

4.4.12 A24 and A25 Fuse Board Sample Circuits

Five +230 VDC sample circuits are located on the two fuse boards. These five samples are routed to the LED Board, Analog Input Board, and Driver Supply Regulator. The Analog Input Board sample is located on the A25 Fuse Board and the other four samples are located on the A24 Fuse Board.

4.4.12.1 Analog Input Sample

A DC power supply compensation signal for circuitry on the Analog Input Board comes from R22, R23, R24, R27, and C3. Refer to SECTION J, Analog Input Board, for the circuit description.

4.4.12.2 Driver Supply Regulator Sample

Parallel resistors R25-R26 from the +230 VDC supply are collector load resistors for the Driver Supply Regulator Q2 circuit. Refer to SECTION E, Driver Supply Regulator, for the circuit description.

4.4.12.3 Supply Fault Sample

An AC sample of power supply “ripple” for the power supply protection circuit on the LED Board is provided by voltage divider R14 and R15. Capacitors C1 and C2 block DC and form an AC voltage divider. Transzorb CR11 provides overvoltage or transient protection. Refer to SECTION Q, LED Board, for a description of the Power Supply Protection circuit.

4.4.12.4 PA Supply VDC sample

Resistors R16, R17 and R18 form a voltage divided signal for remote and local PA Supply VDC readings. The signal passes through the LED Board and then to the Controller. A voltage follower amplifier on the Controller provides outputs to the front panel multimeter and to the External Interface for remote supply voltage metering. Refer to SECTION P, Controller, for a description of the PA Supply VDC metering circuit.

4.4.12.5 PA Supply Overvoltage Sample

Resistors R19, R20 and R21 form a voltage divider for the overvoltage circuit on the LED Board. Refer to SECTION Q, LED Board, for a circuit description.

4.4.13 AC Power Protection Circuits

The following information highlights circuits that function as a result of variations in AC line conditions.

4.4.14 Overvoltage and Undervoltage Protection

The “PA Power Supply” DC overvoltage protection on the LED Board will shut the transmitter OFF in case of overvoltage conditions. If high or low supply voltages to the Driver stage results in excessive RF drive level changes, RF Overdrive or Underdrive circuits on the LED Board also shut the transmitter off.

4.4.15 Loss of Phase and “Brown-Out” Protection

Circuitry on the LED Board provides protection against loss of phase or line imbalance (Brown-out). If either condition is detected, a circuit will turn off the PA Power Supply and a Supply Fault will be indicated on the ColorStat™ panel. Refer to SECTION Q, LED Board, for a description of the Power Supply Protection circuit.

4.5 Air System and Sensing Circuits

Refer to the DX-25U Cabinet Outline drawing, 839-7855-152, and Overall schematic, 839-7855-151. Additional information is also available in SECTION II, Installation/Initial Turn-On, SECTION V, Maintenance, and SECTION S, Driver Encoder/Temp Sense Board.

4.5.1 Fans

Four fans, B1 through B4, are used in the DX-25U for transmitter cooling. Each fan uses a 1/3 HP, dual voltage 3-phase motor, powered when T1 is energized. T1 primary taps also function as an auto transformer when the line feed is greater or less than the ±10% tolerance of the motor.

4.5.2 Air Flow and Temperature Sensing

Air flow reduction or loss and over temperature conditions are sensed by circuitry located on the Driver Encoder/Temperature Sense Board. The two separate and independent circuits are detailed in SECTION S. A brief description of their system operation is as follows:

4.5.2.1 Air Flow Sensing

Circuitry on the Driver Encoder/Temp Sense Board will cause the AIR INTERLOCK LED on the ColorStat™ panel to illuminate AMBER if one fan has failed, or if the air flow is reduced to that level. A "Blower Fault" status output is generated by the External Interface for remote monitoring. Solid state air flow device U17 on the Driver Encoder/Temp Sense Board sends an active LOW signal to the LED Board if two fans fail or if air flow is further reduced. The AIR INTERLOCK LED on the ColorStat™ panel indicator will illuminate RED and the transmitter will turn OFF. An "Air Fault" status output is generated by the External Interface for remote monitoring.

4.5.2.2 Temperature Sensing

Two temperature probes are attached to the heat sinks of PA Modules RF1 and RF2. The temperature is sensed by circuitry on the Driver Encoder/Temp Sense Board which sends a "LOWER" power command signal to the LED Board if the temperature rises above a preset threshold. The amount of power reduction is determined by the severity of the over dissipation. As the power is stepped down, the heat sink temperature will decrease until it is under the threshold of the sensing circuit, at which time the LOWER command will stop. The POWER must be increased to the original level by an operator induced RAISE command. A "Temperature Caution" or "Over Temperature" condition will illuminate LED's on the Driver Encoder/Temp Sense Board. A DC temperature sample voltage from the RF1 sensor is available at TB1-10 for remote temperature monitoring.

4.6 Interlocks

The interlock circuits protect personnel and external equipment from dangerous or unsafe conditions. For a description of interlock circuits and logic, refer to SECTION P, Controller. The interlock circuitry is detailed on the DC Regulator schematic, 839-7855-163, and the DX-25U Overall Schematic, 839-7855-151, in the Drawing Package.

4.6.1 Door Interlock Circuit

The door interlock circuit turns the transmitter OFF if any of the three interlocked RF Amp Compartment doors are opened. The DOOR interlock LED on the ColorStat™ panel will illuminate RED.

4.6.2 External Interlock Circuit

The external interlock circuit turns the transmitter OFF if any external interlock interrupts the normally closed connection between TB1-1 and TB1-2. The EXTERNAL interlock LED on the ColorStat™ panel will illuminate RED.

The EXTERNAL interlock circuit includes relay K3, 1 Amp fuse F24, pull up/pull down resistors on the DC Regulator and interlock logic on the Controller. External Interlock connections are detailed in SECTION II, Installation/Initial Turn-On.

4.7 RF Circuits

Refer to Sheet three of the DX-25U Overall Schematic, 839-7855-151, for the following circuit information.

Most of the RF drive circuits are detailed in their own sections. The Block Diagram Description has already explained how each section contributes to the drive system in the DX-25U, therefore no further information is necessary in this section.

Refer to the following sections for more information:

Oscillator
Buffer
Predriver
Driver
Driver Combiner
Driver Supply Regulator
Driver Encoder/Temp Sense — Section S
RF Multimeter

4.7.1 RF Drive Splitter, A15

The combined RF output from the Driver stage feeds the RF Drive Splitter. The splitter has provision for 256 outputs, two for each of the 128 PA Modules in a DX-50, however, only 128 are utilyzed in the DX-25U. An additional connector (J17) on the splitter assembly provides three RF sample signals to other parts of the transmitter, as follows:

a. To the Driver Supply Regulator and Driver Encoder/Temp Sense Board: An RF sample for the RF drive Automatic Gain Control (AGC) loop.
b. To the Analog to Digital Converter: A synchronizing signal for the analog to digital conversion process.
c. To the LED Board: An RF drive sample, for Overdrive and Underdrive Fault sensor circuits and for "Relative RF Drive" Metering.

4.7.2 RF Drive Cables

The RF drive splitter outputs, at connectors J1 through J16, are very low impedance, and the 128 separate RF drive cables to the PA Module inputs provide additional isolation so that a fault at one module input will have little or no effect on other RF drive signals.

The 16 connectors from the splitter provide connections for two sets of eight coaxial cables. Each group of eight cables from each connector form a cable bundle which goes to an input connector on a PA Combiner/Motherboard. All RF drive cables are the same length, so that all PA Module inputs are in phase.

4.7.3 Power Amplifier Description

In the Power Amplifier stage, the digital information constructed by the Analog to Digital (A/D) converter is used to switch 64 RF amplifiers ON and OFF. The output combiner sums the individual units of RF voltage developed by each amplifier.

The Power Amplifier stage may be thought of as a Digital to Analog (D/A) converter, where the output is a high power, amplitude modulated, RF signal.

The action of the RF combiner and RF amplifier modules produce RF voltage “steps” at the combiner output. The power output of each RF amplifier depends on the total number of modules switched ON at any time. Switching on twice as many RF amplifiers will produce TWICE THE VOLTAGE output and FOUR TIMES THE POWER output. If a small number of modules are switched on, each module has a small power output. If a large number of modules are switched on, each module has a larger power output.

The DX-25U uses a 12-bit digital “word” to control the RF amplifiers. If the Power Amplifier stage consisted only of binary “weighted” amplifiers, each bit would control one amplifier and it would require 12 RF amplifiers to represent the digital word. However, the RF voltage delivered by the amplifier representing the most significant bit would have to be equal to one-half of the peak RF voltage created with all 12 modules ON. In an RF voltage combiner, all RF voltages are added in series. The same current flows through all outputs as through the load, and one-half the peak voltage is also one-half the peak power. The largest “step”, then, would have to be able to deliver over 75 kilowatts, the next over 37.5 kilowatts, and so on. It is more practical to use a larger number of smaller power amplifiers.

The DX-25U uses 58 equal RF voltage “Big Step” amplifiers and six “Binary Step” amplifiers. The binary amplifier outputs equal 1/2, 1/4, 1/8, 1/16, 1/32 and 1/64 of a “Big Step” amplifier output and are controlled by the six least significant bits of the digital word. The six most significant bits control the total number of “Big Step” amplifiers ON at any time. Typically, 23 RF amplifiers are ON for a 25kW carrier.

However, AM transmitter PEAK output power requirements are much greater than the transmitter CARRIER power. Also, broadcasters may require additional transmitter power to overcome antenna system power losses. For this reason, the carrier power output of the DX-25U is rated at up to 30kW. The positive peak modulation capability of an AM broadcast transmitter depends on the maximum peak power output available from the transmitter. For example, a +100% modulation peak represents a peak output power of four times the carrier power, or 100kW for a 25kW transmitter. This requires that double the number of amplifiers be ON for the peak as compared with the carrier level. Therefore, at the 100% positive peak modulation of a 25kW carrier, 47 RF amplifiers are ON. With a carrier power of 30kW, a 125% positive peak requires a peak output power of 151.9 303.8kW and additional RF amplifiers are turned ON.

SUMMARY: The more “steps” or RF amplifiers that are turned on, the more power will be transmitted. The DX-25U uses a combination of 58 equal RF voltage “Big Step” amplifiers and six binary weighted RF voltage “Binary Step” amplifiers to develop the modulated RF envelope. The modulated RF output is made up of equal VOLTAGE steps, not equal power steps. Assuming that the supply voltage remains the same, the RF output VOLTAGE from each module remains the same no matter how many other modules are on. Since the combiner secondaries are in series, the TOTAL RF VOLTAGE induced on the combiner rod will increase by the number of STEPS turned on. With a constant combiner impedance of approximately 8 Ohms, an increase in RF voltage will increase the RF current in the combiner and increase the power. The power output from each amplifier module changes, however, depending on the total number of amplifier “steps” that are switched on.

4.7.3.1 Switching RF amplifiers On or Off

RF amplifiers are switched ON or OFF by applying or removing RF drive to the module with a solid state switching circuit. Because low voltage, low current circuits are used in the switching process, very little power is consumed.

4.7.4 Combiner Description

Sheet 4 of the DX-25U Overall Schematic, 839-7855-151, identifies motherboards and module numbers as viewed from the rear of the transmitter.

The Power Amplifier stage is made up of 64 plug-in RF amplifier modules. These include 58 “Big Step” modules RF33-RF90 and six “Binary Step” modules RF91-RF96, which plug into three Main Combiner/Motherboards, A5-A7, and one Binary Combiner/Motherboard, A8.

Sixteen ferrite core toroid transformers on each motherboard combine the RF voltage outputs of the modules through a solid copper rod which which passes through the center of the transformers. The four Combiner/Motherboards are assembled as a single column.

The PA Combiner RF ground point is at the bottom of the column. When the A/D Converter sample frequency is one-half carrier frequency, a parallel resonant circuit consisting of L4 and C4 present a high impedance to the half-carrier frequency.

One Modulation Encoder (A37) takes the digital output from the Analog to Digital Converter and converts it into control signals for the RF amplifier modules. Due to the way the system would be configured as a DX-50, the RF Amplifier steps controlled by the A37 Modulation Encoder are RF33 through RF96 with the last 6 steps being the Binary Steps (RF91 through RF96).

The PA Modules are also identified by step number on the interlocked module access doors in the Center Control Compartment and Left Control Compartment. Each module has two LED “fault” indicators, visible through openings in the access door. If a shorted MOSFET causes a fuse to open, the “fault” indicator for that fuse illuminates. When a module is switched ON, a green LED indicator illuminates.

Refer to the following sections for additional information on the Power Amplifier:

a. SECTION A: RF Amplifier Module.
b. SECTION G: RF Combiners

4.7.5 RF Samples from the Output Combiner

Four RF samples from various points on the RF combiner are distributed to various circuits elsewhere in the transmitter. Refer to Sheet 4 of the DX-25U Overall Schematic, 839-7855-151, to locate the following sample transformers.

4.7.5.1 T9: Bandpass Filter VSWR Detector

An RF current sample from T9, near the RF ground point in the combiner, is fed to the Output Monitor and compared to the RF voltage sample at the output of the Bandpass Filter section of the Output Network. During a VSWR condition, a phase shift in the RF current and voltage samples will be detected by the phase angle detection circuitry. Refer to SECTION H, Output Monitor, for additional information on VSWR protection.

4.7.5.2 T6: Oscillator Sync Signal

During a VSWR condition, all power amplifier modules are quickly turned OFF. Because of the resonant circuits, “ringing currents” will continue to flow in the output network, and in the RF combiner secondary, for several RF cycles. For maximum MOSFET reliability during this condition, Q1/Q12 and Q2/Q9 in all PA Modules must switch in phase with these output network ringing currents. This is accomplished with the Oscillator Sync circuitry on the Oscillator.

A current sample from ferrite inductor transformer T6 at the combiner output is fed to J3 on the Oscillator. A phase shift network, amplifier stage and an analog switch are used to synchronize RF drive phase with output network ringing current during VSWR shut-downs. Refer to SECTION A, Oscillator, for additional circuit information, and to SECTION V, Maintenance, for adjustment procedures.

4.7.5.3 T1: Neutralization Board

T1 on the Neutralization Board is a ferrite toroidal transformer similar to the ones used in the RF combiner and is only used for IQM reduction for AM Stereo operation. The transformer is wired to the Predriver output splitter T8.

4.8 Output Network Description

The Output Network of the DX-25U is comprised of a Bandpass Filter and Pi Matching network and contained in the Output Network cabinet.

4.8.1 Bandpass Filter

The bandpass filter/output network serves as both an impedance matching network and filter and consists of L1, C1A, and C1B. At the very high end of the medium wave band, 1500kHz and above, C6 is also a part of the bandpass filter. Vacuum variable capacitor C1A is brought out to the front of the transmitter as the TUNE control. The TUNE control is adjusted for a peak in output power. The combiner output impedance is low, approximately 8 Ohms, and is matched to approximately 50 Ohms.

The bandpass filter also “smooths” the small steps in the output signal that remain after the Digital to Analog conversion by the Power Amplifier stage. Any other harmonic and spurious signals in the RF output are also attenuated by the bandpass filter.

Refer to SECTION V, Maintenance, for information on tuning and adjustment of the bandpass filter if required by a frequency change or major component failure.

4.8.2 PI Matching Network

The PI Matching Network consists of C2A, C2B, L3, C3A, C3B, C4A, C4B and C5. Parallel capacitors C2A and C2B comprise the first leg of the π network. Inductor L3 and capacitors C3A, C3B, and, at some frequencies, C5 are adjusted and tuned to $3f_c$. The parallel resonant circuit provides further attenuation of the 3rd harmonic to FCC specifications while passing the carrier frequency. VACuum variable capacitor C4A is brought out to the front of the transmitter as the LOAD control. The LOAD control adjusts the amount of Power Amplifier current.

4.8.3 Spark Gap, E2

A spark gap at the output of the transmitter protects against high transient voltages caused by lightning or electrostatic discharge. This does NOT substitute for proper DC grounding chokes, ball gaps, and other protection at the towers. Set E2 at .090".

4.9 Digital Modulation Principles

4.9.1 Digital Terms and Concepts

The discussion of Analog to Digital and Digital to Analog Conversion includes terms, abbreviations, and concepts which may not be familiar to some Broadcast Station engineers and technicians. Most terms will be explained in the discussion, but a summary is included for review or reference.

a. ANALOG refers to a continuous range of values. Examples include audio signals from a microphone, a turntable cartridge, CD, etc.
b. DIGITAL is related to digits, or discrete quantities. An analog signal changes continuously, but a digital signal changes in steps. An analog signal has an infinite number of possible values, and a digital signal has a finite, or limited, number of possible values.
c. BINARY: Has only two possible values. A BINARY NUMBER is represented using only the digits 0 and 1. This is useful because a circuit can be two states, either ON or OFF.
d. BINARY can also refer to a series where each step is either multiplied or divided by two to get the next step. An example in the transmitter are the Binary RF amplifier steps: the 1/2 step; 1/4 step; 1/8 step; 1/16 step; 1/32 step

and 1/64 step. In this series, each step is divided by two to get the next step. A Binary series could also be 1, 2, 4, 8, 16, 32 etc.

e. BIT: A Binary digit, 0 or 1.

f. DIGITAL WORD: A digital word is a group of bits representing a complete piece of digital information. The term "DIGITAL WORD," when used here, will always refer to a binary number, which is a series of ones and zeros. The number of bits in a digital word refers to the total number of digits (ones and zeros).

g. MSB: Abbreviation for MOST SIGNIFICANT BIT. In a digital word, as in a decimal number, the first digit represents the largest change, and is the MSB.

h. LSB: Abbreviation for LEAST SIGNIFICANT BIT. In a digital word, as in a decimal number, the last digit represents the smallest change, and is the LSB.

i. BIT 1, BIT 2, etc: In a 12-bit digital word, the bits are numbered from 1 through 12, where Bit 1 is the MSB, and Bit 12 is the LSB.

j. A/D: Also written "A to D." Abbreviation for "Analog to Digital."

k. D/A: Also written "D to A." Abbreviation for "Digital to Analog."

Some Basic Digital Circuit Concepts used in the following discussion, and in circuit descriptions, are also included for review or reference.

In logic circuits, representing a digit by either zero or one is useful because it can be represented by a switch or a circuit that is either "OFF" or "ON." The digits "zero" and "one" may also be represented by a voltage that is LOW for "zero" and HIGH for "one."

In circuit descriptions and on schematic diagrams, the terms "logic LOW" and "logic HIGH" are used. These terms are also represented by the letters "L" and "H" on schematic diagrams.

In most logic circuits, normal TTL (transistor-transistor logic) levels are used. In these circuits, a "logic LOW" is represented by a voltage between approximately zero and one Volt, and a "logic HIGH" is represented by a voltage between approximately +3.5 and +5 Volts.

On block diagrams and on schematic diagrams, when a signal description is followed by "-L" or "-H," the letter indicates the logic state when the signal is ACTIVE. Examples:

a. "RESET-L" indicates that when the signal is logic LOW, a RESET will occur, or a RESET command is being given.

b. "VSWR-H" indicates that when the signal is logic HIGH, a VSWR fault has occurred.

A DIGITAL WORD can represent only a finite number of quantities, or steps, depending on the number of bits in the digital word.

a. If n = the number of bits in the digital word, then: 2^n = the number of quantities that may be represented by that word, including zero. For example, if a digital word has 6 bits, it may represent 2^6=64 quantities. If a digital word has 12 bits, it may represent 2^{12}=4096 quantities.

a. "VALUE" OF EACH BIT: The least significant bit (LSB) represents one unit. The next least significant bit represents two units. The most significant bit represents one-half of the total quantity that the word can represent. For example, in a 6 bit "digital word", the number of quantities that may be represented is 2^6=64:

1. Bit 1 (MSB) represents 32 units
2. Bit 2 represents 16 units
3. Bit 3 represents 8 units
4. Bit 4 represents 4 units
5. Bit 5 represents 2 units
6. Bit 6 (LSB) represents 1 unit.

4.9.2 Analog to Digital Conversion

An (Audio + DC) signal from the Analog Input Board is converted into a series of 12 bit digital words by the Analog to Digital Converter. The digital signal is then processed by the Modulation Encoder to provide signals to turn individual RF amplifier modules ON and OFF. The Power Amplifier stage acts as the Digital to Analog converter to create a high power, amplitude modulated, RF output signal.

The DC component of the (Audio + DC) signal controls the number of amplifiers on for carrier power and is adjusted using the RAISE and LOWER buttons on the front panel. The audio signal is then added to the DC component. The (Audio + DC) signal is then sent to the Analog to Digital Converter.

The Analog to Digital (A/D) conversion process takes place in three steps:

a. Divide the time scale into equal intervals by a high speed sampling circuit.

b. At each time interval, sample and record the amplitude of the analog signal.

c. For each recorded sample, construct a 12-bit digital word that represents the analog sample amplitude.

4.9.3 RF Amplifier Control

Refer to SECTION L, Modulation Encoder, for additional information.

The 12-bit digital word is "encoded" on the Modulation Encoder to control the 58 "BIG STEP" and six "BINARY STEP" RF amplifiers. The 12-bit digital word is divided into two groups of information: The first six bits, B1 through B6, form a six bit digital word and are used to control the 58 "BIG STEP" RF amplifiers; the last six bits, B7 through B12, each control a "BINARY STEP" RF amplifier.

On the Modulation Encoder, bits B1 through B6 are used to address ROM, Read Only Memory, address locations. In turn, the data at each address location controls the 58 "BIG STEP" RF amplifiers. The six most significant bits of the 12-bit digital word represent the total number of “BIG STEP” RF amplifiers ON at any time. For example:

a. 010111/XXXXXX = 23 BIG STEPS ON
b. 101111/XXXXXX = 47 BIG STEPS ON
c. 000000/XXXXXX = 0 BIG STEPS ON

The six least significant bits, B7 through B12, each control a “BINARY STEP” RF amplifier. If the bit is a “1”, the associated amplifier is ON. For example:

a. XXXXXX/000001 = B12: ON
b. XXXXXX/000011 = B11, B12: ON
c. XXXXXX/010011 = B8, B11, B12: ON

The RAISE and LOWER controls on the transmitter front panel set the DC component of the (Audio + DC) signal. Under ideal conditions, for 25 kW carrier, the Analog to Digital Converter samples the DC component of the (Audio + DC) signal and turns 23 “BIG STEP” RF amplifiers ON and all the “BINARY STEPS” are OFF:

- 010111/000000

When audio is applied to the transmitter, the audio component of the (Audio + DC) signal is sampled by the Analog to Digital Converter and the “BINARY STEP” amplifiers begin turning ON until the six least significant bits of the 12-bit digital word are all “LOGIC HIGH”:

- 010111/111111

As the audio component keeps increasing, the “BINARY STEP” RF amplifiers turn OFF and another “BIG STEP” RF amplifier turns ON:

- 011000/000000

This process repeats until the positive modulation peak is reached. For 100% modulation of a 25kW carrier, this will require twice the number of “BIG STEP” RF amplifiers ON as are required for carrier, or 47. At that instant, the digital word would be:

- 101111/000000

At this point, the audio component of the (Audio + DC) signal begins to decrease, and RF amplifier modules begin turning OFF.

Refer to SECTION J, Analog Input Board, and SECTION K, Analog to Digital Converter, for additional information.

4.9.4 Amplitude Modulation in the DX-25U

The transmitter Power Amplifier stage uses 64 solid-state RF amplifier modules. Each RF amplifier can be switched on and off very quickly. The RF voltage outputs of the 64 RF amplifiers, or “steps”, are combined to produce the total transmitter RF voltage output. The output of an AM transmitter is an RF voltage which varies according to the audio modulating signal input. Each RF amplifier provides a fixed voltage, and the RF output can be changed by switching the appropriate number of amplifiers ON. A fixed number of amplifiers are switched ON for carrier. If the audio signal increases, more amplifiers are switched ON. If the audio signal decreases, amplifiers are switched OFF. As the audio signal changes from instant to instant, the number of RF amplifiers that are ON changes.

a. For carrier only, no modulation, only enough RF amplifiers to produce the required RF voltage for carrier power are switched ON.
b. A positive modulation peak requires a high RF voltage at the transmitter output and a large number of amplifiers are switched ON.
c. For a 100% negative modulation peak, which corresponds to zero RF voltage output, all the amplifiers are switched OFF.

SUMMARY: Amplitude modulation in the DX-25U is accomplished by turning on only enough RF amplifier modules at any time to produce carrier and the audio modulating signal at that moment.

4.9.5 Power Amplifier Stage

The transmitter Power Amplifier stage contains 64 identical RF amplifier modules. The amplifier modules are used as 58 equal RF voltage “BIG STEP” amplifiers, and six fractional RF voltage “BINARY STEP” amplifiers. The six “Binary Steps” are:

a. B7: = 1/2 “Big Step” RF voltage
b. B8: = 1/4 “Big Step” RF voltage
c. B9: = 1/8 “Big Step” RF voltage
d. B10: = 1/16 “Big Step” RF voltage
e. B11: = 1/32 “Big Step” RF voltage
f. B12: = 1/64 step “Big Step” RF voltage

As the 58 “BIG STEP” amplifiers are turned ON and OFF, the RF output changes in equal VOLTAGE steps, not in equal power steps, because of operating characteristics of the output combiner. For a 100% positive modulation peak, the RF output voltage of the combiner must double. For a 100% negative modulation peak, the RF voltage of the combiner must be zero.

For a typical carrier of 25 kW, approximately 23 “BIG STEP” RF amplifiers are ON. As audio is applied, 47 “BIG STEP” RF amplifiers turn ON for the 100% positive peak and all modules turn OFF for the 100% negative peak.

The “BINARY STEP” amplifiers are switched in sequence to provide smooth transitions between the equal RF voltage steps created by the “BIG STEP” amplifiers. When all “BINARY STEP” amplifiers are ON, their total amplitude equals 63/64 of a “BIG STEP” voltage.

4.9.6 Summary: Digital Modulator

The amplitude modulation process in the transmitter takes place in three steps.

First, The audio input signal is converted into a digital data stream, a series of 12-bit digital words, by an Analog to Digital Converter. This digital data stream is the “digital audio” signal.

Second, the digital data from the Analog to Digital Converter is encoded by the Modulation Encoder to provide the control signals required by the Power Amplifier stage.

Third, the control signals form the Modulation Encoder are used to switch individual RF amplifiers ON or OFF. The individual RF amplifier module outputs are combined in the RF combiner. The RF output of the Power Amplifier stage changes in very small steps, or discrete quantities, and is passed through the bandpass filter to smooth the step transitions.

4.9.6.1 Digital Modulator Characteristics

The patented Harris Digital Modulator uses new technology which produces a very high quality, low distortion amplitude modulated signal for AM broadcasters.

Overall AC to RF efficiency of the DX-25U is very high, because the digital modulator uses very little power and the RF amplifiers are high efficiency, solid-state, Class D switching amplifiers.

The transmitter has little or no overshoot or tilt with square wave modulation, even at very low audio frequencies and the modulation envelope accurately reproduces the audio input signal.

5.1 Introduction

This section provides general system preventive maintenance information, board replacement and alignment procedures and a transmitter frequency change procedure.

5.2 Maintenance

The importance of keeping station performance records cannot be overemphasized. Separate logbooks should be maintained for operation and maintenance. These records can provide data for predicting potential problem areas and analyzing equipment malfunctions.

5.2.1 Maintenance Logbook

The maintenance logbook should contain a complete description of all maintenance activities required to keep the equipment in operational status.

The following is a list of maintenance information to be recorded and analyzed to provide a data base for a failure reporting system:

DISCREPANCY
: Describe the nature of the malfunction including all observable symptoms and performance characteristics.

TIME/DATE
: Time of day and date discrepancy occurred.

CORRECTIVE ACTION
: Describe the repair procedure used to correct the malfunction.

DEFECTIVE PART(S)
: List all parts and components replaced or repaired and include the following details:
a. TIME IN USE
b. PART NUMBER
c. SCHEMATIC NUMBER
d. ASSEMBLY NUMBER
e. REFERENCE DESIGNATOR

SYSTEM ELAPSED TIME
: Total time on equipment

NAME OF REPAIRMAN
: Person who actually made the repair

STATION ENGINEER
: Indicates Chief Engineer noted and approved the repair of the equipment

5.2.2 Preventive Maintenance

Preventive maintenance is a systematic series of operations performed periodically on equipment and consists of six operations: inspecting, feeling, tightening, cleaning, adjusting, and painting.

- INSPECT. Inspection is the most important preventive maintenance operation because it determines the necessity for the others. Become thoroughly acquainted with normal operating conditions in order to readily recognize and identify abnormal conditions. Inspect for the following:
  1. Overheating, which is indicated by discoloration, bulging of parts, and peculiar odors.
  2. Oxidation.
  3. Dirt, corrosion, rust, mildew, and fungus growth.
- FEEL. By checking for overheating, lack of proper ventilation or other defects can be detected and corrected before serious trouble occurs. Become familiar with operating temperatures in order to recognize deviations from the normal range.
- TIGHTEN. Tighten loose screws, bolts, and nuts. Do not overtighten.
- CLEAN. Clean parts only when inspection shows that cleaning is required and only use approved cleaning solvent.
- ADJUST. Make adjustments only when inspection shows that they are necessary to maintain normal operation.
- PAINT. Paint surfaces with the original type of paint (using prime coat if necessary) whenever inspection shows rust or broken paint film.

5.2.3 Maintenance Of Components

The following paragraphs provide information necessary for the maintenance of components.

5.2.3.1 Transistors and Integrated Circuits

Preventive maintenance of transistors and integrated circuits is accomplished by performing the following steps:

CAUTION

USE CARE TO AVOID THE BUILDUP OF STATIC ELECTRICITY WHEN WORKING AROUND INTEGRATED CIRCUITS.

a. Inspect the surrounding area for dirt. Accumulations could form leakage paths.

b. Use compressed dry air to remove dust from the area.

WARNING

ALWAYS WEAR SAFETY GOGGLES WHEN USING COMPRESSED AIR.

c. Examine all transistors for loose connections or corrosion. Tighten the transistor mounting hardware to no more than 5 inch-pounds. Overtightening the transistor hardware will cause the insulators to short. Torque specification for transistor mounting hardware is 5 inch-pounds.

5.2.3.2 Capacitors

Preventive maintenance of capacitors is accomplished by performing the following steps:

a. Examine all capacitor terminals for loose connections or corrosion.

b. Ensure that component mountings are tight. Do not overtighten capacitor mounting straps as excessive pressure could cause internal shorting of the capacitors.

c. Examine the body of each capacitor for swelling, discoloration, or other evidence of breakdown.

d. Use standard practices to repair poor solder connections with a low-wattage soldering iron.
e. Clean cases and bodies of all capacitors.
f. Inspect bleeder resistors when inspecting electrolytic capacitors.

5.2.3.3 Fixed Resistors

Preventive maintenance of fixed resistors is accomplished by performing the following steps:

a. When inspecting a chassis, printed-circuit board, or discrete component assembly, examine resistors for dirt or signs of overheating. Discolored, cracked, or chipped components indicate a possible overload.
b. When replacing a resistor, ensure that the replacement value agrees with the schematic diagram and parts list.
c. Clean dirty resistors with a small brush.

5.2.3.4 Variable Resistors

Preventive maintenance of variable resistors is accomplished by performing the following steps:

a. Inspect the variable resistors and tighten all loose mountings, connections, and control knob set-screws (do not disturb knob alignment). Sliding taps on adjustable resistors should be snug, but not excessively tight. Overtightening can damage the resistor.
b. Clean dirty resistors with a small brush.
c. When dirt is difficult to remove, clean with a lint-free cloth moistened with an approved cleaning solvent.

5.2.3.5 Fuses

Preventive maintenance is accomplished by performing the following steps:

CAUTION

USE ONLY AN EXACT REPLACEMENT FUSE. FUSES OF THE SAME SIZE AND/OR RATING FROM A DIFFERENT MANUFACTURER MAY NOT FULFILL THE REQUIREMENT FOR EXACT REPLACEMENT.

a. When a fuse blows, determine the cause before installing a replacement.
b. Inspect fuse caps and mounts for charring and corrosion.
c. Remove dirt with a small brush.
d. If necessary, tighten fuse clips and connections to the clips. Fuse clip tension may be increased by pressing the clip sides closer together.

5.2.3.6 Switches

Preventive maintenance of switches is accomplished by performing the following steps:

a. Inspect switch for defective mechanical action or looseness of mounting and connections.
b. Examine cases for chips or cracks. Do not disassemble switches.
c. Check contacts for pitting, corrosion, or wear.
d. Operate the switches to determine if they move freely and are positive in action.
e. Be sure to include an inspection of the power supply discharge switches S9, S10 and S12 located in the interlocked RF Amplifier and Driver Compartments.

5.2.3.7 Indicators and Front Panel Switches

Preventive maintenance of indicator lamps and control switches is accomplished by performing the following steps:

a. To remove an indicator bulb (LOW, MED, HIGH, RAISE or LOWER) pull out on the indicator button. The indicator lamp may then be removed. When re-installing the button, care must be taken to avoid disrupting normal operation.
b. Replacement of a front panel switch requires removal of the Switch Board behind the meter panel.

5.2.3.8 Printed Circuit Boards

Preventive maintenance of printed circuit boards is accomplished by performing the following steps:

a. Inspect the printed circuit boards for cracks or breaks.
b. Inspect the wiring for open circuits or raised foil.
c. Check components for breakage or discoloration due to overheating.
d. Clean off dust and dirt with a clean, dry lint-free cloth.
e. Use standard practices to repair poor solder connections with a 40 Watt soldering iron.

5.2.3.9 Air System

a. The air filters should be routinely washed with soap and water. Intervals between cleaning will depend on the environment.
b. Replace filter when it shows signs of deterioration.

5.2.3.9.1 Fan Motor B1 Through B4 Replacement

It is very probable that the fan blade will be locked or “frozen” to the shaft of the motor after years of operation. Because of this it will be necessary to remove the fan frame and blower assembly to service the motor.

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

a. Remove the rear panels of the Output Network Compartment.
b. Disconnect the three wires from the failed motor to the fuse block.
c. Remove the inner fan cage panel which will allow any of the four fans to be pulled straight back.
d. Remove the 4 screws fastening the fan frame to the cabinet and remove the fan assembly.

Strap the replacement motor in the High Voltage configuration (460 VAC) shown in Figure 5-1. Wire the motor as shown on the Overall Schematic, 839-7855-151, to ensure the motor will rotate in the same direction as the other three.

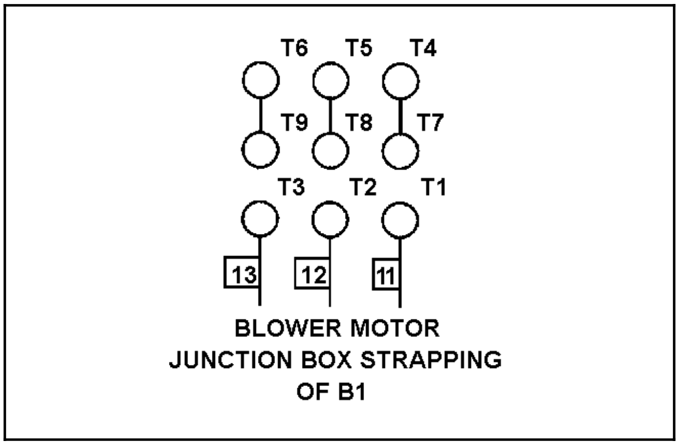

Figure 5-1. Blower Motor Strapping

5.3 Module Replacement/Alignment

DX-25U modules can be grouped in three categories when replacement is required:

- Modules which can be replaced with no adjustments.
- Modules which require preset switch settings or jumper plug positions
- Modules which require adjustments.

5.4 Modules Which Can Be Replaced With No Adjustments

The following modules may be replaced, or components on them can be replaced, without making any adjustments, measurements, or preset switch or jumper plug settings:

- Buffer Amplifier (A39)
- Predriver (A10)
- PA Modules (RF33 through RF96)
- External Interface (A28)
- RF Multimeter (A23)
- Fuse Boards (A24/A25)
- Output Sample (A26)
- Drive Splitter (A15)
- Power Distribution (A39)

5.4.1 Buffer Amplifier (A16)

The Buffer Amplifier is broad-band, with no frequency determined components. If the Buffer Amp is replaced and a drive fault is still indicated on the ColorStat™ panel, check the drive level to the Predriver Module using the procedure outlined under Frequency Change Procedure in this section.

5.4.2 Predriver

The Predriver Module is one of 79 identical RF amplifiers used in the Driver and Power Amplifier stages, and therefore can be interchanged if required. No adjustments are necessary if the Predriver is replaced. Turn the transmitter ON and measure both the Predriver voltage and current on the RF MULTIMETER to verify that they are near the measurements indicated on the Factory Test Data sheet.

NOTE

Adjustment of Predriver tuning control L1 is NOT required when replacing the module. Changing the Predriver tuning can affect the setting of the Oscillator sync used for VSWR protection.

If the Predriver is replaced and a Predriver Fault is still indicated on the ColorStat™ panel, it is advisable to check the output to the Driver stage using the procedure outlined under the Frequency Change Procedure in this section.

5.4.3 PA Modules

The RF amplifiers used in the Power Amplifier stage are completely interchangeable as required. This can be done quickly by depressing the OFF button, and opening the interlocked RF Amp Compartment door inside the Center or Left Control Compartment. Remove the defective RF amplifier by pulling it out and then insert the replacement RF amplifier. The inner door can then be closed and the transmitter returned to operation.

If the low voltage is left on when an RF amplifier is removed, the ColorStat™ panel Cable Interlock LED will illuminate. Depress the reset button to clear the Interlock indication. If the transmitter will not turn on and the Cable Interlock LED remains red, check to make sure the replacement RF amplifier is fully inserted. A definite resistance should be felt when an RF amplifier is removed or inserted in its slot.

For optimum performance the drive level to the PA Modules must be correct. It is possible to get an idea if a replacement PA Module is operating efficiently by operating the transmitter at full power with normal modulation for 5 minutes. Shut the transmitter down, turn off the Low Voltage at CB1 and CB2 and quickly open the interlocked inner door. Compare the temperature of the heat-sink on the replacement PA Module with other PA Modules in the same area. If the PA Module is hotter than the others, drive level and phasing should be checked. For Drive Level and Phasing measurement procedures see “Measuring RF Drive Level” and “Measuring RF Drive Phasing” paragraphs in the Troubleshooting section.

5.4.3.1 Handling MOSFET’S

Due to the fragile nature of the gate of a MOSFET, special care in their handling is required. The gate junction may be destroyed by static electricity if it is allowed to discharge through the MOSFET.

NOTE

MOSFET transistors which are in circuit are immune to this damage.

The MOSFET transistors are shipped in anti-static packaging. The transistors should remain in this packaging until they are to be used or tested.

5.4.3.2 Testing MOSFET’s

The MOSFET’s will have to be removed from the circuit in order to perform the following test.

Observe the precautions in the paragraph entitled “Handling MOSFET’S” in this section.

The following test applies to all MOSFET's used in the transmitter, but is not necessarily applicable to MOSFET's used in other equipment.

The MOSFET's used in the transmitter may be checked with an Ohmmeter. However there is a requirement which restricts the use of some Ohmmeters. If the battery voltage is too low (under 3V) or too high (over 20V) the Ohmmeter cannot be used. A battery voltage less than 3V will not give an operational check of the transistor and a battery voltage greater than 20V may result in damage to the transistor under test. A Simpson 260, which uses a 9V battery on the Rx10k scale works quite well.

This test will show how a MOSFET can be switched "on" and "off" by charging and discharging the gate of the MOSFET.

Connect the positive lead of the Ohmmeter to the drain or case of the transistor. Connect the negative lead to source. Alternately touch a jumper from gate to source and then from gate to drain. The Ohmmeter should read towards infinity or at least 2M Ohms when the MOSFET is switched off and less than 90k Ohms when the MOSFET is switched on. (To switch the MOSFET on hard, near zero Ohms, use +5 VDC gate to source signal.) When doing this test, lay the MOSFET on a flat surface or hold sides of the case. The resistance of your finger tips and skin will affect the readings when you touch the leads.

5.4.3.3 Replacing MOSFET's

When repairing an RF amplifier, it is recommended that all four MOSFET's of the failed half of the RF amplifier be replaced. Even though only one or two of the four MOSFET's are found to be shorted, the remaining MOSFET's may have been stressed internally and may fail when supply voltage is reapplied. The repair process would then have to be repeated which can be very frustrating. A Blown fuse on one half of the amplifier does not affect the other half of the amplifier.

MOSFET's that appear to be undamaged after testing should be kept as spares for use if new replacements are not available. Also keep in mind that the amplifiers used in the Driver stage and Power Amplifier stage are identical except that the Driver Modules operate at half voltage. This allows you to rotate a repaired RF amplifier into a Driver position if so desired.

NOTE

In most cases, the transistor will stick to the heatsink because of seal created by the transistor pad. This seal will have to be broken before a heatsink can be removed. Pry the transistor out, away from its heatsink. DO NOT TRY TO PRY THE HEATSINK AWAY FROM THE PC BOARD WITH TRANSISTORS STUCK TO THE HEATSINK OR THE PC BOARD MAY BE DAMAGED AND THE HEATSINK MAY DISTORT. Sometimes the transistor pad will tear when the seal is broken. Remove stuck pieces and replace the pad.

a. Remove all the screws from heatsinks and transistors.
b. Remove the heatsinks one at a time starting with the outer most sink. Break seals on transistor pads as each pair is exposed.
c. Replace failed transistors. Save and reuse the ferrite bead on the center leads of Q3/Q10 and Q4/Q11. Do not solder leads until heatsinks are in place.
d. Reattach heatsinks in reverse order as they were removed. Tighten heatsink and pc board screws first and then tighten transistor screws (torque to 3 inch-lbs).
e. Make sure the ferrite beads are on the center leads of Q3/Q10 and Q4/Q11.
f. Solder transistor leads and trim.
g. Replace blown fuse(s).

5.4.4 RF Drive Splitter Removal

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

a. Remove the Driver Compartment rear door.
b. Remove all RF drive cable assemblies from the RF Drive Splitter.
c. With a 9/16" socket wrench, remove the bolt that connects the splitter to the Driver Combiner output rod.
d. Remove the standoffs for the cable support ring in the four corners of the splitter and remove the splitter.

5.4.5 RF Drive Splitter Replacement

Replacement of the RF Drive Splitter is the reverse of the removal process. Make sure all drive cables are fully inserted and locked into their sockets.

5.5 Boards Which Require Preset Switch Settings or Jumper Plug Positions

The following boards have no adjustments, but may have jumpers or switches that can be preset to match the settings on the board being replaced.

- Modulation Encoder (A37)
- Controller (A38)
- Driver Combiner/Motherboard (A14)
- Binary Combiner/Motherboard (A8)
- Main Combiner Motherboards (A5-A7)

5.5.1 Modulation Encoder (A37)

When replacing the Modulation Encoder A37, make sure that binary output jumpers are all in place. Make sure the gold jumpers for Big Step encoder signals 33 through 96 (P-1 through P-6) are in place. A FlexPatch™ jumper should be in place from P-15 to P-10. Make sure that P20 is connected between J20-1&2 and P21 is connected between J21-1&2. Extra FlexPatch™ jumpers can be stored in P9.

NOTE

To assure the proper connections for J1 through J8, consult drawing number 839-7855-151.

5.5.2 Controller A38

Once a new Controller is installed the low voltage circuit breakers CB1 and CB2 can be turned on. Check to see that regulator fault indicator DS1 is not illuminated. A dc voltmeter can be used to ensure that the regulators are operational. Check the following test points for the indicated voltage.

TP2 .... +5VDC
TP3 .... +15VDC
TP7 .... -15VDC

NOTE

Do not install battery backup BT1 through BT3 until the Controller has been installed and power has been applied for at least 1 minute. This will allow time for C44, backup supply capacitor, to fully charge.

Once the regulator voltages have been measured, ensure that the PA turn off switch S2 is in the ON position (down). The transmitter can now be turned ON by depressing the LOW, MEDIUM OR HIGH button. The power output on all three power levels will be zero. Reset the transmitter output to the desired power by pressing the RAISE button. Refer to the Operation Section of the manual for further information.

5.5.3 Binary Combiner/Motherboard, Main Combiner/Motherboards (A5-A8).

The Binary Combiner/Motherboard contains jumpers J30 through J33 to select the proper amplitude of Binary Steps B-7 through B-10. Set these jumpers to the same configuration as the board to be replaced or refer to the Factory Test Data sheet. Also, ensure that JP1-JP8 and J30-J33 are configured properly for the board to be replaced. Check and set the taps on efficiency coils L1 through L16 on every motherboard to be replaced.

5.5.3.1 Combiner Motherboard Removal

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

All combiner motherboards are of similar construction and therefore will require the same basic procedure.

a. Remove all 16 RF amplifiers from the front.
b. Disconnect all wiring and cables from the motherboard being replaced.
c. Remove only as much of the combiner cover as necessary.

CAUTION

LOCATE AND REMOVE ANY HARDWARE THAT IS DROPPED. IF LOST HARDWARE IS REPLACED, MAKE SURE NONE OF IT HAS LODGED ON ANY RF AMPLIFIER MODULE.

d. Depending on which board is being removed do one of the following two steps.
   1. On the Main and Binary motherboards, remove the two end screws from the combiner secondary rod.
   2. On the Driver/Combiner motherboard, the secondary rod will have to be removed through the top of the transmitter. If top removal is not possible because of an overhead clearance problem, remove the RF Drive Splitter and lower the rod down to where it will rest on T1. Continue with the rest of the motherboard removal. Tilt the motherboard back and continue to slide the rod down and forward across the top of T1.
e. Remove the motherboard fastening hardware beginning with the two 4-40 screws in the front center card guide support. The 4-40 screws to be removed can be identified by the six inch (15cm) aluminum rods attached to the card guide support bar.
f. Carefully remove the motherboard from the rear of the transmitter.

5.5.3.2 Combiner Motherboard Installation

Replacement of the Main Combiner/Motherboards is essentially the reverse of the removal procedure.

a. During installation of a motherboard, it may not appear to fit in as easily as it came out. This is due to the blue card guides not fitting back in their slots at the same time.
   1. Install the board, using only a few of the screws to mount the board to the supports.
   2. From the front of the RF Amp Compartment, place the card guides into their respective slots.
b. Once the motherboard has been fully mounted, insert the allen screws that bolt the Combiner rods together but do not fully tighten.
c. Loosen the two set screws in the fiberglass supports on the motherboard that hold the rod in place. Now tighten the Allen screws on the copper rod to 150 inch/lbs.
d. Re-tighten the set screws on the motherboard. Replace the Combiner cover, RF amplifiers, and the interconnection plugs.

NOTE

Replace all combiner cover screws. The majority of combiner RF ground current flows through the combiner covers.

5.5.4 Driver Combiner/Motherboard A14

The Driver Combiner/Motherboard has no adjustments. There are taps on efficiency coils L2-L15 that need to be placed in their proper frequency determined location. Set these coil taps to the same configuration as the board to be replaced or refer to the Factory Test Data sheet.

5.6 Printed Circuit Boards Which Require Adjustments

The remaining boards in the transmitter have adjustments which must be checked and possibly preset before applying high voltage. Some controls may need further adjustment after applying high voltage. The following paragraphs describe these boards and adjustments.

These boards are:

- Analog to Digital Converter (A34)
- Analog Input Board (A35)
- Oscillator (A17)
- Driver Supply Regulator (A22)
- DC Regulator (A30)
- Output Monitor (A27)
- LED Board (A32)
- Driver Encoder/Temp Sense Board (A19)
- Switch Board/Meter Panel (A31)

5.6.1 Analog to Digital Converter (A34)

The Analog to Digital Converter contains two adjustments, two DIP switches, and two sets of jumpers. The first step in replacing the Analog to Digital Converter is to make sure that switches S1 and S2 are set the same as the board to be replaced. S1 sets the A/D sample phasing and is critical to the proper operation of the transmitter. Set jumper P10 and P11A/B to the same settings as on the board to be replaced.

5.6.1.1 Delay Adjustment: R78

The delay adjustment is normally set during factory testing of the board but can be checked and adjusted if needed using the following procedure:

a. Once the new Analog to Digital Converter is installed, apply low voltage to the transmitter and verify that all LED's on the ColorStat™ panel are green.

b. Locate the PA TURN-Off switch S2 on the Controller and move it to the OFF (up) position.

c. Depress the LOW power button on the front panel and note that the transmitter completes the step-start sequence and that the +230 Vdc supply energizes.

d. The PA OFF indicator LED of DS1 on the Modulation Encoders (A37) should be illuminated and there should be no rf output.

e. Connect a scope with a minimum bandwidth of 30 MHz to TP3 on the Analog to Digital Converter and ground the probe on TP19, 20, or 21. This is the conversion pulse for the A/D converter IC. The width of the positive portion of the pulse should be approximately 40ns.

f. Adjust the pulse to the correct width with R78. The Conversion Error LED DS1 on the Analog to Digital Converter should be green.

5.6.1.2 Offset Adjustment: R7

The Offset adjustment is set during factory testing of the board, but can be adjusted if needed. The most significant affect of the offset adjustment is on modulation tracking. In other words, equal modulation percentage at all power levels. To check the setting of the Offset adjustment:

a. Operate the transmitter at 25 kW and modulate with a 100Hz tone at 95%.

b. Operate the transmitter at 5.0 kW and measure the percent of modulation. If it is within 1% of the level noted at 25 kW, no further adjustment of the Offset control is necessary.

c. If the modulation is not within 1% of the level noted at 25 kW, adjust R7 to bring the modulation level within 1%.

d. Operate the transmitter at 25 kW and note the percent of modulation. Adjust R7 if necessary.

This adjustment will affect the power output on all power settings, but will have the most affect at low power. Normally, satisfactory modulation tracking should be obtained within two turns of where the control was previously set.

5.6.2 Analog Input Board (A35)

The Analog Input Board has five adjustments that are preset during factory tests. It is normally advisable to recheck these settings using the procedures given here, however it may be necessary to install the board quickly to return the transmitter to the air. In this case, the adjustments can be set to the same resistance values as on the board to be replaced and a complete set-up procedure can be performed later. This procedure assumes the controls on the board to be replaced have not been changed from their factory settings. The controls to be preset, and the most convenient measurement points given are shown in Table 5-1.

5.6.2.1 Dither Frequency Adjust: R41

Dither Frequency adjustment is factory set and should not need any further adjustment. To check the dither frequency:

a. Connect a frequency counter to TP10.

b. Adjust R41 for a nominal frequency of 72 kHz. This is not critical and can vary anywhere from 70 kHz to 74 kHz.

5.6.2.2 Maximum Power Adjust: R27

a. Turn on the transmitter at LOW power with no modulation. If the Maximum Power adjust is set correctly the transmitter should come up at the previously set low power level.

b. If it does not, adjust R27 for the correct low power output.

Table 5-1. Analog Input Board A35 Preset Controls

CONTROL	FUNCTION	MEASUREMENT POINTS	RECORDED VALUE
R15	AUDIO GAIN ADJ.	U6-2 to R16 (Left side)	
R27	MAX. POWER ADJ.	TP3 to ground	
R41	DITHER FREQ ADJ.	U3-2 to junction of R38, R39, CR11	
R43	DITHER LEVEL ADJ.	TP9 to ground	
R84	OFFSET ADJ.	R83 (right side) to ground	
R85	GAIN ADJ.	U5-5 to ground	

c. Depress the HIGH power button. If HIGH power was previously set for 25 kW, the transmitter output should now be approximately 25 kW.

d. Depress the RAISE button until the power output reaches 30 kW or stops raising.

   1. If the maximum power output is less than 30 kW, adjust R27 for 30 kW output.

   2. If the power output exceeds 30 kW, adjust R27 so that the transmitter power will not exceed 30 kW.

5.6.2.3 Offset Adjustment: R84 (Modulated B-)

a. Connect a scope to the modulated B- output at A30 TP30 of the DC Regulator.

b. Operate the transmitter at 5.0 kW and modulate 100% with a 100 Hz sine wave.

c. Set up the scope at 1.0 Volt per division to measure a dc coupled audio waveform. You should view a distorted sine wave of approximately 2.0 Vp-p on a -3.0 VDC negative offset. See Figure 5-7.

d. Adjust R84 so that the positive peak of this waveform just begins to clip, then back off the control slightly. Note that the waveform will reach the clip point as it moves more positive. This positive peak of audio corresponds to the modulation envelope negative peak.

5.6.2.4 Audio Gain Adjust: R15

The Audio Gain Adjust is normally factory preset for 100% modulation with an audio input level of +10.0 dBm. It can be adjusted for 100% modulation with audio input levels from -10.0 dBm to +10.0 dBm. To adjust:

a. Operate the transmitter at the desired output power and slowly increase the output of the audio generator to the desired level.

b. Adjust R15 for 100% modulation.

c. The RF output may vary when adjusting this control. Once R15 is adjusted, the power output may need to be reset with the RAISE and LOWER buttons.

5.6.2.5 Dither Level Adjust: R43

The Dither control is preset and there should be no need for readjustment. If it is desired to check the setting of the control, use the following procedure.

a. Operate the transmitter at approximately 1.0 kW output and modulate with a 100 Hz tone at 95%.

b. Use a scope to display one cycle of demodulated audio from the modulation monitor.

c. Expand the vertical sensitivity of the scope to display only a portion of the waveform.

d. Adjust R43 maximum counterclockwise. At this point it should be possible to see some of the individual Digital Modulation voltage steps. (It may be possible to see the steps better at a lower modulation level, but it may also be necessary to externally sync the scope with the audio generator).

e. While observing the individual steps, adjust R43 clockwise until the individual steps can no longer be distinguished. This should occur within two turns of R43. Additional clockwise adjustment of the control may appear to further smooth out the steps but will result in additional noise on the waveform.

f. Only increase the Dither Level enough to just smooth out small step transitions. Other, slightly larger, steps or glitches will be seen at low power and modulation levels. This is normal. Do not use R43 to try and smooth these out. Never use more than three clockwise turns of R43.

5.6.3 Oscillator (A17)

Preset the replacement board before installation by placing all jumpers in the same positions as in the board to be replaced. These are identified in Table 5-2.

a. Set S1, a four section DIP switch, to the same setting as the board to be replaced.

b. Adjust the tuning slug of L4 with a non-inductive tuning tool for approximately the same amount of penetration into the coil.

c. Remove the heater assemblies from crystals Y1 and Y2. An angle bracket bolts to the PC board and holds the crystal heaters in place.

d. Carefully remove the crystals and reinstall them on the new board. Install the heater assemblies on each crystal.

5.6.3.1 Carrier Frequency Adjust: C1/C3

a. Select crystal oscillator and heater Y1 by moving jumpers J1 and J6 to position 1-2.

b. Turn the low voltage on for 15 to 20 minutes.

c. Connect a frequency counter to BNC connector J5 and adjust C1 with a non-inductive tuning tool for the correct carrier frequency.

Table 5-2. Oscillator A17 Preset Jumpers

JUMPER	FUNCTION
P1	CRYSTAL SELECT
P2	CRYSTAL FREQUENCY DIVIDER SELECT
P3	INTERNAL/EXTERNAL OSCILLATOR SELECT
P4	SINGLE/COMBINED TRANSMITTER SELECT
P5	EXTERNAL INPUT TERMINATION SELECT
P6	CRYSTAL HEATER SELECT

d. To set the output frequency of crystal Y2, turn off the low voltage and move jumpers J1 and J6 to positions 1-3. Repeat the above procedure by adjusting C3.

5.6.3.2 Oscillator Sync Adjustment: S1/L4

The Oscillator Sync adjustment is critical to the proper operation of the VSWR circuitry. If the circuit is not adjusted properly, damage to the RF amplifiers could result during a VSWR condition.

a. Using a dual trace scope connect channel one to TP5 and channel two to TP4 on the Oscillator. Sync the scope to channel one.

b. Operate the transmitter at full power and note a 5.0 Vp-p square wave at the carrier frequency on channel one. Channel two will also have a 5.0 Vp-p square wave displayed.

c. Adjust the scope to display one or two cycles of RF. If the positive going edges of the two waveforms are lined up, no further adjustments are required. Refer to Figures 5-9 and 5-10, Oscillator Sync waveforms.

d. If the two waveforms are not in phase and adjusting L4 does not line up the positive going edges, then different combinations of capacitance can be switched in by S1.

e. When switching in different values of capacitance use the least amount necessary to achieve phase alignment of the two signals. If too much capacitance is used there may not be enough signal input at TP4.

f. Operate the transmitter at 5.0 kW and make sure there is still a signal present at TP4. The two signals may not be as well aligned as at full power.

5.6.4 Driver Supply Regulator (A22)

The Driver Supply Regulator sets the proper voltage to Driver 8A and 8B. Two controls and one switch must be set properly for correct transmitter operation. If the Regulator is not operational, note DRIVER 8A voltage on the Factory Test Data sheet and the normal transmitter log reading.

5.6.4.1 Removing The Driver Supply Regulator Assembly

a. Turn off the primary AC power at the main disconnect.

b. Remove the clear plastic safety cover over the Driver Supply Regulator.

c. Disconnect all cables from the assembly. Remove the bolts holding the assembly to the transmitter wall.

5.6.4.1.1 Removing Printed Circuit Board From The Heat Sink

The printed circuit board is mounted on the heat sink, using six screws and spacers. The seven MOSFET's are soldered to the printed circuit board, and are mounted on the heat sink using screws, compression washers, and insulator pads.

To remove the printed circuit board, the seal between the transistors and the insulator pads will have to be broken. Use a long knife or ice pick to slide underneath the pc board to pry the MOSFET off the pad. The pad may tear or peel when the seal is broken. Always replace damaged pads.

5.6.4.2 Preset Adjustments

To prevent drive overloads, it is recommended that the two adjustments be preset by measuring the resistance of the controls on the board to be replaced. The most convenient measurement locations are shown in Table 5-3.

NOTE

Before proceeding with any adjustments, determine that the AC line voltage is at normal voltage levels. If the voltage is either higher or lower than normal, recheck your adjustments when the AC line has returned to normal.

5.6.4.2.1 Open Loop Adjust: R2

a. Set S1 on the Driver Supply Regulator to the OPEN LOOP position.

b. On the Controller, switch PA TURN-OFF switch S2 to the OFF (up) position.

c. Turn on Low Voltage at CB1 and CB2 and depress the LOW power button. The +230 VDC supply should be energized but there should be no RF output.

d. Note DRIVER D8A voltage. If the voltage is close to the normal voltage or to the recorded voltage on the Factory Test Data sheet, then no further adjustment of the Open Loop control is necessary.

e. If adjustment is necessary, use an insulated tuning tool to adjust R2 for normal operating voltage on D8A.

5.6.4.2.2 Closed Loop Adjust: R12

a. Switch S1 to the CLOSED LOOP position.

b. Adjust R12 (Closed Loop Adjust) so that DRIVER D8A voltage is the same as the Open Loop voltage.

c. Return the PA TURN-OFF switch to the PA-ON position and readjust R12 for the correct reading at normal power output.

5.6.5 DC Regulator (A30)

The DC Regulator has two adjustments which should be preset before the transmitter PA Power supply is turned on. Refer to the Factory Test data sheet for the LCD Multimeter readings on the DC Regulator.

a. Place P1 in the TEST position.

b. Turn on the Low Voltage supply with CB1 and CB2 and monitor TP8 with an external meter. Adjust for +2 VDC with R1.

Table 5-3. Driver Supply Measurements

CONTROL	FUNCTION	MEASUREMENT POINTS	MEASURED RESISTANCE
A22R2	OPEN LOOP ADJ	U2-2 to ground	
A22R12	CLOSED LOOP	R14(Left side) to R13(Left)	

WARNING: Disconnect primary power prior to servicing.

c. Adjust the voltage of "REG B B- OUT" with R93 and "REG A B-OUT" with R51 for approximately 2.5 VDC with the Low Voltage ON.
d. Turn the transmitter ON and modulate 100% with a 1 kHz tone at 25 kW.
e. Adjust the "A" and "B" voltages as needed to match those recorded on the Test Data Sheet. These voltages will normally be between -4.5 and -5.3 Volts.

NOTE

Place P1 in the NORMAL position after adjustments are completed. This is important to prevent overheating of the regulator transistors whan the transmitter is OFF and there is no air flow through the compartment.

5.6.6 Output Monitor (A27)

The Output Monitor performs three main functions:

- Forward and reflected power metering
- VSWR overload sensing
- Modulation monitor sample level adjustment

All of these functions must be calibrated for proper transmitter operation. Set all jumpers and switches listed in Table 5-4 to the same position as on the board to be replaced.

Since all of these circuits require adjustment while the transmitter output network is set to 50 + j0 Ohms, it is preferred that the transmitter be operated into a 50 Ohm load. This procedure can be performed into the antenna, but operating the transmitter into a load will make measurements easier due to the lack of interference, compared to that existing on the antenna system.

5.6.6.1 DETECTOR NULL (Antenna) Adjustment

a. Set the PA TURN-OFF switch S2 on the Controller to the OFF (up) position.
b. Depress the LOW power button. The PA Supply voltage should be present but no power should be indicated on the Forward Power meter.
c. Depress and hold the LOWER button for approximately 30 seconds.
d. Set the PA TURN-OFF switch S2 on the Controller to the ON (down) position and hold the RAISE button until the transmitter output power is approximately 2.5kW.
e. Using a Dual trace scope, connect a 10x probe on channel 1 to TP6 and a 10x probe on channel 2 to TP5. A signal should be visible at both TP6 and TP5.
f. While depressing momentary button switch S5, set the Normal/Calibrate switch S8 to the Calibrate position. Note that the signal at TP5 has dropped in amplitude.
g. Adjust capacitor C29 for minimum signal at TP5. This signal will contain mostly harmonics of the carrier frequency. It may be necessary to add additional capacitance with S9-1 and S9-3 at the low end of the band or additional inductance with S9-2 and S9-4 at the high end of the band to achieve a minimum signal.
h. Set the Normal/Calibrate switch S8 to the Normal position and release momentary pushbutton switch S5. Make sure that the vertical sensitivity of both channels of the scope are the same.
i. Connect both scope probes to TP6 to ensure that both traces are the same amplitude. Return the other probe to TP5.
j. Set the time base on the scope to display 2 to 3 cycles of RF.
k. Adjust C15 to make the signal at TP6 the same amplitude as TP5. Note that the two signals are probably not in phase with each other. See Figure 5-4.
l. Using a non-inductive tuning tool, adjust L12 to phase align the two signals. It may be necessary to readjust C15 to make the two signals equal in amplitude. Note that it may not be possible to get both signals equal in amplitude using C15 until some adjustment of L12 is made.
m. If, by adjusting L12, it is not possible to align the two signals in phase, select a different value of capacitance across L12 by switching in one or more sections of S6 then readjusting L12 for an in phase signal.
n. Note that as the amplitude and phase of the two signals are matched, the meter reading in the DETECTOR NULL (Antenna) position will null. Fine adjustments of these controls will be made at full power once the Bandpass Filter controls are set.

5.6.6.2 DETECTOR NULL (Bandpass Filter) Adjustment

a. Using a Dual trace scope connect a 10x probe from channel 1 to TP10 on the Output Monitor. Connect a 10x probe from channel 2 to TP1. A signal should be visible at both TP1 and TP10.
b. While depressing the momentary pushbutton switch S5, set the Normal/Calibrate switch S8 to the Calibrate position. Note that the signal at TP10 has dropped in amplitude.
c. Adjust capacitor C21 for minimum signal at TP10. Also note that the minimum residual signal will contain mostly harmonics of the carrier frequency.
d. If a minimum cannot be achieved due to the capacitor C21 running out of range, use S1 to select a different value of capacitance (C3 or C5), or a different value of inductance (L2 or L3) to null out the signal at TP1. Note that some frequencies may not require any added reactance. Normally capacitance is added at the low end of the frequency band and inductance is added at the high end of the band.

Table 5-4. Output Monitor A27 Jumper/Switches

JUMPER/SWITCH	FUNCTION
P3	Directional Coupler select
P1	Directional Coupler select
S8	Normal/Calibrate
S6	Antenna VSWR Phasing
S7	Bandpass VSWR Phasing
S2	Bandpass VSWR Amplitude
S9	Antenna Null Detector Resonance
S1	Bandpass Filter Null Detector Resonance

e. Set the Normal/Calibrate switch S8 to the Normal position, and release momentary pushbutton switch S5. Make sure that the vertical sensitivity of both channels of the scope is the same.
f. Set the time base on the scope to display 2 to 3 cycles of RF.
g. Adjust C16 to make the signal at TP1 the same amplitude as TP10, and also note that it may not be possible to get both signals equal in amplitude using C16 until some adjustment of L5 through L8 (selected by S7) is made. Capacitance can be added with S2 if the signal cannot by nulled with C16.
h. Note that the two signals are probably not in phase with each other. See Figure 5-5.
i. Using a non-inductive tuning tool, adjust L5 through L8, depending on which one is selected by the DIP switch S7, to phase align the two signals. It may be necessary to readjust C16 to make the two signals equal in amplitude.
j. If, by adjusting the selected variable inductor L5-L8, is not possible to align the two signals in phase, select another value of variable inductance with S7. Note that as the amplitude and phase of the two signals are matched the DETECTOR NULL (Filter) position on the Multimeter will also null.

5.6.6.3 Fine Tuning

a. With the transmitter operating at 2.5 kW, both the DETECTOR NULL (Antenna) and the DETECTOR NULL (Filter) positions on the front panel multimeter should indicate near zero.
b. To prevent possible modulation monitor damage, turn both the MEDIUM and HIGH power modulation monitor adjustment controls R7 and R8 full CCW.
c. Bring the transmitter to 25 kW and note the DETECTOR NULL (Antenna) position on the multimeter. If the reading is now above zero, null this reading using both C15 and L12.
d. Note the DETECTOR NULL (Filter) indication on the multimeter. If it is above zero, null it using C16 and L5 through L8, depending on what was selected by S7. The final adjustments will be made into the antenna at full operating power.
e. Modulate the transmitter with a 10 kHz tone, or one which causes the greatest upward deflection on the DETECTOR NULL (Antenna) meter reading, and recheck nulls.
f. Use a digital voltmeter or a dc coupled oscilloscope and adjust for minimum voltage at TP8 and TP9 with reference to ground.

5.6.6.4 Trip Threshold Adjustment

The overload settings for the Antenna and Bandpass circuit are listed in the Factory Test Data sheet. After the replacement board has been installed, set the overload settings as follows:

5.6.6.4.1 Antenna VSWR overload

a. Turn on the Low Voltage at CB1 and CB2.
b. Connect a voltmeter to TP4.
c. Adjust R24 until the voltage matches the Factory Test Data sheet.

If the Factory Test Data sheet is unavailable or if it is necessary to verify the original overload setting, use the following procedure:

a. Verify that the DETECTOR NULL (Antenna) reading on the front panel multimeter is nulled (zero) at full power.
b. Press LOW power, and adjust the RF output for 3.5 kW.
c. Depress the OFF button.

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

d. Remove the rear panels from the Output Network Compartment.
e. Reverse the Antenna VSWR current sample by placing P1 from 1-2 and P2 from 2-3 on the Output Sample Board.
f. Replace the rear panels on the Output Network Compartment.
g. Restore primary AC voltage at the main breaker.
h. Depress the LOW power button.
i. Switch the front panel multimeter to the DETECTOR NULL (Antenna) position. Note that the meter reads upscale.
j. Adjust R24 until the transmitter indicates an ANTENNA VSWR condition on the ColorStat™ panel.
k. Turn the transmitter OFF.

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

l. Remove the rear panels from the Output Network Compartment.
m. Place P1 and P2 on the Output Sample Board in the Normal position.
n. Replace the rear panels on the Output Network Compartment.

5.6.6.4.2 Bandpass VSWR Overload

a. Turn on the Low Voltage at CB1 and CB2.
b. Connect a voltmeter to TP10.
c. Adjust R23 for 1.0 VDC for a DX-50; 0.8 VDC for a DX-25U.

5.6.6.5 Forward/Reflected Power Adjustments C6 and C40

a. With the transmitter operating at 25 kW and no modulation, read the Reflected power indication on the front panel meter.
b. Adjust C40, Reflected Balance control, to null the meter indication. Note that C30 is added by P2 at the low end of the band to allow the meter indication to null.
c. Depress the OFF button.
d. Locate P1 and P3 on the Output Monitor. Move both jumper plugs from position 1-2 to position 1-3.
e. Turn the transmitter back on at full power. Note that the Reflected meter position now indicates forward power and the Forward meter position now indicates reflected power.
f. Operate the Forward/Reflected meter switch to the Forward power position. Adjust C6 to null this indication.
g. Depress the Off button and move jumpers P1 and P2 to position 1-2.

5.6.6.6 Modulation Monitor Sample Adjustments

Refer to the Initial Turn-On procedure in SECTION II, Installation/Initial Turn-On, for the procedure to set the Modulation monitor sample adjustments.

5.6.7 LED Board (A32)

The LED Board contains five overloads which can be preset to the correct reference voltage or resistance before the board is replaced. The Factory Test Data sheets list the voltage setting for each overload except the Power Supply overload.

If the Factory Test Data information is not available, measure the test point voltages on the original board before removing it from the transmitter. Use Table 5-5 to record the voltages for future reference.

5.6.7.1 LED Board Replacement

To replace the LED Board:

a. Turn off the Low Voltage supply at CB1 and CB2.
b. Remove all cables from the LED Board.
c. Remove the pushbutton caps from the VSWR Self Test switch S2 and the Reset switch S3 on the ColorStat™ panel.
d. Remove the screws holding the LED Board to the Center Control Compartment door and remove the board.
e. Using an Ohmmeter, measure the resistance from the right side of R92 to ground. Record this measurement in Table 5-6 for future reference. Adjust R86 on the replacement LED Board for the same resistance reading.
f. Install the replacement LED Board.
g. Turn on the Low Voltage supply at CB1 and CB2.
h. Using a digital multimeter, set the following test point voltages to match those recorded on the Factory Test Data sheets:
   1. TP6 (R42): Average Current Overload
   2. TP5 (R41): Overdrive Overload
   3. TP7 (R68): Peak Current Overload
   4. TP8 (R67): Underdrive Overload

If it is not possible to preset the replacement board voltages or if the correct overload operation needs to be verified, the following procedure for setting each overload should be used.

5.6.7.2 Overload Adjustment Procedures

The following procedures are used to set individual overloads on the LED Board.

5.6.7.2.1 Drive Overloads

These overloads protect the RF amplifiers from drive levels below 20.0 Vp-p or above 27.0 Vp-p. The nominal drive level is 21 to 25.0 Vp-p, measured at the MOSFET gate on the RF amplifiers. The first step in setting the drive overloads is to remove the supply voltage to all the RF amplifiers so that no damage will occur while the drive level is varied. Next the drive level will be varied to the overload limits and the overloads will be set.

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

a. Remove all AC primary power from the transmitter at the AC main breaker.
b. Remove the RF Amp Compartment and Driver Compartment rear access panels.
c. Remove the following fuses:
   1. A25: F1-F8
   2. A24: F1-F9
   3. F20: (on top of T1)
d. Reinstall the access panels.
e. Locate Big Step RF amplifier RF33 behind the interlocked RF Amp Compartment access door.
f. Connect 10x scope probe with an extended tip, Harris part 610-1131-000, through the door to the anode of CR3 in front of the heatsink. Ground the probe to door.
g. Set up the scope to measure an RF waveform of approximately 23.0 Vp-p.
h. Restore AC primary power at the main breaker.

NOTE

When measuring RF amplifier drive amplitudes or phasing, the RF amplifier to be measured must be turned “ON” to give a correct drive measurement. The drive waveform of an “OFF” RF amplifier will be below 0.0 VDC and the peaks may be clipped.

Table 5-5. LED Board Preset Voltages

TEST POINT	CIRCUIT FUNCTION	MEASURED DC VOLTAGE
TP5	OVERDRIVE	
TP8	UNDERDRIVE	
TP7	PEAK CURRENT	
TP6	AVERAGE CURRENT	

i. To turn on an RF amplifier, depress the LOW power button and note that the PA Power supply voltage comes up as indicated on the front panel multimeter but no RF power or PA current is indicated.

j. Depress the RAISE button to illuminate the green LED indicator on RF33.

k. Measure the peak-to-peak drive level on the scope monitoring the drive.

l. The waveform should measure from 21.0 to 25.0 Vp-p and it should be centered on the 0.0 VDC line of the scope.

m. If the waveform falls totally below the 0.0 VDC line of the scope, the Step 1 RF amplifier is turned “OFF”. See Figures 5-3 and 5-4 for drive waveforms.

n. Record the reading on the RF Multimeter position for DRIVER D8A and D8B. The Driver Supply Regulator will be set back to this voltage once the overloads are adjusted.

5.6.7.2.2 Underdrive Overload: R67

To adjust Underdrive overload R67, the drive must be reduced to 18.0 Vp-p.

a. To reduce the drive, depress the OFF button and allow the PA Voltage to discharge.

b. Open the interlocked door inside the Driver Compartment and remove Driver Module D1.

c. Remove both supply voltage fuses and re-insert the RF amplifier into position.

d. Close the interlocked door and depress the LOW button.

e. Driver D8A voltage will be higher than normal and there may be a voltage reading on the D8B position.

f. Measure the drive level at RF33 on the scope. If the drive level is above 18.0 Vp-p, repeat the above procedure for Driver Module D2.

g. Continue removing fuses from Driver Modules D3 through D5 until the level decreases to 18.0 Vp-p.

h. When a level of 18.0 Vp-p is achieved, adjust R67 on the LED Board until the transmitter turns OFF and displays an Underdrive Fault on the ColorStat™ panel.

i. Replace all fuses removed from the Driver Modules to restore the Driver stage to the correct output.

j. Press the LOW power button. The transmitter PA Power supply should energize, there should be no power out, and the drive level to the PA Modules should be the same as measured originally.

5.6.7.2.3 Overdrive Overload: R41

To adjust the Overdrive Overload, the RF drive must be increased to 26.0 Vp-p.

a. To adjust the Overdrive overload, place switch S1 on the Driver Supply Regulator in the OPEN LOOP position and note the voltage of D8A and D8B on the RF MULTIMETER.

b. Adjust R2 on the Driver Supply Regulator clockwise (CW) until the drive level reaches 26.0 Vp-p. If the voltage will not reach 26.0 Vp-p, place S1 on the Driver Encoder/Temp Sense Board to the ON position. This will turn on the spare Driver Module D6.

c. Adjust the Overdrive overload R41 on the LED Board until the transmitter turns OFF and an Overdrive overload is indicated on the ColorStat™ panel.

d. Turn the OPEN LOOP adjustment R2 two turns CCW and return S1 on the Driver Encoder/Temp Sense Board to the OFF position if moved.

e. Depress the LOW power button. The PA Power supply should energize and there should be no RF output from the transmitter.

f. Readjust R2 to the same voltage as earlier recorded on the multimeter DRIVER D8A and place S1 in the CLOSED LOOP position. The RF drive level should be the same as first noted.

g. Remove the 10x scope probe from the RF amplifier.

h. Turn the transmitter OFF and note that PA Voltage decreases to zero on the multimeter.

i. Remove primary AC power from the transmitter at the main breaker.

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

j. Remove the Driver Compartment and RF Amp Compartment rear access panels and replace all the PA Power Supply fuses.

k. Replace all panels and restore primary AC power to the transmitter at the main breaker.

5.6.7.3 Peak Current Overload: R68

a. Turn the PEAK current overload R68 fully CCW.

b. Operate the transmitter at 25 kW and modulate at 100% with a 20 Hz sine wave. Increase the audio level 1.4 dB. Adjust the PEAK current overload R68 for an overcurrent trip.

5.6.7.4 Average Current Overload: R42

a. Operate the transmitter at 25 kW and modulate with 20 Hz at 100%.

b. Increase modulation 0.5 dB.

Table 5-6. LED Board Preset Resistances

CONTROL	FUNCTION	MEASUREMENT POINTS	MEASURED RESISTANCE
R86	POWER SUPPLY FAULT	R92(Right side) to ground	

c. Adjust the AVERAGE CURRENT overload R42 until the OVERCURRENT LED lights AMBER.
d. Modulate the transmitter with 100 Hz at 100%.
e. Increase the audio in 1 dB steps. The PA current should not increase further than near full scale on the PA current meter.
f. Further increase the audio level until the transmitter shuts off and recycles back on. If the audio level is not reduced, the transmitter may shut OFF and stay OFF at this time.
g. The Overcurrent LED will illuminate RED and can be reset from the ColorStat™ panel.
h. Turn the transmitter back ON and verify that the transmitter takes at least +10 dB of audio overdrive before shutting OFF.

5.6.7.4.1 Average Current Overload Test

a. Modulate the transmitter 100% with 400 Hz sine wave.
b. Verify it will continue to operate with at least +10.0 dB over 100% audio overdrive.
c. The transmitter should trip OFF from a Current Overload with between 10.0 and 15.0 dB of overdrive.
d. The supply current should not exceed 250 amperes during the test.

5.6.7.4.2 Program Modulation Test

If OVERCURRENT overloads occur during program modulation conditions, the PEAK CURRENT OVERLOAD may be backed off 1-2 turns, but the voltage at TP7 must NOT exceed 11.5 VDC.

5.6.7.5 Power Supply Protection Overload R86

a. Operate the transmitter at maximum output power. Modulate the transmitter with 120 Hz at 100% modulation.
b. Increase the audio modulation 0.5dB (6%). Note: Use 100Hz modulation if operating at 50 Hz AC line frequency.
c. Adjust R86 clockwise until the transmitter shuts OFF with a Power Supply Protection Overload. Note hat the Supply Fault LED on the ColorStat™ panel is RED and that the transmitter will not recycle for this fault.
d. Adjust R86 1/4 turn counter-clockwise.
e. Depress the reset button to reset the fault indicator to GREEN.

NOTE

It is not required to depress the RESET button on the ColorStat™ to restart the transmitter. The RESET button only clears the fault indication.

f. Depress the HIGH power button to operate the transmitter at maximum output power.
g. Modulate the transmitter at 100% with 120/100 Hz. The transmitter should not trip OFF with a Power Supply fault.

5.6.8 Driver Encoder/Temp Sense Board (A19)

If the power supply circuits on the original board are operational, measure the following Test Point voltages on the original board and adjust the new board to the same voltages:

- TP1 (R17): Driver Threshold Reset
- TP2 (R19): Driver Threshold ON
- TP3 (R49): Temp Cal
- TP4 (R50): Step 1 Temp
- TP5 (R51): Step 2 Temp
- TP6 (R60): Temp Thresh
- TP11 (R98): Air Flow

After the replacement board voltages have been calibrated, ensure that JP1, JP2 and JP3, J5, S1 and S2 are in the correct position to correspond to the original board. The transmitter is now ready for operation.

If it is necessary to calibrate the replacement board, use the following procedure:

5.6.8.1 Over Temperature Circuits

Set the Over Temperature circuits on the Driver Encoder/Temp Sense Board as follows:

NOTE

The transmitter should be OFF and at room temperature when the Over Temperature circuits are calibrated.

a. Adjust R49 to set TP3 for 2.73 VDC.
b. Determine the ambient temperature in degrees centigrade and multiply this value by 0.1 (25 degrees C X 0.1 = 2.5).
c. Adjust R50 to set this value at TP4, and R51 to set this value at TP5.
d. Set the voltage at TP-6 to 7.0 VDC with R60.

5.6.8.2 Auto Driver circuits

The Auto Driver circuit should turn the Auto Driver Module D7 ON when the D8B voltage on the RF MULTIMETER reaches maximum, approximately +115 VDC. The Auto Driver circuit should turn the Auto Driver Module D7 OFF when the D8A voltage on the RF MULTIMETER reaches zero.

Set the Auto Driver circuit thresholds on the Driver Encoder/Temp Sense Board as follows:

a. Turn the transmitter ON at LOW power.
b. Make sure S2 on the Driver Encoder/Temp Sense Board is in the AUTO position
c. Locate the Driver Supply Regulator in the Driver Compartment. Move S1 to the OPEN LOOP position.
d. Record the D8A and D8B voltage on the RF MULTIMETER.
e. Adjust R2 on the Driver Supply Regulator until the D8B voltage reaches maximum, +115 VDC.
f. Adjust R17 on the Driver Encoder/Temp Sense Board until the AUTO DRIVER LED DS1 illuminates.
g. Adjust R2 on the Driver Supply Regulator until the D8A voltage reaches zero.
h. Adjust R19 on the Driver Encoder/Temp Sense Board until the AUTO DRIVER LED DS1 turns OFF.
i. Adjust R2 on the Drive Supply Regulator so the D8A and D8B voltages are the same as recorded at the beginning of the procedure.
j. Return S1 on the Driver Supply Regulator to the CLOSED LOOP position.

5.6.8.3 Air Flow Monitor Circuits

Set the Air Flow Monitor circuits on the Driver Encoder/Temp Sense Board as follows:

NOTE

For all adjustments and verifications, allow the air sensor at least one minute to stabilize. Fans are easily shut off by removing two of the three fuses mounted near each fan in the Output Network Compartment.

a. Operate the transmitter for a minimum of 15 minutes at full power at 100% modulation with a 1 kHz tone. All fans should be operational.

b. With the DRIVER COMPARTMENT DOOR OPEN, adjust the AIR FLOW CAL adjustment R98 for a +2.25 VDC reading at TP11.

c. Close the Driver Compartment door and verify that this reading increases to +2.5 VDC (+/- 0.05 VDC).

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

d. Remove the left rear access panel from the Output Network Compartment to expose the four cooling fans.

e. Remove any two of three fuses from one of the fans.

f. Replace the left rear panel on the Output Network Compartment.

g. Reapply primary AC voltage and turn the transmitter ON at HIGH power.

h. Modulate at 100% with a 1 kHz tone.

i. Observe that the transmitter will remain ON with ALL DOORS CLOSED.

j. The AIR INTERLOCK LED on the ColorStat™ should turn AMBER after a few minutes of operation.

k. The voltage at TP11 on the Driver Encoder/Temp Sense Board should now be between +2.8 and +3.1 VDC.

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

l. Remove the left rear access panel from the Output Network Compartment to expose the four cooling fans.

m. Remove any two of three fuses from a second fan.

n. Replace the left rear panel on the Output Network Compartment.

o. Reapply primary AC voltage and turn the transmitter ON at HIGH power. Modulate at 100% with a 1 kHz tone.

p. The transmitter should shut OFF within 15 minutes and the AIR LED on the ColorStat™ panel should turn RED.

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

q. Remove the left rear access panel from the Output Network Compartment to expose the four cooling fans. Replace the fuses and the rear panel. Restore primary AC voltage to the transmitter.

5.6.9 Switch Board/Meter Panel (A31)

There are three adjustments on the Switch Board/Meter Panel.

5.6.9.1 Forward Power Calibrate R14

This adjustment is calibrated at the factory by measuring transmitter power output in a calorimetric dummy load. This calibration adjustment should not be changed unless some means of accurately measuring transmitter power is available. If no external RF Power measuring device is available and the Switch Board/Meter Panel or Power Meter is replaced, a close approximation of output power can be determined by using the efficiency factor of the transmitter, number of PA Modules ON and PA Current as recorded on the Test Data sheet. Forward Power Calibration adjustment R14 should then be adjusted for the correct power reading on the front panel meter.

5.6.9.2 Reflected Power Calibrate R13

Once the Forward Power reading has been calibrated, operate the front panel to the REFLECTED position and move P1 and P2 on the Output Monitor board to the 1-3 position. The Power Meter will now read Forward Power on the Reflected Power position. Adjust R13 for the correct power reading on the Power Meter. Return P1 and P2 on the Output Monitor board to the 1-2 position.

5.6.9.3 PA Volt Meter Calibrate R8

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

a. Open the Driver Compartment door and locate the Driver Supply Regulator. Remove the clear protective cover.

b. Attach the positive lead of a volt meter capable of reading +250 VDC to where wire #6 connects to the PA Power Supply discharge switch S1. Attach the negative lead to transmitter ground.

c. Replace the Driver Supply Regulator clear protective cover.

d. Apply primary AC voltage to the transmitter.

e. Operate the transmitter at normal operational power.

f. Adjust R8 on the Switch Board/Meter Panel so the front panel multimeter PA Supply +VDC reading corresponds to the reading on the external meter.

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

g. Remove the Driver Supply Regulator clear protective cover and remove the external meter connections.

h. Replace the Driver Supply Regulator clear protective cover.

5.7 Frequency Change Procedure

The following is a step by step procedure for changing the frequency of the transmitter. If a complete frequency change is desired this procedure can be followed in order. If only a specific tuning procedure is desired (ex. Driver tuning) then only that section needs to be looked at. In some cases, time is a consideration in changing frequency of the transmitter. To allow a faster frequency change, procedures which are performed to achieve optimum transmitter performance, yet are not critical to the reliable operation of the transmitter, are covered after the section on "Basic Frequency Change."

5.7.1 Test Equipment Required for Frequency Change

The following is a list of the test equipment required to perform a frequency change. A frequency change should not be attempted unless the proper equipment is used.

- Audio Generator and Distortion Analyzer
- Oscilloscope
- Frequency Counter
- Modulation Monitor
- Digital Multimeter (preferred)
- Vector Impedance meter or Impedance Bridge
- Frequency programmable RF Generator (must operate up to 3 times carrier frequency)
- RF Load, 125 kW average dissipation
- Function Generator (optional)

NOTE

Output Network setup can be performed with a Vector Impedance Meter or Impedance Bridge and RF Generator. A Vector Impedance Meter is usually faster but can be sensitive to interference. An Impedance Bridge can be more effective in an RF environment.

5.7.2 Frequency Determined Components

Refer to the FD Chart, 839-7855-137, in the Drawing Package. Install all the proper parts listed for the new desired frequency. Oscillator crystal frequencies and part numbers are on drawing 817-1280-025.

Note that the FD chart for the output network components is organized in bands A through L. The mounting hardware, straps, plates, etc. are all listed on the parts list. When installing these components, make sure all connections are tight. Use special care when handling vacuum capacitors.

Table 5-7. Frequency Determined Jumpers and Switches

BOARD	FREQUENCY DETERMINED PRESETS
ANALOG INPUT A35	R85, R84, R43
OSCILLATOR A17	P2, S1, J3
A TO D CONVERTER A34	P10, S1
OUTPUT MONITOR A27	S1, S2, S6, S7, S9, P2
DRIVER COMBINER A14	J14, J15, J16-J32
BINARY COMBINER A8	J30-J33, L1-L16
MAIN COMBINERS A5 thru A7	L1-L16
SWITCH/METER PANEL A31	R1, R2
LED BOARD A32	R41, R67
DC REGULATOR A30	R51, R93

5.7.3 Frequency Determined Jumpers and Switches

Refer to the Tuning Chart, 839-7855-140, in the Drawing Package. Many of the frequency determined components on the transmitter are permanently installed and are changed by moving the desired jumper, coil tap or switch position. The Frequency Tuning chart lists all jumpers, taps, and switches that need to be set per frequency. Some of these settings are considered presets and may need to change during a specific procedure. A list of boards with frequency determined jumpers, taps, preset adjustments, and switches is shown in Table 5-7.

5.7.4 Output Network Dry Tune

Preset all output network taps according to the Frequency Tuning chart with all FD capacitors in place. If a high power dummy load is not available, a small terminating 50 Ohm resistor can be used.

WARNING

ENSURE ALL PRIMARY AC VOLTAGE HAS BEEN REMOVED FROM TRANSMITTER AND A GROUNDING STICK IS USED TO GROUND ALL POINTS WHERE AC OR RF POWER HAS BEEN APPLIED BEFORE PROCEEDING WITH THE FOLLOWING PROCEDURE.

Using a Vector Impedance meter or Impedance Bridge, adjust the following output network sections to their appropriate X_C or X_L values at the desired carrier frequency. The sections should be isolated (disconnected) from the rest of the other components and only the necessary connecting straps and hardware should be used to make the measurements. See table below.

2C2	13∠-90, 0 -j13 (2C2A and 2C2B capacitors only)
2C4	75∠-90, 0 -j75 (2C4A and 2C4B capacitors only)
2L3	42∠90, 0 + j42 (2L3 coil only)

At frequencies where C5 is installed in series with 2L3:

- Adjust 2L3 for A∠+90 or 0 + jA where A = 100,000/(1.257 x Fo) + 42.

- Example: for a carrier frequency of 1000 kHz; A = 100,000/(1.257 x 1000) + 42 = 121.5 = 121.5 ∠90 or 0 + j121.5.

5.7.4.1 Third Harmonic Trap 2L3, 2C3

After setting the X_L for 2L3, reconnect 2C3A (and 2C3B if necessary), but still isolate the trap circuit from 2C2 and 2C4 sections. Set the Vector Impedance meter to $3f_c$ and adjust 2C4A for resonance (maximum impedance).

5.7.4.2 LOAD and TUNE

Reconnect all sections in the output network except the Combiner Output connection. Connect the Vector Impedance meter at 2C6 with 2C6 disconnected from the combiner output pipe or at 2L1 if 2C6 is not used at your frequency. Adjust the TUNE and LOAD controls for 8∠0 or 8 +j0.

5.7.4.3 Half Frequency Trap 1L4, 1C4 (820 kHz - 1705 kHz)

Calculate the value to tap 1L4 as follows:

a. 1L4(Ohms) = 1000/(3.14 x Fo x C4)

b. Example: for Fo = 1000 kHz, C4 = 0.04 Mfd. 1L4(Ohms) = 1000/(3.14 x 1000 x 0.04) = 7.96 Ohms.

Using a vector impedance meter, or RF generator and bridge, adjust 1L4 tap for the correct resistance and install the 1L4/C4 combination in the transmitter.

5.7.5 RF Circuits Checkout

Before primary AC voltage is restored to the transmitter, make sure all FD components have been properly installed and all FD jumpers, coil taps, and switches have been properly set. Check all connections in the output network for proper tightness, and make sure that all panels removed for the frequency change have been installed.

5.7.5.1 Oscillator A17

NOTE

Remember that the RF is held off by the VSWR-H input at J7-5 on the Oscillator until the Power Amplifier stage is turned on. Use S1 on the LED Board to turn the output of the Oscillator ON during troubleshooting and setup.

a. Connect a frequency counter to J5 (frequency monitor sample).

b. Apply primary AC voltage to the transmitter and turn on the low voltage at CB1 and CB2. Allow the Oscillator to warm up for approximately 10 minutes.

c. Adjust trimmer C1 for the exact carrier frequency.

d. If a second crystal is installed in Y2, set the jumpers P1 and P6 to positions 1-3. After a short warmup, adjust C3 to the carrier frequency.

e. If an external RF source is used, i.e. stereo generator, verify that it is setup for the correct frequency.

NOTE

Recheck the frequency after 30 minutes. This must be repeated for both crystals.

5.7.5.2 Buffer Output (A16)

a. Turn off the low voltage to the transmitter at CB1 and CB2.

b. Locate the Predriver in the Driver Compartment.

c. Attach a 10x scope probe, Harris part #610-1131-000, through the ventilation slots in the interlocked Driver Compartment door to the anode of CR3.

d. Reapply the low voltage at CB1 and CB2.

e. Press S1 on the LED Board. Verify that the drive level to the Predriver is approximately 8 to 12.0 Vp-p. See Figure 5-2.

f. The amplitude may be adjusted with R2, Buffer Voltage adjust.

g. Move the probe and check the anode of CR4 on the Predriver for the same level.

5.7.5.3 Predriver Tuning

WARNING

ENSURE ALL PRIMARY AC POWER IS REMOVED FROM TRANSMITTER AND THAT A GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL POTENTIAL WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

a. Remove the rear access panels from the Driver Compartment and the left rear RF Amp Compartment.

b. Remove the following PA Supply fuses:
   1. A25: F1-F8
   2. A24: F1-F10
   3. F20: (on top of T1)

c. Make sure the proper value of C1 is installed and T8 is tapped per the initial setting from the Tuning Chart.

d. Replace the rear access panels on the Driver Compartment and the RF Amp Compartment

e. Reapply primary AC power to the transmitter.

f. Temporarily defeat the Underdrive Fault by connecting a jumper between TP8 and ground on the LED Board.

g. Set S1 and S2 on the Driver Encoder/Temp Sense Board to the OFF position.

h. Set JP1, JP2, and JP3 on the Driver Encoder/Temp Sense Board to the ON, 1-2, position.

i. Insert the 10x probe, Harris part #610-1131-000, through the ventilation slots in the interlocked Driver Compartment and attach it to CR3 or CR4 of RF Driver D1.

j. Depress the LOW power button. The PA Power supply contactors will energize and apply the +60 VDC Predriver supply voltage.

k. Adjust Predriver Tuning L1 for a peak in amplitude while observing the waveform on the Driver Module D1. (L1 tuning may be fairly broad at some frequencies.) The amplitude should be between 18 to 21 Vp-p.

l. If RF level is too low, change the tap setting on T8. Check all Driver Modules, D2 through D14, for consistent RF level.

WARNING

ENSURE ALL PRIMARY AC POWER IS REMOVED FROM TRANSMITTER AND THAT A GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL POTENTIAL WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

m. Remove the rear access panel from the Driver Compartment and replace Driver supply fuse A24F10. Replace the panel.

5.7.6 Initial Driver Tuning and Setup

Refer to SECTION VI, Troubleshooting, for additional information on measuring RF drive. Make sure all jumpers and switch settings on the following boards are in the correct position:

Driver Supply Regulator A22
- S1 to Open Loop.

Driver Encoder/Temp Sense Board (A19)
- S1 to OFF
- S2 to OFF
- JP1, JP2, and JP3 ON.

FD Chart and Tuning check list:
- 1C1
- 1C3
- 1C4
- 1L4
- 1L5
- Efficiency Coil Tap Settings
- T10 - (Note: Attach both leads together on chassis ground for initial tuning.)

NOTE

When measuring RF amplifier drive amplitudes or phasing, the RF amplifier to be measured must be turned "ON" to give a correct drive measurement. The drive waveform of an "OFF" RF amplifier will be below 0.0 VDC and the peaks may be clipped.

a. Driver tuning must be done with all Power Amplifier stage control signals ON. To turn all modules "ON", temporarily remove P1 on the Analog Input Board.

b. Connect the 10x scope probe, Harris part #610-1131-000, to CR3 or CR4 on PA Module RF33 through the ventilation slots in the interlocked RF Amp Compartment.

c. Depress the LOW power button and note that the PA Power supply voltage comes up as indicated on the front panel multimeter but no RF power or PA current is indicated.

d. With the scope dc coupled, note that an RF sine wave is now displayed on the scope. The waveform should normally measure between 22.0 and 25.0 Vp-p and it should be centered on the 0.0 VDC line of the scope. The drive level may be lower than 20.0 Vp-p at this time. The GREEN LED on the PA Module should be ON.

e. If the waveform falls totally below the 0.0 VDC line of the scope, the PA Module is turned OFF. See Figures 5-3 and 5-4 for drive waveforms.

f. To turn a PA Module ON, first make sure that the PA TURN-OFF switch S2 on the Controller is set to ON (down) position.

g. Press the RAISE button until the desired PA Module turns ON as indicated by the correct drive waveform. Note that green LED indicators will light if drive level is high enough. The RF MULTIMETER should also indicate current on the DRIVER IDC position.

h. The Driver/Combiner is now adjusted for resonance. Resonance is indicated by a peak in the drive amplitude and the DRIVER IDC reading on the RF MULTIMETER.

1. Resonance is achieved by adjusting the length of the strap, 1L5, that connects the Driver Combiner center conductor (copper rod) to C3. This strap is located in the top of the Driver Compartment and can be accessed through a panel on top of the transmitter.
2. The length of the strap must be increased if changing to a lower frequency and decreased if changing to a higher frequency.
3. A temporary strap can be made from 2" wide copper. Punch holes every 1" to allow easy changing of the length.
4. The strap should be adjusted in 1-2" increments in order to see the affects and obtain resonance. When the final length is found, cut a strap to length for the final setup.

i. Resonance is indicated by a peak in the drive amplitude and in the DRIVER IDC reading on the RF MULTIMETER.

j. Once a resonance peak is achieved, the drive amplitude is adjusted by:

1. BUCK/BOOST transformer T10
2. The number of Driver Modules ON: JP1, JP2 and JP3 on the Driver Encoder/Temp Sense Board
3. Driver Regulator Adjustment (D8A/D8B)

k. Monitor both the drive waveform on the scope and the DRIVER D8A voltage on the multimeter.

l. Adjust the OPEN LOOP adjustment R2 on the Driver Supply Regulator clockwise.

m. As R2 is adjusted, the drive will increase along with the voltage on the multimeter.

n. Adjust R2 until the drive level reaches 24.0 Vp-p on the scope or the DRIVER D8A voltage reaches 100 Volts.

1. If 24 Vp-p drive is indicated on the scope and the DRIVER D8A voltage is between 40 and 95 VDC continue on to paragraph, "Closed LOOP Adjustment."
2. If drive level is greater than 24 Vp-p and DRIVER D8A voltage is less than 30 VDC, turn one Driver Module OFF at a time by placing JP1, JP2 or JP3 on the Driver Encoder/Temp Sense Board in the OFF position.
3. If all three jumper plugs are in the OFF position and the drive level is still too high, T10 may be used to reduce, or "BUCK", the amplitude of the drive. This is achieved by attaching one lead of the transformer winding to the driver/combiner bar and the other lead to the combiner bar cover. The length of the Driver Tuning strap 1L5 may need to be changed to achieve resonance if T10 is used.

o. If the drive level is less than 22 Vp-p and DRIVER D8A voltage is greater than 90 VDC, BUCK/BOOST Transformer T10 may need to be used to increase, or “BOOST”, the amplitude of the drive. This is achieved by attaching reversing the lead connections on the transformer winding to the combiner bar and the combiner bar cover. The length of the Driver Tuning strap 1L5 may need to be changed to achieve resonance if T10 is used.

p. The optimum combination is:
   1. Driver Current of 22 Amps or less
   2. All Driver Modules active (D1-D5 and D9-D14)
   3. The Drive Regulator operating with DRIVER D8A voltage between +40 and +95 VDC
   4. BUCK/BOOST transformer T10 out of circuit or in the “BOOST” mode

q. When the optimum drive level is obtained, refer to the Driver Encoder/Temp Sense section for the AUTO Driver circuit adjustment procedure.

5.7.6.1 Closed LOOP Adjustment

a. When the RF drive level has been set at 24.0 Vp-p, note the DRIVER D8A voltage.

b. Set the LOOP select switch S1 on the Driver Supply Regulator to the Closed position.

c. Adjust Closed Loop adjustment R12, on the Driver Supply Regulator, for the same reading on the DRIVER D8A reading. The RF drive level should remain between 22.0 and 24.0 Vp-p. The LOOP select switch is normally left in the Closed position for normal operation.

NOTE

MAKE SURE TO REINSTALL P1 ON THE ANALOG INPUT BOARD IN THE NORMAL POSITION BEFORE PROCEEDING WITH INITIAL TUNING AT LOW POWER.

d. Remove jumper between TP8 and ground on the LED Board. This activates the Underdrive Overload circuitry.

5.7.6.2 Underdrive/Overdrive overloads

If it is desired to set the Underdrive and Overdrive overloads refer to the “Underdrive and Overdrive Overload Setting” paragraphs in the LED Board adjustment procedure.

5.7.6.3 RF Drive Phase

Even though not necessary for a frequency change, the RF drive phasing and Drain Phasing can be checked. For Drive Level and Phasing measurement procedures see “Measuring RF Drive Phasing,” paragraph and “Measuring RF Amplifier Drain Phasing,” paragraphs in SECTION VI, Troubleshooting.

5.7.7 Initial Tuning At Low Power

WARNING

ENSURE ALL PRIMARY AC POWER IS REMOVED FROM TRANSMITTER AND THAT A GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL POTENTIAL WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

a. Remove the rear access panels from the Driver Compartment and the left rear RF Amp Compartment and replace the following PA Power Supply fuses:
   1. A25: F1-F8
   2. A24: F1-F9
   3. F20: (on top of T1)

b. Apply primary AC power to the transmitter. Turn on the low voltage at CB1 and CB2.

c. Verify that all LED’s on the ColorStat™ panel are illuminated Green.

d. Verify that the transmitter is properly terminated into a Dummy load.

e. Turn the PA TURN-OFF Switch on the Controller to the OFF (up) position.

CAUTION

REMOVE JUMPER FROM THE LED BOARD A32 FOR PROPER DRIVE SENSING BEFORE PROCEEDING.

f. Depress the LOW power button. The PA Power supply should energize, but no RF output or PA current should be indicated.

g. Connect a meter to measure between 0.0 and +3.0 VDC to TP7 on the Analog input Board.

h. Press and hold the Fast Power Set switch S1 on the Controller. While holding S1 down, press the LOWER button on the front panel. The voltage at TP7 should quickly drop to zero. The power output of the transmitter is now set to zero.

i. Set the PA TURN-OFF switch to the ON (down) position.

j. Press the RAISE button. Power output should begin to increase along with the PA current indication. Continue to raise power until the power meter indicates 5.0 kW.

k. Change the Multimeter selection switch from PA +VDC to FILTER NULL. Power meter selector switch should be in FWD.

l. Adjust the TUNING control for maximum output as noted on the front panel Power meter.

m. FILTER NULL and ANTENNA NULL may begin to rise. Adjust the Antenna and bandpass filter null on the Output Monitor if necessary. Refer to the adjustment procedure for the Output Monitor in this section.

5.7.7.1 Modulated B-Check

a. Modulate the transmitter at 5.0 kW with a 100 Hz sine wave at 100% modulation.

b. Connect a scope probe to TP6 or TP30 on the DC Regulator. Displayed will be the Modulated B- waveform similar to the one in Figure 5-7.

c. Set the scope for 1 volt per division, dc coupled and the 0.0 VDC line on the top graticule. The positive peak of the waveform should be from -2.0 to -2.7 VDC. The negative peak should occur between -3.0 and -4.5 VDC.

d. If the waveform is not within these tolerances then the Modulated B-Adjustments should be set using the procedure in the Analog Input Board and DC Regulator paragraphs in this section.

5.7.7.2 A/D Phasing Check

Make sure that the switches and jumpers are preset according to the Frequency Tuning chart.

a. Operate the transmitter at 5 kW modulated at 100% with a 10 kHz tone.

b. Feed the demodulated output of the Modulation monitor to the Distortion Analyzer.

c. Measure the 10 kHz THD. It should typically be 1.5% or less.

   1. If the 10 kHz THD is 2% or higher, check 1 kHz THD. If this, too, is 2% or higher, see the troubleshooting section on “higher than normal audio distortion.”
   2. If the distortion is 2% or less, the 10 kHz distortion can be reduced by selecting different combinations of capacitance and inductance with S1 on the Analog to Digital Converter.

NOTE

If during the final adjustment of the A/D phasing at full power, the THD at 10 kHz is much higher than the 1 kHz THD, the Modulated B- adjustment may not be correct and should be rechecked. See the adjustment procedures under the Analog Input Board and DC Regulator replacement sections in this section.

5.7.8 Tuning At High Power

a. Press MEDIUM then RAISE to slowly raise power to 15 kW. This should occur with approximately 14 PA Modules turned ON.

b. Press HIGH then RAISE to slowly raise power to 25 kW.

c. At 25 kW power output, the PA Supply Current should be between 105 and 122 amps with 23 PA Modules ON. Refer to the Factory Test Data and use the following information to help tune the transmitter:

   Power Output (meter)
   PA Voltage
   PA Current
   PA Efficiency
   Antenna Null
   Filter Null
   # of Steps turned on

d. The TUNE control is adjusted for a peak in power output. This control may be rather broad, especially at the low end of the medium wave band.

e. The LOADING control adjusts the PA Current for a given number of PA Modules ON.

f. Use the number of steps turned on from the Factory Test Data to help determine if the LOADING needs adjusting.

   1. If the desired # of steps is 23 and more than 25 are on, press the LOWER button until 23 steps are ON and increase the PA Current with the loading control.
   2. If less than 23 PA Modules are ON, press RAISE until 23 PA Modules are turned ON and decrease the PA Current with the loading control.

g. Perform A/D Phasing check at 25 kW. Refer to Figure 5-6.

h. Check the Oscillator Sync Adjustment. Refer to the Oscillator adjustment procedures.

5.7.9 Completion of Basic Frequency Change of Transmitter

The following procedures allow the transmitter to be checked and adjusted for optimum performance. They are not critical for reliability and basic performance of the transmitter.

5.7.9.1 Binary RF Amplifier Phase Alignment

Binary RF amplifier phase alignment is performed to achieve optimum stereo performance. This alignment is performed by measuring the phase difference between the Big Step and Binary RF amplifiers at the output of each RF amplifier and adjusting the tap on the Efficiency coil for minimum phase difference. The taps on the Binary RF amplifier efficiency coils have already been preset per the frequency tuning chart.

Because the Binary RF amplifiers B7-B12 are designed to produce output RF voltages less than that of the “Big Step” RF amplifiers, they do not always operate at the same output phase of RF as the Big Steps. This phase difference can be anywhere from 0 to 30 degrees. Because the RF amplifiers operate at lower voltage potentials, this situation does not affect reliability. However, it can have an affect on the amount of IPM (Incidental Phase Modulation) products.

a. Connect the 10x probe, Harris part #610-1131-000, to the drain TP1 test point of Q3 on PA Module RF33 by inserting the probe through the ventilation slots on the interlocked RF Amp Compartment door.

NOTE

THE 10X SCOPE PROBE, HARRIS PART #610-1131-000 MUST BE USED. ALSO ENSURE THAT THE SCOPE PROBE IS PROPERLY GROUNDED.

b. Set the scope on AC coupled, 50 Volts per division with the trace centered on the screen.

c. Connect the external sync of the scope to J5 on the Oscillator and make sure the scope sync is set to External.

d. Operate the transmitter at 25 kW with no modulation.

e. Adjust the Horizontal vernier on the scope so that one full RF cycle occupies 9 divisions on the screen. Each division now equals 40 degrees of phase shift.

f. Using the Horizontal positioning and triggering level on the scope, place the transition time of the scope on the center vertical line of the screen.

g. Increase the vertical sensitivity of the scope to expand the waveform.

h. Switch the scope to the X10 position and readjust the horizontal position so that the RF transition again crosses the center line of the scope. This will be the reference for the phase measurements. If another RF amplifier transition occurs at the first large division on the right, this RF amplifier is operating at 4 degrees lagging from the reference.

i. Check the drain of Q3 on RF33 to RF35 to verify that they are all within +/-5 degrees of each other.

j. Check the drain of Q3 on the Binary RF amplifier B7. Note that Q3 is now the right hand MOSFET when viewing the module from the front.

k. Operate the transmitter again at 25 kW. If no waveform appears, then depress the RAISE or LOWER button until this step turns on.
l. As the power is changed, the Binary amps are turning on and off at different rates. The vertical sensitivity of the scope can be increased since B7 through B10 operate at 1/2 the supply voltage.
m. If the Phasing of B7 is within +/-5 degrees, move to B9.
   1. If the phase difference is greater, then the tap on L1 can be changed to put the B7 RF amplifier in phase.
   2. Typically, more of the inductor will be shorted out for the Binary amps than for the Big Steps.
   3. Do not reduce Efficiency coil turns to less than 1/2 of the given Frequency determined value.
n. Continue to check the phasing on the remaining binary amps. Note that the amount of active turns on the Efficiency coils will tend to be less on the smaller binary steps.

5.7.9.2 Binary Amplitude Alignment

The output of the Binary RF amplifiers can vary from frequency to frequency. To optimize the linearity of the modulation signal, the output amplitude of the Binary RF amplifiers can be varied in 5% increments. Triangle or ramp modulation must be used for this procedure.

a. To check the Binary alignment, operate the transmitter at 5 kW output with 10%, 100 Hz triangle modulation.
b. Connect the external sync input of the scope to the output of the generator.
c. On the scope, display the demodulated output of the modulation monitor.
d. Expand the vertical and horizontal display to view the positive going portion of the ramp.
e. Connect the other channel of the scope to the Modulation Encoder gold jumper for Big Step RF amplifier RF37.
f. Raise or lower the modulation until a transition from 0.0 to 5.0 Volts can be seen on the Step 37 display. From this display it is possible to see at which point in the modulation ramp Step 37 is being turned on.
g. Move the scope probe to the Modulation Encoder signal for Step 38.
h. Raise and lower the modulation until Step 38 can be seen to turn on. A small transition in the demodulated waveform may be noticed where a big step turns on. See Figure 5-11.
i. By making small changes in both the power level and modulation level, it should be possible to display the demodulated ramp between two big steps. This is the area to look at for binary alignment.
j. If the binary alignment is proper, the transitions between big steps will be smooth. If, for instance, the 1/2 Step, B7, amplitude is too low, you will see a transition approximately halfway between Step 37 and Step 38. This is the half step transition. You may also see that there is now a transition at Step 37 and Step 38 also. See Figures 5-11 and 5-12.

WARNING

ENSURE ALL PRIMARY AC POWER IS REMOVED FROM TRANSMITTER AND THAT A GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL POTENTIAL WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

k. Determining which binary step amplitude is not lining up with the others can take some trial and error.
   1. For example, to change the binary amplitude for the 1/2 Step, open the interlocked inner door.
   2. Remove the 1/2 Step RF amplifier B7 and Big Step RF amplifier RF33.
   3. Look through the slots of the removed amps and move J30 on the motherboard to the next desired position.
   4. Reinsert the modules and check the ramp linearity.
   5. Repeat for all Binary Steps B7 through B11 using J31, J32 and J33, if necessary. Binary RF amplifier B12 does not have amplitude adjustments.

NOTE

The ramp may not appear to be perfect, even at what appears to be optimum binary alignment. This is because the displayed ramp is at LOW power at around 10% modulation.

CAUTION

ENSURE THAT THE BINARY JUMPER PLUGS ARE PROPERLY INSERTED AND SEATED. A LOOSE OR MISSING JUMPER WILL CAUSE BINARY TOROID DAMAGE.

5.7.10 Other Adjustments

These adjustments should normally not change during a frequency change, but it is advisable to check their setting for optimum transmitter performance.

5.7.10.1 Audio Gain Adjust: A35R15

This sets the proper audio modulation level into the transmitter. Refer to the paragraphs on the Analog Input Board replacement.

5.7.10.2 Offset Adjust: A34R75

This control adjusts the Modulation Tracking of the transmitter or, in other words, how equally it will modulate at different power levels. Refer to the paragraphs on the Analog to Digital Converter replacement procedure.

5.7.10.3 Dither Adjust: A35R43

This control reduces the small modulation steps caused by the Digital Modulation process. Refer to the paragraphs on the Analog Input Board replacement.

5.7.10.4 Modulated B- Adjustments

This signal optimizes the switching time of the PA Modules and affects high frequency distortion and response. Refer to the paragraphs on Analog Input Board and DC Regulator replacement for B- adjustments.

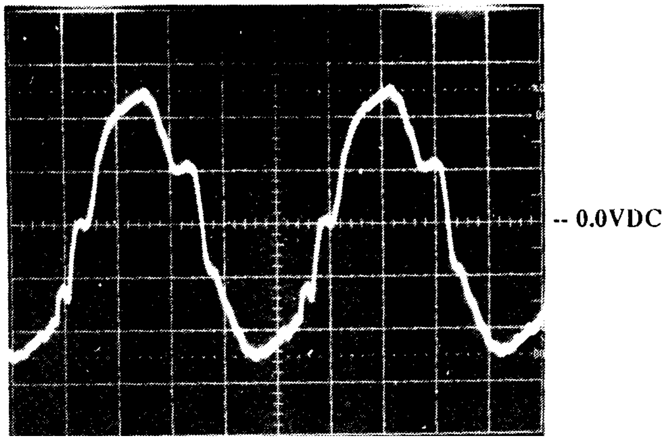

Figure 5-2
Predriver Input drive waveform, measured at the anode of CR3 or CR4 on Predriver module (2Vp-p per division)

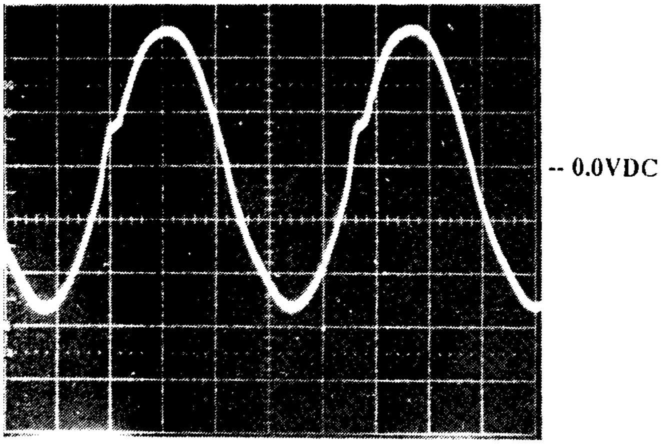

Figure 5-4
RF Drive Waveform at RF Amplifier, Gate of Q3 (anode of CR3). RF AMplifier turned ON. (5Vp-p per division)

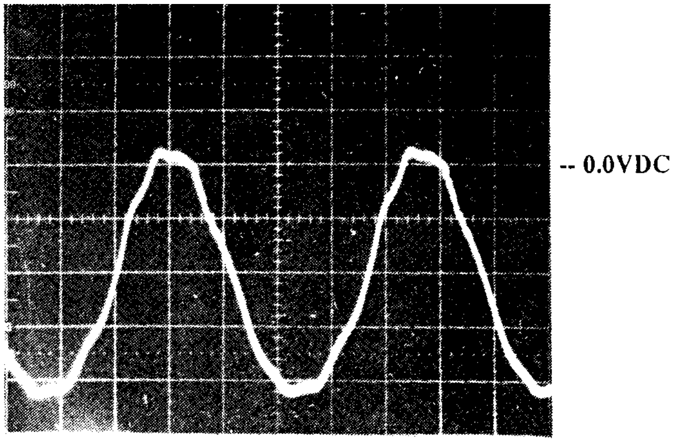

Figure 5-3
RF Drive Waveform at RF Amplifier Gate of Q3 (anode of CR3). RF Amplifier turned OFF. (5Vp-p per division)

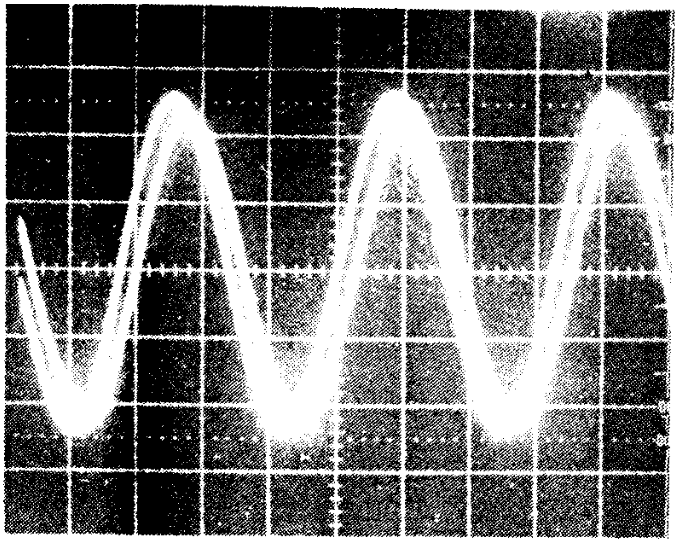

Figure 5-5
Antenna VSWR Detector voltage and current samples as measured at Output Monitor A27TP1 and TP2. Also typical of Bandpass filter samples.

WARNING: Disconnect primary power prior to servicing.

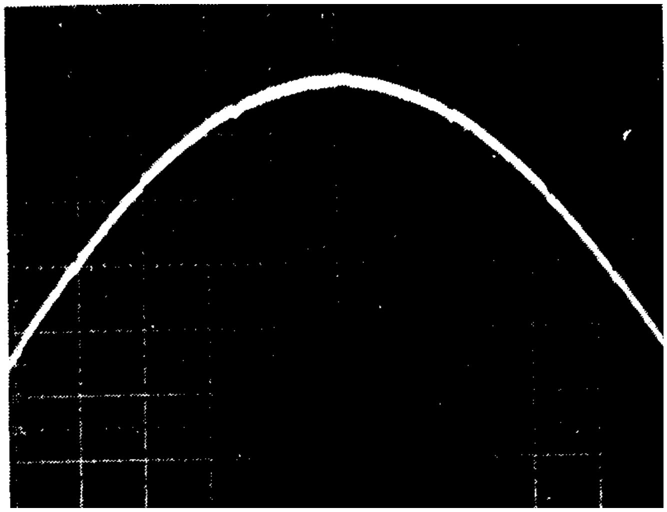

Figure 5-6
Demodulated Audio of 100 Hz sinewave at 30% modulation at 25 kW. Scope view of positive peak expanded to show glitches due to improper A to D phasing adjustment.

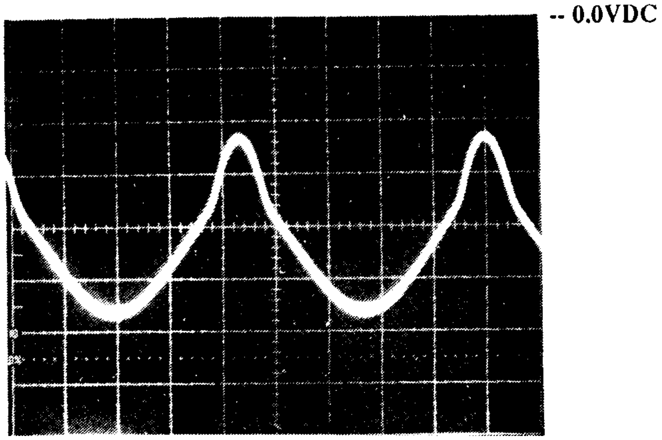

Figure 5-8
Modulated B- waveform at DC Regulator A30TP30. 25kW operation with 100 Hz, 100% modulaltion.

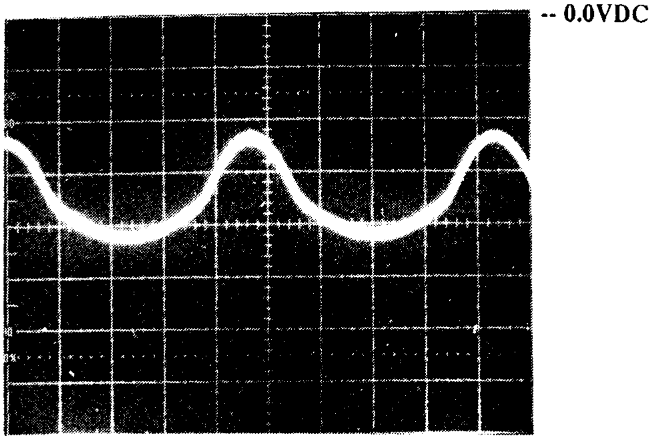

Figure 5-7
Modulated B- waveform at DC Regulator A30TP30. 5 kW operation with 100 Hz, 100% modulation. 1V per division, 0.0 Vdc at top line.

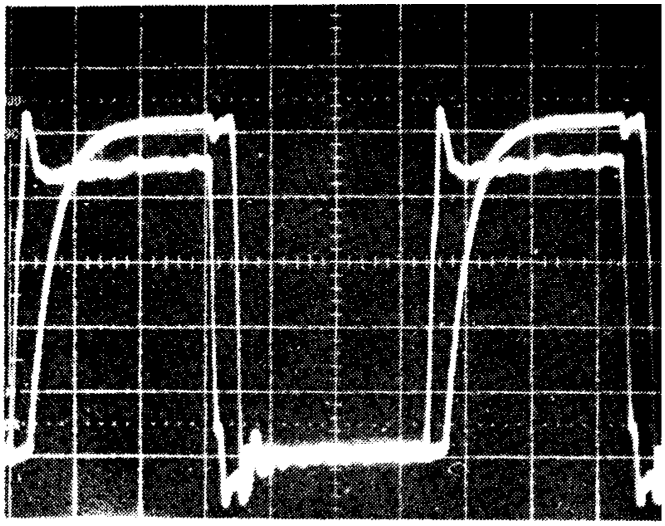

Figure 5-9
Oscillator sync samples at Oscillator A17TP4 and TP5. Transmitter operating at 25 kW with no modulation. The two samples are not in phase.

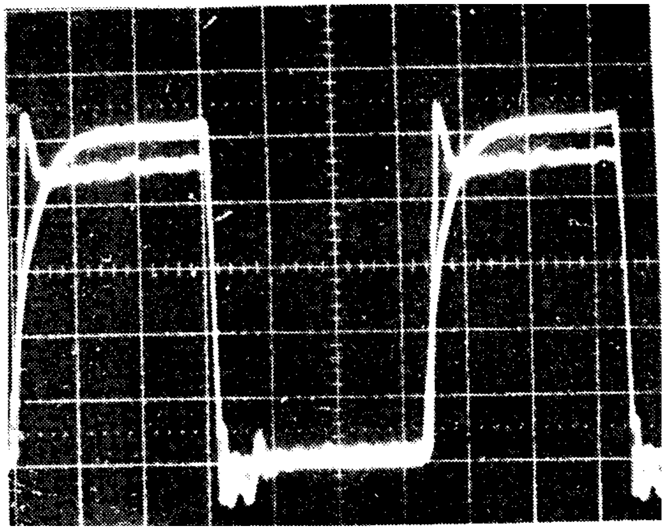

Figure 5-10
Oscillator sync samples at Oscillator A17TP4 and TP5. Transmitter operating at 25 kW with no modulation. The two samples are in phase.

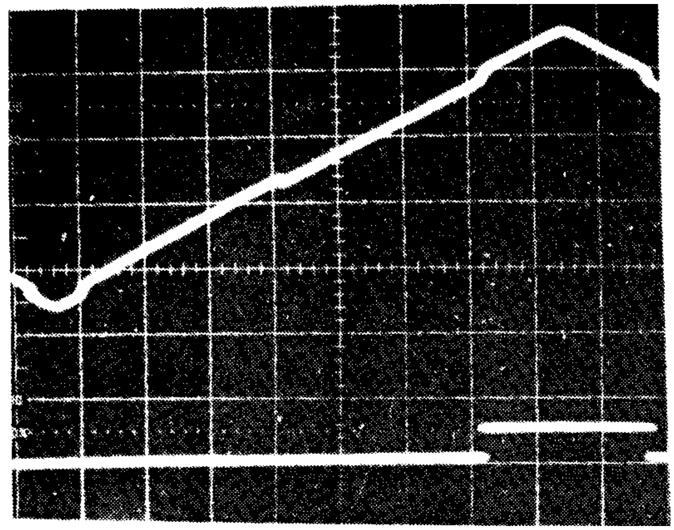

Figure 5-12
Demodulated audio. Transmitter operaeting at 5kW with 100 Hz, approximately 10% triangle modulation.
Top Trace - Demodulated audio.
Bottom Trace - Modulation Encoder waveform of Step 6. Insufficient 1/2 Binary Step output shown.

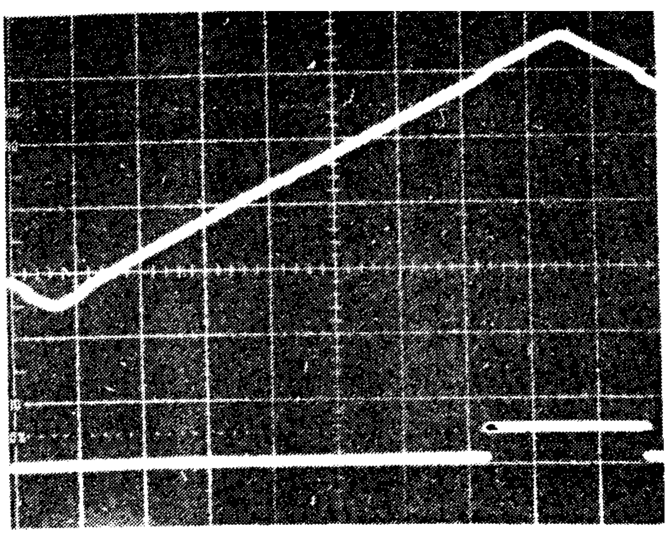

Figure 5-11
Demodulated audio. Transmitter operating at 5 kW with 100 Hz, approximately 10% triangle modulation
Top Trace - Demodulated Audio
Bottom Trace - Modulation Encoder waveform of Step 6. Good binary alignment shown.

6.1 Introduction

This section of the technical manual contains troubleshooting procedures for the DX-25U.

Problems that could cause an OFF AIR situation and how they relate to the front panel ColorStat™ indicators, including overloads and interlocks will be discussed first.

This section is a troubleshooting guide for the transmitter as a system. For additional information related to an individual module or board, refer to the section of the manual for that particular board.

This section contains techniques and guidelines to assist the engineer in isolating the problem more quickly. The engineer using this section of the manual must have the proper test equipment available and has a good working knowledge of the transmitter and the operation of the individual modules and boards.

Table 6-0. Troubleshooting the Transmitter

Section VI
Troubleshooting
Introduction 6-1
Symptom: Transmitter will not turn ON - No ColorStat™ panel indicators are illuminated.. 6-6
Possible Causes 6-6
Loss of AC Power 6-6
Loss of +5V Supply on LED Board 6-6
Loose Connectors 6-6
Symptom: Transmitter will not turn on - all ColorStat™ panel indicators are illuminated Green. 6-6
Possible Causes 6-6
+5B Circuit Not Up To Operating Voltage. 6-6
Contactor Turn On Logic On The Controller 6-6
Contactor Drive Circuitry. 6-6
+30 VDC Feedback Auxiliary Signal 6-6
240 VAC Coil Voltage. 6-6
Open Contactor Coil On K1 or K2 6-6
Symptom: Transmitter will not turn on - one or more ColorStat™ panel indicators are illuminated RED. 6-7
Possible Causes 6-7
Symptom: Transmitter will turn ON but immediately turns OFF - one or more ColorStat™ panel indicators illuminate RED. The transmitter may try to turn on twice and a fault indicator illuminates AMBER then RED.. 6-7
Possible Causes 6-7
Symptom: Transmitter turns On (LOW, MEDIUM or HIGH buttons illuminate) but there is no power output and no PA current is indicated. Supply voltage is indicated on the multimeter. 6-7
Possible Causes 6-7
PA Turn-Off Command Given To Transmitter. 6-7
Type 4 or Type 5 Fault 6-7
Power Output Is Set To Zero. 6-7
Symptom: Transmitter is running, but power is lower than normal. 6-7
Possible Causes 6-7
Power Reduction Circuitry Activated 6-7
Symptom: Unable to raise power past a certain point. ColorStat™ panel ANT and/or FILTER LED indicate RED. . 6-8
Possible cause 6-8
Symptom: Unable to raise power past a certain point. No ColorStat™ panel indicators Illuminated RED. 6-8
Possible cause 6-8
Analog Input Board maximum power adjustment R27 misadjusted or defective. 6-8
Analog Input Board, half power step up circuit may have failed. 6-8
PA Turn on/Turn Off control signals on Modulation Encoder A37 may be incorrect.. 6-8
Open fuses on Fuse Boards A24 or A25. 6-8
Symptom: Transmitter turns ON (Low, Medium, or High Indicators Illuminate) but will not modulate. 6-8

Possible Causes 6-8
Modulation not reaching transmitter 6-8
Analog Input Board 6-8
ColorStat™ panel Overcurrent Fault Indication 6-8
Random Faults With Program Audio. Possible Causes: 6-8
Faults With Tone Modulation. Possible Causes: 6-9
Overloads on Turn On. Possible Causes:. 6-9
ColorStat™ panel Overvoltage Fault. 6-9
Possible Causes 6-9
Supply Voltage Too High 6-9
ColorStat™ panel Supply Fault 6-10
Possible Causes 6-10
Input AC 3 Phase Line Imbalance 6-10
Open +115 VDC Supply Rectifier Fuse 6-10
Failed PA Power Supply Transformer T1 6-10
Low Frequency, High Level Modulation 6-10
Overload Settings. 6-10
ColorStat™ panel Underdrive Fault 6-10
Possible Causes 6-10
High Voltage Supply Short 6-10
Failed Driver Supply (+115 VDC) 6-10
Failed Predriver Supply (+60 VDC) 6-10
No Drive To The Driver Stage 6-11
Driver Module Failure 6-11
Excessive RF Amplifier Failures 6-11
Driver Supply Regulator Failure 6-11
Driver Supply Regulator Loop Select 6-11
Defective Driver Encoder Signals 6-11
Severe Driver Mistuning 6-11
ColorStat™ panel Overdrive Fault 6-11
Possible Causes 6-11
High AC Line Voltage 6-11
Defective Driver Encoder Signals 6-11
RF Amplifier ON/OFF Circuitry 6-11
Driver Supply Regulator Failure 6-11
ColorStat™ panel Door Interlock 6-12
Possible Causes 6-12
Defective Interlock Switch 6-12
deleted 03-01-96 6-12
Bad Connection at DC Regulator 6-12
ColorStat™ panel External Interlock. 6-12
Possible Causes 6-12
External Interlock Terminals Open 6-12
External Interlock Fuse F24 6-12
External Interlock Relay K3 6-12
DC Regulator Components 6-12
ColorStat™ panel Air Interlock 6-12
Possible causes 6-12
Fans Not Operating Properly, Failed/Running Backward 6-12
Dirty Filters 6-12
Top Air Exhaust Restricted 6-12
Rear Access Panel Open 6-12
Air Interlock Sensing Circuitry 6-12
Air Interlock Detector U17 6-12
ColorStat™ panel Oscillator Fault. 6-13
ColorStat™ panel Buffer Fault 6-13

WARNING: Disconnect primary power prior to servicing.

ColorStat™ panel Predriver Fault 6-13
ColorStat™ panel RF Amp Fault 6-13
ColorStat™ panel Analog Input Board: +15V and -15V Supply Faults 6-13
ColorStat™ panel Analog to Digital Converter 6-13
+15V, -15V, and +5V Supply Faults 6-13
Conversion Error Fault 6-13
ColorStat™ panel Modulation Encoder: Cable Interlock Fault 6-13
Possible Causes 6-14
RF Amplifier Module Not In Place 6-14
Modulation Encoder Cable Not In Place 6-14
ColorStat™ panel DC Regulator B+ and B- Supply Faults 6-14
ColorStat™ panel Output Monitor Faults 6-14
+5V and -5V Supply Faults 6-14
VSWR Faults 6-14
General Discussion Of VSWR Protection of the Transmitter 6-14
First Stage VSWR Protection 6-15
Second Stage VSWR Protection 6-15
Antenna VSWR Fault 6-15
Possible Causes of VSWR Overloads 6-15
Possible Causes of Arcing 6-15
Possible Causes of Transient Signals 6-15
Load Impedance Changes 6-15
Bandpass Filter VSWR Fault 6-16
Bandpass Filter VSWR Caused By Problems In The Output Network 6-16
Symptom: Loss Of Positive Peak Capability 6-16
Possible Causes 6-16
Power Supply Voltage Low 6-16
Audio Processor Equipment Defective or Incorrectly Set 6-16
Incorrect Transmitter Tuning 6-16
Transmitter Operated In FlexPatch™ Mode 6-16
Failed RF Amplifier 6-16
Symptom: Higher Than Normal Audio Distortion 6-16
Possible Causes 6-16
Failed RF Amplifier(s) 6-16
Transmitter Mistuning 6-16
Operating Into a Bandwidth Restricted Antenna 6-16
Low RF Drive Level To The PA Modules 6-16
Additional Tips For Troubleshooting Audio THD 6-16
Symptom: Consistent Loss of RF Amplifiers 6-17
Repeated Loss of Same RF Amplifier In Any Position 6-17
Possible Causes 6-17
Defective Transistor Pad 6-17
Defective Turn On/Turn Off Circuitry 6-17
Improper RF Drive 6-17
Poor Solder Connection on PC Board 6-17
Consistent Loss Of An RF Amplifier In One Particular Position 6-17
Possible Causes 6-17
Improper RF Drive 6-17
Improper Drain Phasing 6-17
Defective Output Toroid 6-17
Improper Control Signal 6-17
Consistent Loss Of Modules In Random Positions 6-17
Possible Causes 6-17
Analog to Digital Phasing Improperly Set 6-17
Modulated B- Improperly Set 6-17
Improper VSWR Circuit Operation 6-17

Improper Overload Settings 6-17
Improper Air Flow 6-17
Transmitter Mistuning 6-17
Other Troubleshooting Techniques 6-18
Handling MOSFET’s 6-18
Testing MOSFET’s 6-18
Finding A Missing Step 6-18
Using FlexPatch™ for Bypassing a Failed PA Module 6-18
Using FlexPatch™ for Isolating Modulation Encoder/RF Amplifier Problems. 6-19
Measuring Drive Level 6-19
Measuring Drive Phasing 6-19
Excessive Drive Phase Difference 6-20
RF Amplifier Drain Phasing. 6-20
Excessive Drive Phase Difference 6-20
Measuring Steps 50-123: TEST SWITCH 6-21

Table 6-1. DX 25U Fault Types

TYPE 1	TURNS PA POWER SUPPLY OFF (Manual Restart Required)
EXT	External Interlock
AIR	Air Flow Fault
DOOR	Door Interlock
SUPPLY FAULT	PA Power Supply Protection
OVER VOLTAGE	PA Power Supply Overvoltage Protection
CABLE INTERLOCK	Modulation and Driver Encoder Cables
B+	DC Regulator B+ Regulated Fault
B-	DC Regulator B- Regulator Fault
+5V	Output Monitor +5V on board Regulator Fault
+15V	Output Monitor +15V on board Regulator Fault
REPEATING TYPE 2 FAULT	See NOTE below
TYPE 2	TURNS PA POWER SUPPLY OFF (Recycles Back ON)
UNDER DRIVE	RF Drive Level to PA LOW
OVER DRIVE	RF Drive Level to PA HIGH
OVER CURRENT *	PA Power Supply +230 Vdc Overload
* Transmitter will attempt to limit current first, then shut off high voltage if limiting is not sufficient.	
NOTE: If Type 2 fault condition is still present when the transmitter cycles back on,or repeats within 2.4 seconds after the transmitter cycles back on, it becomes a Type 1 fault and will require a manual restart.	
TYPE 3	LOWER POWER OUTPUT
BANDPASS VSWR	Output Monitor detects sucessive VSWR’s
ANT. VSWR	Output Monitor detects sucessive VSWR’s
TEMPERATURE	Driver Encoder/Temp Sensor detects an over temperature condition
TYPE 4	PA TURN OFF ONLY (PA Kill only, High Voltage Remains ON)
BANDPASS VSWR	Output Monitor detects one shot VSWR
ANT. VSWR	Output Monitor detects one shot VSWR
+15V	A/D Converter on board +15V Regulator Fault
-15V	A/D Converter on board -15V Regulator Fault
+5V	A/D Converter on board +5V Regulator Fault
+15V	Analog Input on board +15V Regulator Fault
-15V	Analog Input on board -15V Regulator Fault
TYPE 5	CLEAR MODULATOR DIGITAL AUDIO DATA
CONVERSION ERROR	A/D Converter
TYPE 6	FAULT DISPLAY ONLY
RF AMP	PA RF Amplifier Fuse Blown

6.2 Symptom: Transmitter will not turn ON - No ColorStat™ panel indicators are illuminated.

6.2.1 Possible Causes

6.2.1.1 Loss of AC Power

If no indicators on the ColorStat™ panel are illuminated, check for correct unregulated Low Voltage supply readings on the front panel multimeter. Make sure that the Low voltage power supply breakers CB1 and CB2 are set to the ON position. Finally check the AC primary power to the transmitter to ensure that the fuses or circuit breakers have not opened.

6.2.1.2 Loss of +5V Supply on LED Board

If the ColorStat™ panel LED's are not illuminated, but the unregulated Low Voltage readings are correct, this indicates a problem with the Controller or LED Board. The +5 VDC supply for the LED Board is developed on the Controller. Check for +5 VDC at the Controller on TP2. DS1 on the Controller will illuminate any time any of the three regulators on the controller fails.

6.2.1.3 Loose Connectors

Check for loose or improperly installed connectors on both the LED Board and Controller. Also check the connectors on the Power Distribution Board A39.

NOTE

Do not remove any plugs with the power on.

6.3 Symptom: Transmitter will not turn on - all ColorStat™ panel indicators are illuminated Green.

6.3.1 Possible Causes

6.3.1.1 +5B Circuit Not Up To Operating Voltage

If the +5B supply which uses the 1 farad capacitor backup is not operational then the transmitter will not turn ON. If the transmitter does not have a good set of backup batteries BT1-BT3 installed and the transmitter has been off for more than two hours, the backup capacitor C44 requires approximately 1 minute to recharge. This keeps the transmitter from turning ON. Measure TP6 on the Controller and verify that the +5B voltage is present. If it is not, troubleshoot the +5B supply.

6.3.1.2 Contactor Turn On Logic On The Controller

Measure the voltage at Q10-1 on the Controller. It should be approximately +15 VDC. While monitoring this voltage, depress the LOW power button. The voltage should drop to near 0 VDC for approximately 1 second. If it does not, troubleshoot the Controller contactor drive logic circuits. If the voltage does drop down or is not present, the problem is in the contactor drive circuitry.

WARNING

TO MEASURE THE VOLTAGES IN THE FOLLOWING STEP REMOVE PRIMARY VOLTAGE AT THE MAIN BREAKER OR FUSE PANEL. THEN REMOVE THE STEP START PANEL COVER AND ATTACH YOUR MEASURING DEVICE TO THE TERMINALS LISTED.

6.3.1.3 Contactor Drive Circuitry

Measure the +15 VDC on 3TB1-8 in the Step Start panel. If voltage is not present or does not drop when the LOW button is depressed, the wire or cable continuity is broken at some point or solid state relay K101 is defective. If K1 energizes but K2 does not, measure for +15 VDC at 3TB1-10. It should be present, and drop to close to zero shortly after K1 energizes. If it does not, check for wire continuity or defective K102.

6.3.1.4 +30 VDC Feedback Auxiliary Signal

The +30 VDC AUX signal sent back to the Controller to indicate K1 and K2 have energized may be missing. Measure for +30 VDC at 3TB1-5. If not present, measure at TB3-5 in the transmitter.

a. Voltage present at TB3-5: Continuity problem between transmitter and step-start panel.
b. Voltage not present at TB3-5: Troubleshoot +30 VDC supply.

If +30 VDC is present at 3TB1-5 in the step-start panel, measure the return voltage at 3TB1-6. When K1 energizes, +30 VDC should be present 3TB1-6.

NOTE

If the contactor circuit for K1 (step start contactor) is inoperative, no sound from the Step Start panel will be heard when the LOW, MEDIUM, or HIGH button is depressed. If the contactor circuit for K2 (run contactor) is inoperative, two clicks will be heard when the transmitter LOW, MEDIUM, or HIGH button is depressed. This is the step start contactor energizing and de-energizing.

6.3.1.5 240 VAC Coil Voltage

WARNING

TO MEASURE THE VOLTAGES IN THE FOLLOWING STEP FIRST REMOVE ALL VOLTAGES APPLIED TO STEP START PANEL AND TRANSMITTER. YOU CAN THEN REMOVE THE STEP START PANEL COVER AND ATTACH YOUR MEASURING DEVICE TO THE TERMINALS LISTED. ROUTE LEADS OUT OF STEP START PANEL AND THEN REATTACH STEP START PANEL COVER. NOW APPLY POWER AND RUN TEST. AFTER TEST IS COMPLETED, REMOVE ALL POWER, REMOVE COVER, REMOVE LEADS, AND REATTACH COVER.

Measure the voltage between 3TB1-15 and 16. The 240 VAC from K1 and K2 coils should be present when CB1 is switched on. Measure for 240 VAC on K1 and K2 coils when the LOW, MEDIUM or HIGH buttons are depressed. If not present, possible defective K101 or K102.

6.3.1.6 Open Contactor Coil On K1 or K2

Measure the resistance of each contactor coil. The nominal resistance should be approximately 200-250 Ohms for K1 and 10-20 Ohms for K2.

6.4 Symptom: Transmitter will not turn on - one or more ColorStat™ panel indicators are illuminated RED.

6.4.1 Possible Causes

See the “Troubleshooting ColorStat™ Panel Indicator Faults” paragraph in this section.

6.5 Symptom: Transmitter will turn ON but immediately turns OFF - one or more ColorStat™ panel indicators illuminate RED. The transmitter may try to turn on twice and a fault indicator illuminates AMBER then RED.

6.5.1 Possible Causes

In the case of the Overcurrent, Overdrive and Underdrive overloads, the transmitter will try to restart one time before indicating a fault. This indicates that the fault still exists and must be repaired before the transmitter will become operational. See the “Troubleshooting ColorStat™ panel Indicator Faults” paragraph in this section.

6.6 Symptom: Transmitter turns On (LOW, MEDIUM or HIGH buttons illuminate) but there is no power output and no PA current is indicated. Supply voltage is indicated on the multimeter.

6.6.1 Possible Causes

6.6.1.1 PA Turn-Off Command Given To Transmitter

The PA Turn-Off command will allow the PA Power Supply to energize, but will not allow any of the RF amplifiers to be turned ON to produce power output. To check for a PA Turn-Off command, open the Center Control Compartment door and observe section DS1-9 on the Modulation Encoder. If the transmitter PA Power Supply is energized and DS1-9 is illuminated RED, a PA Turn-Off command is being given to the transmitter. Check the following items for a PA Turn-Off command:

a. PA Turn-Off Switch S2 on Controller set to OFF Position. Check to make sure this is set to the ON (down) position.

b. External PA Turn-Off Circuit Activated

The External Interface allows the use of an External PA Turn-OFF command for customer applications such as Day/Night switching on a Phasor. If this feature is connected, make sure that the device associated with the PA Turn-Off is not at fault. To check, remove the wire connected to the Customer Remote control terminal strip TB1-22.

6.6.1.2 Type 4 or Type 5 Fault

Regulator faults that occur on the Analog to Digital Converter and the Analog Input Board will generate a Type 4 fault and cause a PA Turn-Off command. A Type 5 fault is generated by the Analog to Digital Converter conversion error fault circuit and will also produce a PA Turn-Off command. If any of these fault indicators are illuminated on the ColorStat™ panel, refer to the “Troubleshooting ColorStat™ panel Indicator Faults” paragraph in this section.

6.6.1.3 Power Output Is Set To Zero

No transmitter output power and the PA OFF LED segment DS1-9 on the Modulation Encoder is not illuminated, indicates that the output power has been lowered to zero. Press the RAISE button to see if power begins to rise. If it does, hold the RAISE button until the desired output power is reached. Reset the other power levels to the desired output power. A power reset normally occurs only when the battery backup power supply on the Controller

discharges and the transmitter AC power has been off for over one hour. Replace the batteries and check the +5V “B” supply on the Controller if this is a common occurrence.

If the power is zero and cannot be increased by the RAISE control, investigate the power control circuitry on the Analog Input Board and the Controller. See the specific section for each of these boards for circuit information.

6.7 Symptom: Transmitter is running, but power is lower than normal.

6.7.1 Possible Causes

6.7.1.1 Power Reduction Circuitry Activated

a. ANTENNA LED on the ColorStat™ panel is RED. This indicates a VSWR problem in the load, phasor, combiner or antenna system. Press the RESET button on the ColorStat™ panel. If the LED turns GREEN, press RAISE and set power back to normal. This indicates that the VSWR problem is not active anymore. If the LED will not reset GREEN, the problem is still active and must be investigated. If further testing does not reveal a problem in the RF load that the transmitter is connected to, investigate components in the phase angle detector on the Output Monitor. refer to SECTION H, Output Monitor, for additional information.

b. BANDPASS LED on the ColorStat™ panel is RED, power cannot be raised. This indicates a VSWR problem in the matching network between the power amplifier and output network stage in the transmitter. Likely causes are defective vacuum capacitors. If capacitors in the bandpass circuit are not defective, investigate components in the phase angle detector(s) on the Output Monitor. Refer to SECTION H, Output Monitor, for additional information.

c. No ColorStat™ panel indicators are illuminated RED. Check the Over Temp LED DS2 on the Driver Encoder/Temp Sense Board. If it is RED, the circuitry has initiated a Temperature Induced Lower command to the Controller. Possible causes include transmitter tuning or RF combiner problems resulting in excessive heat sink temperature on PA Modules RF33 and RF34 or defective temperature monitoring circuitry. Refer to SECTION S, Driver Encoder/Temp Sense Board and the transmitter tuning instructions in the initial turn-on paragraphs in SECTION II, INSTALLATION.

6.8 Symptom: Unable to raise power past a certain point. ColorStat™ panel ANT and/or FILTER LED indicate RED.

6.8.1 Possible cause

If the ANT and/or FILTER ColorStat™ panel indicators are Illuminated RED. The VSWR sensor(s) trip and power reduction circuitry is activated. There are two possible causes:

a. The phase angle detector(s) on the Output Monitor are not nulled yet on a new installation or recent antenna system work. Refer to SECTION II, Installation/Initial Turn On, for the phase angle detector null procedure.

b. If detectors are nulled and transmitter has been operating normally for some time, troubleshoot the cause of VSWR problems.

6.9 Symptom: Unable to raise power past a certain point. No ColorStat™ panel indicators Illuminated RED.

6.9.1 Possible cause

6.9.1.1 Analog Input Board maximum power adjustment R27 misadjusted or defective.

Check associated circuitry and monitor at test points TP3, TP1, and TP4. Refer to SECTION J, Analog Input Board, for more detailed information.

6.9.1.2 Analog Input Board, half power step up circuit may have failed.

Check Q7 and Q8 circuitry. Refer to SECTION J, Analog Input Board, for more detailed information.

6.9.1.3 PA Turn on/Turn Off control signals on Modulation Encoder A37 may be incorrect.

If this type of failure is of such magnitude to limit full power output, severe audio distortion should also be noted. Check for the correct number of steps to be turned on by viewing the green LED’s on each of the PA Modules. If LED’s are not illuminated, i.e. steps 1-48, check to see if the control signal is at the appropriate Encoder output. Refer to SECTION L, Modulation Encoders, for additional information.

6.9.1.4 Open fuses on Fuse Boards A24 or A25.

If a fuse has opened, there will be no voltage to a group of eight amplifiers.

6.10 Symptom: Transmitter turns ON (Low, Medium, or High Indicators Illuminate) but will not modulate.

6.10.1 Possible Causes

Because audio is added to a DC voltage relative to the power output level, any problem that would affect the (Audio + DC) signal would also affect the power level. The DC is added to the audio early in the analog input circuitry. If the transmitter power output control functions normally but there is no modulation, the problem is either before the transmitter or is occurring in the first few stages of the Analog Input Board.

6.10.1.1 Modulation not reaching transmitter

Verify that audio is reaching the audio input terminals on the External Interface.

6.10.1.2 Analog Input Board

Only the circuitry associated with Analog Input Board components U6, U9, and U7 would affect modulation but not the power control. Refer to SECTION J, Analog Input Board, for additional information.

6.11 ColorStat™ panel Overcurrent Fault Indication

The Overcurrent Fault monitors the supply current of the PA Power Supply and will generate a TYPE 1 Fault any time the PA current reaches a preset overload level. Both average and peak current are monitored and combined for the Overcurrent Fault.

6.11.1 Random Faults With Program Audio. Possible Causes:

a. OVERMODULATION: Random faults with modulation often indicates that the peak overload current is being exceeded by overmodulation of the transmitter. Check the modulation level with an oscilloscope if the calibration of the modulation monitor is in question.

b. LOW FREQUENCY SIGNALS: If the modulation level is correct, there may be sub-audible signals feeding into the transmitter. Take note of when the overloads occur and try to relate the overloads to a particular source. Turntable rumble, especially during start-up, can be of such level to cause Overcurrent overloads. A switchable high-pass filter in the program line, some audio processors have switchable low frequency cut-off filters, will filter out the sub-audible signals without degrading the ON AIR sound of the transmitter.

c. DC OFFSET: Some audio processors have a DC offset which can shift with modulation, at either a sub-audible or audio rate. This shifting offset voltage will generate carrier shift, and if the "offset" shifts in a positive direction at the same time as positive modulation peak occurs, an Overcurrent overload could occur.

WARNING

ENSURE ALL PRIMARY AC POWER IS REMOVED FROM THE TRANSMITTER AND THAT THE GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL VOLTAGE WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

d. OPEN +230 VDC RECTIFIER FUSE: An open 250 Amp fuse for one of the +230 VDC supply rectifiers can cause excessive power supply ripple which can cause the transmitter to trip off with an Overcurrent overload when modulated with low frequencies. Remove the rear panel to the PA Power Supply and check all rectifier fuses. If an open fuse is detected, check the associated rectifier for a short.

e. OVERLOAD ADJUSTMENT: To check the setting of the Overcurrent overloads, refer to procedures in SECTION V, Maintenance.

CAUTION

DO NOT MAKE ANY ADJUSTMENTS TO THE OVERCURRENT OVERLOAD SETTINGS UNTIL ALL OF THE PRECEDING CHECKS LISTED ABOVE HAVE BEEN PERFORMED. TRANSMITTER DAMAGE COULD OCCUR IF THE OVERCURRENT OVERLOADS ARE IMPROPERLY SET.

6.11.2 Faults With Tone Modulation. Possible Causes:

If the transmitter is being tested with tone modulation it is possible to generate Overcurrent overloads with high level low frequency modulation. Second, many audio test generators will also have a DC offset voltage in their output when they are switched from one frequency range to another; this offset can cause an overload. Third, if the transmitter is turned ON with a high level, low frequency tone at the audio input, overloads may occur due to the surge current produced as the transmitter is ramping up to power with full modulation.

6.11.3 Overloads on Turn On. Possible Causes:

a. OVERMODULATION: If the transmitter indicates an Overcurrent overload on turn on, the most likely cause is low frequency, high level modulation. Lower the modulation level before turning on the transmitter.

b. POWER CONTROL CIRCUIT: A problem in the power control circuit that would release the PA OFF command before the PA Power Supply capacitors had fully charged could cause an Overcurrent overload on turn on. Turn the PA OFF switch to the OFF (up) position on the Controller. If the transmitter turns ON, refer to the turn-on sequence in SECTION P, Controller, and SECTION J, Analog Input Board, for additional information.

WARNING

ENSURE ALL PRIMARY AC POWER IS REMOVED FROM THE TRANSMITTER AND THAT THE GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL VOLTAGE WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

c. PA POWER SUPPLY SHORT: If the transmitter will not turn ON with the PA OFF switch in the OFF position, the problem could be in the PA Power Supply. Isolate the PA Power Supply from the RF amplifiers by removing F1 through F9 on Fuse Board A24, F1 through F8 on A25, and F20 located on T1. Measure the resistance to ground of the PA Power Supply +230 VDC bus bar on the Fuse Boards. The resistance should be approximately 500 Ohms. If it is not, troubleshoot the PA Power Supply Discharge Circuit (crowbar). Refer to the DX-25U Overall Schematic, 839-7855-151, in the Drawing Package for circuit details.

6.12 ColorStat™ panel Overvoltage Fault

The Overvoltage Fault indicates that the PA Power Supply voltage is excessive.

6.12.1 Possible Causes

6.12.1.1 Supply Voltage Too High

NOTE

The PA Power Supply voltage will be at its highest with the PA Power Supply ON and the power output at zero. The supply voltage will be at its highest. The transmitter should not incur an overload in this condition.

If the transmitter has been operating with the proper supply voltage for some time, check to see if the power line voltage has increased for the normal operating voltage. Measure the AC line voltage and tap both the high and low voltage transformers for the correct voltage. If the transmitter will remain ON long enough to measure the PA Supply +VDC on the front panel multimeter, compare this reading to that recorded on the factory Test Data Sheet. If the reading is significantly higher, the PA Power Supply transformer primary tapping must be changed. If the transmitter will not stay on long enough for a measurement, tap the transformer down to obtain the next lowest supply voltage.

NOTE

The highest tap setting for T1 is 485/+4% (502VAC). If line voltage is higher than 505VAC it will be necessary for the utility company to lower the line voltage.

WARNING

ENSURE ALL POWER IS REMOVED FROM TRANSMITTER AND THAT THE GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL VOLTAGE WHERE POWER HAS BEEN APPLIED BEFORE THE TAPS ON THE HIGH VOLTAGE AND/OR LOW VOLTAGE TRANSFORMERS ARE CHANGED.

For example if the supply voltage reading is too high, remove all AC power to the transmitter and retap the PA Power Supply transformer T1 to the next highest primary number. If the transformer is presently tapped to 430/0, change the tapping to 430/+4% to reduce the supply voltage.

6.13 ColorStat™ panel Supply Fault

The PA Power Supply Fault circuit will not allow the transmitter to operate if an imbalance exists in the 3-phase AC input. This will cause excessive heating of the PA Power Supply transformer. If the overload occurs only intermittently, the power supply balance is marginal and is probably faulting on low frequency modulation peaks. If the fault occurs consistently, even without modulation, the problem is more serious and should be attended to immediately.

6.13.1 Possible Causes

6.13.1.1 Input AC 3 Phase Line Imbalance

Measure the 3 phase line voltages. They should be within 5% of each other. If the line voltages are not in balance, the utility company should be contacted to rectify the problem. Note that line imbalance not only affects the transformer heating, but will also degrade the transmitter AM signal-to-noise performance.

WARNING

ENSURE ALL POWER IS REMOVED FROM THE TRANSMITTER AND THAT THE GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL VOLTAGE WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

6.13.1.2 Open +115 VDC Supply Rectifier Fuse

Remove the rear panel of the Driver Compartment and check F13, F14, and F15. If an open fuse is detected, check the associated +115 VDC supply rectifier.

6.13.1.3 Failed PA Power Supply Transformer T1

If the rectifiers check good and the AC line voltage balance is within specifications, the PA Power Supply transformer may have failed windings in one of the sections. It is sometimes possible to compare resistance readings for each primary winding to locate a failed winding

6.13.1.4 Low Frequency, High Level Modulation

The sensing circuit for the Supply overload fault detects the amount of full wave power supply ripple on the +115 VDC supply. This 100Hz/120Hz component will be the greatest when the transmitter is modulated at this audio frequency range. High modulation levels with frequencies from 90-140Hz could be sensed as a fault. This condition should normally not occur if the three phase line voltages are well balanced. If the balance is marginal, then Supply fault overloads could occur.

6.13.1.5 Overload Settings

Refer to SECTION V, Maintenance, for the Power Supply Protection overload adjustment procedure.

CAUTION

DO NOT MAKE ANY ADJUSTMENTS TO THE POWER SUPPLY PROTECTION OVERLOAD SETTINGS UNTIL ALL OF THE PRECEDING CHECKS LISTED ABOVE HAVE BEEN PERFORMED. TRANSMITTER DAMAGE COULD OCCUR IF THE OVERLOADS ARE IMPROPERLY SET.

6.14 ColorStat™ panel Underdrive Fault

NOTE

The transmitter may indicate an UNDERDRIVE overload if a direct short exists in the PA Power Supply. This could be caused by shorted MOSFET transistors in the PA Supply Discharge circuit (crowbar) or a defective shorting switch. The overload indicated could be an UNDERDRIVE fault if the Driver Supplies do not reach their proper voltage. An Underdrive condition could be sensed before an OVERCURRENT overload is detected.

WARNING

ENSURE ALL POWER IS REMOVED FROM THE TRANSMITTER AND THAT THE GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL VOLTAGE WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

6.14.1 Possible Causes

6.14.1.1 High Voltage Supply Short

Remove AC power to the transmitter and remove the Driver Compartment and RF Amp Compartment rear access panels. Isolate the PA Power Supply from the RF amplifiers by removing F1 through F9 on Fuse Board A24, F1 through F8 on A25, and F20 located on T1. Measure the resistance to ground of the PA Power Supply +230 VDC bus bar on the Fuse Boards. The resistance should be approximately 500 Ohms. If it is not, troubleshoot the PA Power Supply Discharge Circuit (crowbar). Refer to the DX-25U Overall Schematic, 839-7855-151, in the Drawing Package for circuit details.

6.14.1.2 Failed Driver Supply (+115 VDC)

Note the PA Supply +VDC reading on the front panel multimeter while pressing the LOW button. If the voltage deflects upward, but the DRIVER +VDC indication on the RF MULTIMETER does not, there is a problem in the driver supply voltage circuit. Check F10 on the Fuse Board A24. Also check F13, F14, F15, and C7, C8, C9. Refer to the DX-25U Overall Schematic in the Drawing Package for circuit details.

6.14.1.3 Failed Predriver Supply (+60 VDC)

Observe the voltage rise in the PREDRIVER +VDC position on the RF MULTIMETER. It should reach approximately 50 Volts within 1 second. If it does not deflect upscale, check F21, C10, L3. Refer to the DX-25U Overall Schematic in the Drawing Package for circuit details.

6.14.1.4 No Drive To The Driver Stage
The Driver Modules require a minimum of 20Vp-p of drive to each module. This drive is generated on the Oscillator, and amplified by the Buffer and Predriver. If any of these stages is inoperative an Underdrive fault will occur. With only the Low Voltage on, the Oscillator, Buffer, and Predriver Indicator LED's should all be GREEN. Depress S1 on the LED Board to turn the Oscillator ON and activate the RF Sense circuits. The Predriver LED should now change to RED until the PA Power Supply is energized. At that time, the Predriver LED will change back to GREEN when all drive levels are normal in all stages. If the Oscillator or Buffer LED's are RED, troubleshoot that particular stage. To measure the RF drive to the Driver Modules, refer to the "Measuring RF Drive" procedure in SECTION V, Maintenance.

6.14.1.5 Driver Module Failure
The transmitter has a gain controlled Driver stage with redundant Driver Modules to maintain drive level if a module fails. If additional modules fail, it may not be possible for the control circuits to keep the drive level within limits. Check for a Driver Module failure by viewing the LED's on each of the Driver Modules. Depress the LOW power button and note if any of the LED's illuminate RED before the transmitter shuts OFF. If any LED's illuminate RED, remove all power from the transmitter and replace or repair the modules. If a spare module is not available, exchange the defective module with a PA Module, starting with RF90.

6.14.1.6 Excessive RF Amplifier Failures
The failure of a large number of PA Modules could load the drive level down enough to cause an Underdrive Overload. To check for this type of failure, observe the PA Module LED's through the interlocked inner doors. Depress the LOW power button and note any LED's that illuminate during the step-start sequence. If more than five LED's are RED on any combination of PA Modules, repair the modules before proceeding with further attempts to troubleshoot an Underdrive problem.

6.14.1.7 Driver Supply Regulator Failure
If the Driver voltage is present, (DRIVER +VDC deflecting towards +110 VDC during the step-start sequence), the Driver Supply regulator can be checked. Operate the RF Multimeter switch to the DRIVER D8A position. Depress the LOW power button. The meter indication should deflect upward before the transmitter shuts back down. If the reading does not deflect upward, the Driver Supply regulator could be defective. Refer to SECTION E for more information on Driver Supply Regulator.

6.14.1.8 Driver Supply Regulator Loop Select
If the Driver Supply Regulator is the problem, it may be possible to get the transmitter operational by switching the regulator loop select switch S1 to the OPEN LOOP position. This switch is set through the cover over the Driver Supply Regulator in the Driver Compartment. If the transmitter will operates, the problem is in the Closed Loop regulator section of the Driver Supply Regulator. The transmitter will operate normally with the loop set in the OPEN position, but it will not have the Automatic gain control feature enabled.

6.14.1.9 Defective Driver Encoder Signals
Check the PA Module control signals from the Driver Encoder/Temp Sensor Board, A19. Most of the GREEN LED's on the Driver Modules should illuminate when the PA Power Supply is energized. Under normal conditions D6 and D7 are held off in reserve capacity depending where S1 and S2 are positioned. Another module in the D5, D9, or D10 position may be factory selected to be off. Refer to SECTION S, Driver Encoder/Temp Sense Board, for additional information.

6.14.1.10 Severe Driver Mistuning
The control circuits will normally compensate for slight tuning problems. If the mistuning is severe the regulator will not be able to keep the drive level in range. To check the Driver stage tuning, refer to "Driver Adjustments" in SECTION V, Maintenance. It is possible for one of the Driver tuning capacitors to have failed and change the tuning. Failed capacitors can sometimes be identified by checking for abnormal temperature after operating for a short time.

6.15 ColorStat™ panel Overdrive Fault

6.15.1 Possible Causes

6.15.1.1 High AC Line Voltage
The RF drive regulation should compensate for most line variations. However, if the AC line increases are greater than the regulation capabilities of the Driver, an OVERDRIVE overload can occur.

6.15.1.2 Defective Driver Encoder Signals
Some of the Driver Amplifiers are selected to be off under normal conditions. If circuitry fails on the Driver Encoder, some or all of these modules could turn on which could create an OVERDRIVE fault. Refer to SECTION S, Driver Encoder/Temp Sense Board, for additional information.

6.15.1.3 RF Amplifier ON/OFF Circuitry
The on/off circuitry on the amplifiers could fail in such a way as to permanently activate the RF amplifier. The most probable cause would be a shorted Q5 or Q6. See SECTION C, RF Amplifier, for more information.

6.15.1.4 Driver Supply Regulator Failure
If the transmitter incurs an Overdrive fault as soon as the PA Power Supply is energized, it is still possible to see if the regulator has a problem before the transmitter turns off. Operate the RF MULTIMETER to the DRIVER D8A position. Monitor the meter reading while depressing the LOW power button and note the meter deflection during the step-start sequence. It will probably deflect near the +115 VDC mark. Now operate the RF MULTIMETER switch to the DRIVER D8B position. Again depress the LOW power button and note the meter deflection. If the meter deflects upward toward the +115 VDC mark, the Driver Supply regulator is turning on both sections due to some

malfunction. Refer to SECTION E, Driver Supply Regulator, for additional information.

6.16 ColorStat™ panel Door Interlock

Refer to SECTION M, DC Regulator, for a simplified diagram of the interlock circuitry. If a Door Interlock fault is indicated check to make sure all doors are securely closed especially where the plunger contacts the interlock switch itself.

6.16.1 Possible Causes

WARNING

ENSURE ALL POWER IS REMOVED FROM TRANSMITTER AND THAT GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL POTENTIAL WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

6.16.1.1 Defective Interlock Switch

If the doors appear to be closing properly, remove all power and ohmmeter each half of each switch for continuity when the switch plunger is depressed.

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6.16.1.3 Bad Connection at DC Regulator

Check the pullup resistors and interconnect wiring between the DC Regulator and the Controller.

6.17 ColorStat™ panel External Interlock

Refer to SECTION M, DC Regulator, for a simplified interlock diagram.

6.17.1 Possible Causes

6.17.1.1 External Interlock Terminals Open

If the external interlock feature was not utilized, a jumper should be connected between TB1-1 and TB1-2. Ensure that the jumper wire is properly connected. If a device requiring an external interlock is connected to these terminals, (Phasor door interlock, dummy load, etc.) make sure that this device is providing closed contacts in the normal operating condition.

6.17.1.2 External Interlock Fuse F24

The external interlock terminals TB1-1 and TB1-2 are protected by fuse F6 in the Center Control Compartment. Check the fuse and replace if open. Make sure that there are no shorts on the External interlock line.

6.17.1.3 External Interlock Relay K3

If F6 is good and the external interlock connections are closed, verify that K3 is energized when the low voltage is on and the external interlock is closed. If it is not, suspect an open coil of K3.

6.17.1.4 DC Regulator Components

Check the components and interconnect wiring on the DC Regulator.

6.18 ColorStat™ panel Air Interlock

Air interlock problems will be either intermittent, as could occur if an air filter becomes blocked, or constant, as during a two or more fan failures.

6.18.1 Possible causes

6.18.1.1 Fans Not Operating Properly, Failed/Running Backward

The transmitter will turn ON for approximately 20 seconds with NO air flow. Press the LOW power button and open the Center Control Compartment door. A steady stream of air should be felt coming from the holes in the interlocked inner door. If there is little or no air flow, verify that the fans are operating in the proper direction by placing a piece of paper on any of the filters. If the fan rotation is correct, the paper will stick to the filter.

If the fan rotation is incorrect, refer to the fan rotation check in SECTION II, Installation/Initial Turn-On.

6.18.1.2 Dirty Filters

Temporarily remove the air filters from the rear panel of the Output Network Compartment. If the transmitter now operates with the filters removed, clean or replace the filters.

6.18.1.3 Top Air Exhaust Restricted

If air is exhausted through air duct installed on the top of the transmitter, a restriction can generate an Air Interlock. If an exhaust restriction is suspected, operate the transmitter with the Driver Compartment door open. Because the exhaust is no longer going through the top, the transmitter should not incur an Air interlock.

6.18.1.4 Rear Access Panel Open

The air system will not operate correctly with any rear access panel open or partially open, due to the loss of air pressure in the Driver Compartment.

6.18.1.5 Air Interlock Sensing Circuitry

The Air interlock sensing circuitry consists of U12, U13, U10 on the LED Board. Measure the DC voltage at J5-1 on the LED Board. Depress the LOW power on button. If the voltage at this point goes to approximately +5 VDC and does not go LOW before the transmitter turns OFF, then the air interlock switch is operating and the LED Board circuitry is suspect. Refer to SECTION Q, LED Board, for additional information.

6.18.1.6 Air Interlock Detector U17

If the logic LOW does not appear at J5-1 on the LED Board, and all the above checks have been made, then the air interlock detector U17 on the Driver Encoder/Temp Sense Board or connecting circuitry is suspect. Refer to SECTION S, Driver Encoder/Temp Sense Board for additional information.

6.19 ColorStat™ panel Oscillator Fault

NOTE

Use S1 on the LED Board while troubleshooting.

If the transmitter is incurring Underdrive faults, and the Oscillator ColorStat™ panel LED is illuminated RED, the Oscillator output is not sufficient. Refer to SECTION A, Oscillator, for additional information.

6.20 ColorStat™ panel Buffer Fault

If the transmitter is incurring Underdrive faults, and the ColorStat™ panel Buffer LED is illuminated RED, the Buffer Amplifier output is not sufficient. Refer to SECTION B, Buffer Amplifier, for additional information.

6.21 ColorStat™ panel Predriver Fault

If the transmitter is incurring Underdrive faults, and the Predriver ColorStat™ panel LED is illuminated RED during PA Supply turn on, the Predriver output is not sufficient. Refer to SECTION C, RF Amplifier, and SECTION D, Driver Combiner/Motherboard, for additional information.

6.22 ColorStat™ panel RF Amp Fault

The function of the RF AMP fault indicator is to alert the operator that an RF amplifier has a blown fuse. This normally indicates shorted MOSFET transistors on the PA Module. This circuit only illuminates the RED LED on the ColorStat™ panel and triggers a remote output if connected. The transmitter will continue to operate normally, with slightly reduced power and/or slightly increased distortion, depending on which amplifier has failed.

In brief, this circuit mimics the RF amplifier blown fuse indicators on each PA Module. The LED will illuminate RED at a steady state or flash to the modulation or program level depending on which step has a blown fuse.

NOTE

Whenever all fuses on A24 and A25 are removed, the RF Amp Fault will illuminate whenever the PA Power Supply is energized or P1 on the DC Regulator is in the TEST position. This is normal.

6.23 ColorStat™ panel Analog Input Board: +15V and -15V Supply Faults

If either the +15V or -15V Fault LED's on the ColorStat™ panel are RED, this indicates that the supply has failed. The transmitter will generate a PA Turn-Off command and no power will be produced. With the low voltage on, measure the voltage at both ends of F2 on the Analog Input Board and verify that it is approximately +22 VDC. Measure the voltage on both sides of F3 and verify that it is -22 VDC. If one fuse has failed, replace the fuse and try again. If the fuse fails again, troubleshoot the regulator circuit. Refer to SECTION J, Analog Input Board, and SECTION M, DC Regulator, for additional information.

NOTE

It is sometimes possible for the regulator circuit to lock into a fault condition if the output is accidentally shorted. If this occurs, turn off the Low Voltage at CB1 and CB2 for approximately 1 minute to allow the power supply to discharge. Reapply Low Voltage and note if the regulator is now reset.

6.24 ColorStat™ panel Analog to Digital Converter

6.24.1 +15V, -15V, and +5V Supply Faults

If any of the Analog to Digital Converter LED's (+15V, -15V, or +5V) are RED on the ColorStat™ panel, this indicates that the Supply has failed. The transmitter will generate a PA Turn-Off command so no power output will be produced. With the Low Voltage on, measure the voltage on both sides of F1 on the Analog to Digital Converter and verify that it is approximately +22 VDC. Measure the voltage on both sides of F2 and verity that it is approximately -22 VDC. Measure the voltage on both sides of F4 and verify that it is approximately +8 VDC. If a fuse has failed, replace the fuse and try again. If the fuse fails again, troubleshoot the regulator circuit. Refer to SECTION K, Analog to Digital Converter, and SECTION M, DC Regulator, for additional information.

NOTE

It is sometimes possible for the regulator circuit to lock into a fault condition if the output is accidentally shorted. If this occurs, turn off the Low Voltage at CB1 and CB2 for approximately 1 minute to allow the power supply to discharge. Reapply Low Voltage and note if the regulator is now reset.

6.24.2 Conversion Error Fault

The Analog to Digital Converter requires a sample of the RF drive to develop the sample frequency for the A/D convertor IC. If this sample is missing or there is a fault in the analog to digital conversion process, the Conversion Error LED on the ColorStat™ panel will illuminate RED and circuitry on the Analog to Digital Converter will generate a PA Turn-OFF command. The PA Power Supply will remain energized but no RF output will be produced. Refer to SECTION K, Analog to Digital Converter, for additional information.

6.25 ColorStat™ panel Modulation Encoder: Cable Interlock Fault

A Cable interlock will prevent a transmitter turn on command from being generated. The step-start sequence will not begin and the PA Power Supply will not energize. This prevents possible damage to combiner toroids and RF amplifiers if cables are removed or amplifiers are not installed in place on the Combiner/Motherboards. The cable Interlock feature is accomplished through the individual Modulation Encoder and DC Regulator cables. If the transmitter will not turn on and the Cable Interlock LED is RED, check the following. Refer to SECTION

WARNING: Disconnect primary power prior to servicing.

L, Modulation Encoder, for additional information and circuit description to help facilitate troubleshooting an interlock problem.

NOTE

Place P1 on the DC Regulator in the TEST position and use the DS1 Bar Graph LED's on each Modulation Encoder to help locate the interlock fault. Refer to the Cable Interlock chart on sheet 4 of the Modulation Encoder schematic, 839-7855-134, in the Drawing Package. After troubleshooting has been completed, place P1 in the NORMAL position.

6.25.1 Possible Causes

6.25.1.1 RF Amplifier Module Not In Place

Refer to the DS1 Bar Graph LED display on each Modulation Encoder to isolate a fault to a group of eight PA Modules. Remove all AC primary power and open the inner front door exposing the RF amplifiers. Make sure all PA Modules are seated properly. Some resistance is normal when inserting and removing Amps. If all modules are seated, swap one module at a time with a known good module to isolate the problem to a particular module. It is possible for a shorted diode on the module to cause a false Cable Interlock indication.

6.25.1.2 Modulation Encoder Cable Not In Place

Locate the Modulation Encoder ribbon cables on the right side of the Modulation Encoder. Make sure all are seated properly with the black “ears” fitting over the connector. Remove all AC primary power and open the inner front door exposing the RF amplifiers. The Modulation Encoder ribbon cables connect to the Combiner/Motherboards with the same type connectors on the side of the motherboards facing the front of the transmitter. The appropriate RF amplifier must be removed to allow access to the ribbon connectors. Check each of these connectors for proper seating.

6.26 ColorStat™ panel DC Regulator B+ and B- Supply Faults

If either the DC Regulator B+ or B- Fault LED's are RED, this indicates that the supply has failed or a cable is not properly seated on the board. Refer to SECTION M, DC Regulator, for additional information.

NOTE

It is sometimes possible for the regulator circuit to lock into a fault condition if the output of the regulator is accidentally shorted. If this occurs, turn off the Low Voltage supply at CB1 and CB2 for approximately 1 minute to allow the power supply to discharge. Reapply Low Voltage and note if the regulator is now reset.

6.27 ColorStat™ panel Output Monitor Faults

6.27.1 +5V and -5V Supply Faults

If either of the Output Monitor +5V or -5V Fault LED's on the ColorStat™ panel are RED, this indicates that the supply has failed. The transmitter will turn OFF and will not be able to be turned ON until the fault is cleared. With the Low Voltage on, measure the voltage on both sides of F1 on the DC Regulator and verify that it is approximately +8 VDC. Measure the voltage on both sides of F2 and verify that it is approximately -8 VDC. If a fuse is open, replace the fuse and try again. If the fuse fails again, troubleshoot the regulator circuit. Refer to SECTION H, Output Monitor, and SECTION M, DC Regulator, for additional information.

NOTE

It is sometimes possible for the regulator circuit to lock into a fault condition if the output of the regulator is accidentally shorted. If this occurs, turn off the Low Voltage supply at CB1 and CB2 for approximately 1 minute to allow the power supply to discharge. Turn the Low Voltage back on and note if the regulator is now reset.

6.27.2 VSWR Faults

6.27.2.1 General Discussion Of VSWR Protection of the Transmitter

A discussion of VSWR protection is included here to aid the station technical and engineering staff in determining when VSWR overloads may indicate a problem that should be located and corrected. The VSWR protection built into the transmitter is both for the protection of the transmitter and the protection of external equipment which might be installed between the transmitter and the antenna system. Operating at high power with a VSWR condition can result in high voltages or currents that can result in arcing, overheating of components, or component failure. The VSWR overloads and limits set in the transmitter protection circuitry should not be bypassed or increased beyond the recommended limits set at the factory.

CAUTION

VSWR OVERLOAD LIMIT SETTINGS THAT EXCEED RECOMMENDED VALUES MAY RESULT IN COMPONENT DAMAGE OR FAILURE.

The transmitter uses two nearly identical circuits to generate a VSWR fault from two different locations. The Antenna VSWR monitors the output load of the transmitter. The Bandpass Filter VSWR circuit detects a VSWR that occurs anywhere in the transmitter output network and combiner. Should any output network part fail, the transmitter will be protected.

The Bandpass Filter VSWR circuit will also sense any antenna load changes, but its sensitivity is set lower. An antenna VSWR will be detected by the Antenna VSWR circuit first and then by the Bandpass Filter VSWR circuit.

The first step in VSWR protection is to try to clear the fault. Most VSWR faults can be cleared by reducing the transmitter power output to zero for a brief period of time. This zero power output is accomplished by turning all PA Modules OFF through modulator action. This occurs in less than 20 milliseconds and may not be noticed by listeners, or will be noticed as a slight “click” or “pop.” If a VSWR fault cannot be cleared by turning the PA Modules OFF for a short period several times, the transmitter will reduce power.

6.27.2.1.1 First Stage VSWR Protection

a. SYMPTOM: VSWR LED flashes RED, carrier level pauses at half-power and then returns to normal power; a slight “Pop or Click” is heard on the air.
b. ACTION: This is the first step in the VSWR protection. The VSWR detectors act in less than a millisecond to detect a VSWR fault and turn off the transmitter RF output for approximately 20 milliseconds or less. The VSWR status indicator flashes RED for approximately one-half second, then returns to GREEN. If the VSWR condition is no longer present, no additional action will occur. The VSWR LED will not stay RED since this is not a serious type of VSWR condition. These types of VSWR actions can occur indefinitely, as long as they do not occur for a consistent period of longer than one second.

6.27.2.1.2 Second Stage VSWR Protection

a. SYMPTOM: The VSWR LED latches RED, the LOWER button illuminates and the PA Current and Power meters read low. Within 10 to 30 seconds, the LOWER indicator extinguishes and the power output and PA Current stay at a lower than normal power level.
b. ACTION: The VSWR sensor has detected a serious VSWR problem. The first stage of VSWR protection was attempted, but the fault existed for more than 1 second of continuous recycling. A LOWER command was given to the transmitter to fold back the power to a level at which the transmitter could still operate. The power level will remain there until given a RAISE command. If the fault still exists the transmitter will again LOWER the power and disregard the RAISE command. In this case, the source of the VSWR fault must be repaired before full power operation can continue.

6.27.2.2 Antenna VSWR Fault

6.27.2.2.1 Possible Causes of VSWR Overloads

VSWR overloads during stormy weather may occur normally, and may be no cause for concern. Proper installation of static drain and static discharge equipment in the antenna system can minimize, but not eliminate, this problem.

Causes of VSWR overloads may be listed in three categories. They will first be listed, then will be discussed in more detail in the following paragraphs.

a. ARCING in the impedance matching network, phasor, switching equipment, transmission line, tuning equipment, or at the tower ball gaps. Once an arc occurs, transmitter output power would sustain the arc. When the transmitter power output is removed, the arc will go out (unless there is some other voltage source to keep it going).
b. TRANSIENTS, or other signal pickup, fed back into the transmitter output from the antenna system.
c. COMPONENT FAILURES causing a change in load impedance at the transmitter output connector.

6.27.2.2.2 Possible Causes of Arcing

Common causes of arcing include:

a. Defective vacuum capacitors. VSWR overloads will probably occur at a certain power level or under modulation.
b. Static discharge or discharge due to lightning, across ball gaps, guy wire insulators, or possibly across components already operating close to their voltage ratings. Static charge buildup can occur on towers that do not have provision made for static discharge, such as static drain chokes. Charge buildup can also occur on insulated guy wire segments. Static charge buildup can occur before, during or after rain, snow, or even blowing dust or sand.
c. Dirt build up or moisture (including condensation) on insulating surfaces, causing the voltage breakdown rating to be reduced. VSWR overloads will probably occur on modulation peaks.
d. Condensation inside a transmission line may cause reduced breakdown voltage of the line. This can occur if pressurized gas filled lines lose pressure or if the dehydrator in the line pressurization unit fails. VSWR overloads will probably occur on modulation peaks.
e. In new systems, insufficient voltage rating of components, such as capacitors or insulators, or spark gaps that are set too close.

6.27.2.2.3 Possible Causes of Transient Signals

TRANSIENT signal pickup may occur during thunderstorms, even from distant lightning strokes in some cases. Lightning strikes may induce currents in towers, causing currents on the transmission lines that can reach the phase detectors and give a VSWR overload indication.

Other station signals can also induce voltages and currents in antenna systems that are large enough to be detected by the phase detector and cause VSWR overloads. The solution in such cases may be a trap or filter in the antenna impedance matching network or phasor.

6.27.2.2.4 Load Impedance Changes

The Reflected Power reading and DETECTOR NULL (Antenna) reading on the front panel multimeter are the best indications of the antenna operating impedance, once the system is initially tuned into the antenna. An impedance change in the transmitter load will change the DETECTOR NULL (Antenna) indication and, to a lesser extent, the reflected power. The load impedance should be checked with proper impedance measuring equipment and corrected if possible.

“Dummy loads” should also be treated with caution. Dummy load resistance or impedance may change with time, and dummy load resistance or impedance may also change as the load heats up when power is applied. If reflected power changes after power has been applied to the load, this is probably the cause.

6.27.2.3 Bandpass Filter VSWR Fault

6.27.2.3.1 Bandpass Filter VSWR Caused By Problems In The Output Network

If a problem occurs in the output network of the transmitter due to a component failure, the Bandpass Filter VSWR circuit will protect the transmitter until the component can be replaced.

a. Do NOT attempt to further raise Power.

b. Do NOT change Tuning or Loading controls

NOTE

During normal operation if a short term VSWR occurs, such as that caused by lighting or static discharge on the antenna system, both the Antenna and Bandpass filter indicators may flash. The antenna VSWR circuit is set to trip slightly before the Bandpass filter circuit. If only the Bandpass Filter indicator flashes, this indicates a problem in the output network.

6.28 Symptom: Loss Of Positive Peak Capability

6.28.1 Possible Causes

6.28.1.1 Power Supply Voltage Low

If the supply voltage for the RF amplifiers is lower than normal, the positive peak capability will be reduced. Nominal PA Supply +VDC should be between +225 and +235 VDC at 60 kW output power. If the voltage is not close to the factory test data sheet, the PA Power Supply transformer T1 must be retapped. Refer to SECTION II, Installation, for information on selecting the proper transformer taps.

6.28.1.2 Audio Processor Equipment Defective or Incorrectly Set

Many problems with positive peaks are due to defective or incorrectly setup processing equipment. Check the manual for that particular piece of equipment for setup and service information.

6.28.1.3 Incorrect Transmitter Tuning

If the transmitter Loading and Tuning controls have not been set properly or a change in the antenna impedance has occurred, positive peaks can be affected. Refer to the initial turn on procedure in SECTION II, Installation, for Tuning and Loading adjustment procedure.

6.28.1.4 Transmitter Operated In FlexPatch™ Mode

If several PA Modules failed and other modules were substituted using the FlexPatch™ feature, then the transmitter will have a slightly reduced positive peak capability. The defective PA Modules must be replaced and the transmitter returned to its normal operating configuration before full positive peak capability will return.

6.28.1.5 Failed RF Amplifier

If an RF amplifier fails, the positive peak capability of the transmitter will decrease. The power output will also decrease if one of the first 23 PA Modules fail. Check the RF amplifier fault LED’s to see if any are illuminated.

6.29 Symptom: Higher Than Normal Audio Distortion

6.29.1 Possible Causes

6.29.1.1 Failed RF Amplifier(s)

If audible distortion is heard on the air and the problem is not in the program content or audio processing equipment, the next step is to determine if an RF amplifier has failed. If any RF amplifier module between position RF33 to RF56 fails, the carrier power will decrease. The failure of a higher step will not be noticed as a drop in power. The audio distortion will also be slightly higher but may not be noticeable with only one RF amplifier failed. If an amplifier has failed, a substitute may be used by the FlexPatch™ method. Refer to the FlexPatch™ procedure in this section.

6.29.1.2 Transmitter Mistuning

The transmitter will tune into a wide range of loads and still produce very good audio performance. Refer to the initial turn on procedure in SECTION II, Installation, for Tuning and Loading procedures

6.29.1.3 Operating Into a Bandwidth Restricted Antenna

If the Distortion is poor, especially at the higher audio frequencies, then the antenna impedance at the sideband frequencies may be incorrect. Operate the transmitter into a known good dummy load. If the high frequency distortion improves, suspect the antenna system.

6.29.1.4 Low RF Drive Level To The PA Modules

Low RF drive levels can cause higher than normal distortion. Typically, the RF drive to the PA Modules should be between 20 and 25 Vp-p. Refer to this section for information on measuring RF drive levels.

6.29.1.5 Additional Tips For Troubleshooting Audio THD

If the distortion problem cannot be found using the above means, an excellent way to determine if the distortion is in the Analog Input or the analog to digital conversion process OR the digital to analog conversion process in the Power Amplifier or Output Network stage, is to measure the distortion out of the Digital to Analog convertor circuit on the Analog to Digital Converter. This sample is an actual reconstructed audio sample from the Analog to Digital Converter. If any distortion is occurring in the Analog Input Board, or in the Analog to Digital conversion process, it will show up here. Connect a scope or a distortion analyzer to J2 on the Analog to Digital Converter. If the distortion is present here, troubleshoot the audio source, Analog Input Board, or the Analog to Digital Converter. If the distortion is not present, the distortion is occurring in the D to A process and could be in the Modulation Encoder, RF amplifiers, or output Network.

6.30 Symptom: Consistent Loss of RF Amplifiers

Any type of consistent or repeated failure indicates a problem on the RF amplifier or in the location in the transmitter.

The most common method of troubleshooting an RF amplifier after a failure is to put the repaired amplifier in a known working step, and to put the working amplifier where the failure first occurred. This will tell whether the amplifier fault was caused by the position it was in or by the amplifier itself.

6.30.1 Repeated Loss of Same RF Amplifier In Any Position

6.30.1.1 Possible Causes

6.30.1.1.1 Defective Transistor Pad

A torn or damaged MOSFET insulator pad can short the transistor. Check for debris lodged in the pad or sharp burr or high spot on heat sink.

6.30.1.1.2 Defective Turn On/Turn Off Circuitry

Check all low level circuitry on the RF amplifier for defective components. If only one side of amplifier fails, then concentrate on that circuitry. If nothing significant is found, check the drive phasing with the amplifier fuses removed. Refer to “Measuring Drive Phasing,” in this section.

6.30.1.1.3 Improper RF Drive

Refer to the “Measuring RF Drive Level” procedure in this section. If RF drive is not correct and the transistors are not defective, suspect RF drive transformers T1 and/or T2 and gate protection transorbs.

6.30.1.1.4 Poor Solder Connection on PC Board

Inspect all solder connections, especially the drive transformer loads of T1 and/or T2.

6.30.2 Consistent Loss Of An RF Amplifier In One Particular Position

6.30.2.1 Possible Causes

6.30.2.1.1 Improper RF Drive

The RF drive to the PA Modules must be between 20 and 25Vp-p for proper operation. The phase of the drive must also be within five degrees of the other modules. Refer to the paragraphs in this section on “Measuring RF Drive Level,” and “Measuring RF Drain Phasing” for drive amplitude and phase measurement procedures. Causes of improper drive amplitude and phasing are defective RF amplifier transistors, defective RF drive cable, or poor motherboard connections.

6.30.2.1.2 Improper Drain Phasing

Just as the RF drive must be within five degrees of the other modules, the phase of the drain switching waveforms of the RF amplifier MOSFET’s must also be in phase within five degrees. Even if the RF drive is correct, other problems can cause the drain phasing to be out of tolerance. To measure the drain phasing, refer to the paragraphs in this section on “Measuring RF Amp Drain Phasing.” Causes of improper drain phasing are a poor connection or wrong tapping of the efficiency coil for the RF amplifier, incorrect MOSFET transistors, or a defective RF amplifier output toroid. An RF amplifier that fails from phasing problems will operate for a short time before failure. During this condition, the module will operate hotter than the other modules. This is a good indication of a module operating out of phase.

6.30.2.1.3 Defective Output Toroid

The output toroid for each RF amplifier must couple the RF output to the combiner. If the toroid is defective, the amplifier will not operate efficiently and fail. Check the toroid for cracks or signs of arcing. Some inspection can be done through the holes in the combiner cover, but a more through inspection requires removal of the combiner cover. Refer to the Main Combiner/Motherboard replacement paragraphs in SECTION V, Maintenance.

6.30.2.1.4 Improper Control Signal

The Turn-on/Turn-off control signals from the Modulation Encoder should be at consistent levels for all steps. Check the Encoder outputs to compare these signals.

6.30.3 Consistent Loss Of Modules In Random Positions

6.30.3.1 Possible Causes

6.30.3.1.1 Analog to Digital Phasing Improperly Set

An improperly set analog to digital phasing circuit will cause random failures of RF amplifiers especially at the higher steps. See paragraphs on “Analog to Digital Phasing Check” in SECTION V, Maintenance.

6.30.3.1.2 Modulated B- Improperly Set

An improperly set Modulated B- can cause random RF amplifier failures. See paragraph on “Overall Modulated B- Adjustment” in SECTION V, Maintenance.

6.30.3.1.3 Improper VSWR Circuit Operation

If the VSWR protection circuit, including the Oscillator Sync circuit, in not set properly, random failures RF amplifiers could occur during VSWR conditions. To test the VSWR circuitry, depress the ColorStat™ panel VSWR SENSOR Manual Test Button. At that time both the Bandpass Filter and Antenna VSWR LED’s should momentarily illuminate RED, then return GREEN. Refer to the paragraphs on “Output Monitor” and “Oscillator Sync” adjustments in SECTION V, Maintenance.

6.30.3.1.4 Improper Overload Settings

If an overload is improperly set or not working, the RF amplifiers could fail during an overload condition. Refer to the “Overload Adjustment Procedures” in SECTION V, Maintenance.

6.30.3.1.5 Improper Air Flow

Insufficient air flow should be detected by the Air interlock circuitry and should shut the transmitter OFF. If the circuit is defective or defeated, overheating modules could cause premature failures. Refer to SECTION V, Maintenance, for air circuit adjustment procedures.

6.30.3.1.6 Transmitter Mistuning

Transmitter mistuning could cause the Power Amplifier stage to be inefficient and cause modules to run hotter. Refer to the transmitter tuning procedure in SECTION II, Installation/Initial turn on, for additional information.

6.31 Other Troubleshooting Techniques

6.31.1 Handling MOSFET's

Due to the fragile nature of the gate of a MOSFET, special care in their handling is required. The gate junction may be destroyed if static electricity is allowed to discharge through the MOSFET. For example, a static charge could build up on a person as they walk across a carpet and discharge across the MOSFET if it is not protected by antistatic packaging.

NOTE

MOSFET transistors which are in circuit are immune to this damage.

The MOSFET transistors are shipped in antistatic packaging. The transistors should remain in this packaging until they are to be used or tested. Proper precautions should be observed to ground any potential static charge before handling the MOSFETS.

6.31.2 Testing MOSFET's

The MOSFET's will have to be removed from the circuit in order to perform the following test.

Observe the precautions in the paragraph entitled "Handling MOSFET'S" in this section.

The MOSFET's used in the DX-25U transmitter may be checked with an ohmmeter. However, there is a requirement which restricts the use of some ohmmeters. If the battery voltage is too low (under 3V) or too high (over 20V) the ohmmeter cannot be used. A battery voltage less than 3V will not give an operational check of the transistor and a battery voltage greater than 20V may result in damage to the transistor under test. A Simpson 260, which uses a 9V battery on the Rx10K scale works quite well.

This test will show how a MOSFET can be switched "ON" and "OFF" by charging and discharging the gate of the MOSFET.

Connect the positive lead of the ohmmeter to the drain or case of the transistor. Connect the negative lead to source. Alternately touch a jumper from gate to source and then from gate to drain. The ohmmeter should read towards infinity or at least 2 megOhms when the MOSFET is switched "OFF" and less than 90k Ohms when the MOSFET is switched "ON." When doing this test, lay the MOSFET on a flat surface or hold sides of the case. The resistance of your finger tips and skin will effect the readings when you touch the leads.

6.31.3 Finding A Missing Step

It is possible to have a failed PA Module without the Fault LED being illuminated. It should be possible to see this problem on the detected audio waveform. If a "Big Step" PA Module is not operating properly, an error in the demodulated audio waveform will be present as seen in Figure 6-1. This kind of error is apparent only with triangle (linear ramp) tone modulation. If a PA Module failure is suspected, operate the transmitter at 30 kW at full modulation. Display the demodulated audio output of a modulation monitor on a dual trace scope. If a big step amplifier is not working, an error will be noticeable on the display. To determine which amplifier is at fault, connect the second channel of the scope to a probe and look at the output of the Modulation Encoder for each big step until the transition from 0 to 5VDC occurs at the same point in time as the error on the wave form. See Figure 6-1.

Because there are 58 "Big Steps", it helps to know where to start to look on the modulation encoder. A good rule is that the higher the positive peak level where the error occurs, the higher the step number. A 100% modulated signal at 30 kW is NOT using all the big steps — steps RF48 through RF58 are only ON during positive peaks. To check these steps, a non-symmetrical audio waveform should be used in order to modulate the transmitter with a steady state tone at 125% positive peak without causing overmodulation, and carrier shift, on the negative peaks.

Figure 6-2 shows a non-symmetrical ramp modulating to 125% positive peak and only 50% negative peak. An error is also shown near the top of the positive peak indicating a big step failure at approximately "Big Step" RF55. The Modulation Encoder waveform is also shown for that step. Once the step causing the error is located, the PA Module can be changed. If substituting the PA Module does not remove the error, then the problem may exist on the Modulation Encoder.

6.31.4 Using FlexPatch™ for Bypassing a Failed PA Module

FlexPatch™ is a Harris feature to allow the engineer to patch a failed RF amplifier from an active step position, such as step RF6, to a step position that is only used for positive peak modulation, such as step RF90. Module RF90 will now operate as module RF6. This patching is done at a "TTL" level basis and can be done while the transmitter is on the air.

Because approximately 47 RF amplifiers are used to create 50 kW carrier, a failed module in the RF6 position will result in a power output drop of approximately 2% and a slight THD increase. The transmitter will operate with no other problems in this condition. However, FlexPatch™ will allow the transmitter to resume operation at full power and optimum modulation clarity with only a slight loss of positive peak capability.

Refer to Figure 6-8 for the following procedure. To use the FlexPatch™ feature to bypass a failed PA Module:

a. On the Modulation Encoder controlling the failed RF amplifier, locate and remove the gold jumper for the failed RF amplifier to be patched.

b. Locate and remove the gold jumper for step RF90 on Modulation Encoder A37. Step RF90 is selected because it would only be ON during the highest positive peaks.

c. Locate and remove one of the FlexPatch™ jumpers and connect one end to the OUTPUT signal side from where the jumper plug was removed for the failed amplifier.

d. Insert the free end of the FlexPatch™ cable into the INPUT signal side from where the jumper plug was removed for step RF90.

CAUTION

WHEN USING FlexPatch™ WITH THE TRANSMITTER OPERATING, MAKE SURE THE FlexPatch™ CABLE IS INSERTED FIRST INTO THE INPUT JACK OF THE MODULE TO BE SUBSTITUTED. THEN INSERT IT INTO THE JACK OF THE STEP 90 AMP. THIS WILL PREVENT INADVERTENT TURN-ON AND POSSIBLE FAILURE OF THE RF AMPLIFIER SHOULD THE FlexPatch™ JUMPER INADVERTENTLY TOUCH ANOTHER COMPONENT ON THE MODULATION ENCODER.

If additional RF amplifiers need to be substituted, the next lowest “Big Step” is selected. Example: Three FlexPatch™ substitutions would use steps RF90, RF89, and RF88 as the substitute amps.

6.31.5 Using FlexPatch™ for Isolating Modulation Encoder/RF Amplifier Problems

The FlexPatch™ feature can also be useful in determining where a fault exists if the fault is not made apparent by an illuminated LED on an RF amplifier. For example during troubleshooting higher than normal distortion, it is discovered that on the demodulated audio signal, a missing step is noted at Step 6. See paragraph entitled “Finding A Missing Step.” The LED on the Step 6 RF amplifier is not illuminated, indicating that it is at fault. The next step is to physically exchange it with a spare module. If this does not fix the problem and the fault still exists at Step 6, the gold jumpers are now removed from the Modulation Encoder for Step 5 and Step 6. Jumper the left hand side (Encoder output) of the step 6 jack to the right hand side (rf amplifier input) of the step 5 jack. Connect the step 5 encoder output (left) to the step 6 RF amplifier input jack (right). Refer to the Modulation Encoder schematic. Note on the schematic that the RF amplifier input side of the FlexPatch™ jacks does go through some driver circuitry on the Modulation Encoder. After performing this patching, it is noted that the error on the envelope now occurs at the Step 5 interval and not Step 6. This indicates that the modulation encoder drive signal for Step 5 that is now going to the Step 6 RF amplifier through the Modulation Encoder drive circuitry, is not operating. This says that the Modulation Encoder drive circuitry for Step 6 has failed. The most likely suspect is U5-4.

In conclusion, by using the Modulation Encoder schematic, with careful thought, it is possible to troubleshoot the circuitry further with FlexPatch™ before attempting time consuming substitutions or circuit measurements.

6.31.6 Measuring Drive Level

This procedure is used to measure the RF drive levels to the PA Modules. This should be done if problems are suspected to be caused by improper drive level.

WARNING

ENSURE ALL AC PRIMARY POWER IS REMOVED FROM TRANSMITTER AND THAT THE GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL POTENTIAL WHERE POWER HAS BEEN APPLIED BEFORE PERFORMING THE FOLLOWING STEPS.

a. Remove all primary AC power from the transmitter. Remove the rear access panel from the RF Amp Compartment and remove fuses F1 through F9 on the A24 Fuse Board, F1 through F8 on the A25 Fuse Board and F20 on transformer T1.

b. Locate RF amplifier RF33 (bottom left RF amplifier). Use a 10x scope probe with an extended tip, Harris part #610-1131-000, and connect it to the anode of CR3 through the interlocked inner door. Connect the ground clip of the probe to the interlocked door.

c. Reapply primary AC power and turn the Low Voltage on with CB1 and CB2. Depress the LOW power button and note that the PA Power Supply energizes, as indicated on the front panel multimeter, but no RF power or PA current is indicated.

d. With the scope DC coupled, note that an RF sine wave is now displayed on the scope. The waveform should normally measure from 21 to 24 Vp-p and should be centered on the 0.0VDC line of the scope. The drive level may be lower than 20Vp-p at this time. If the waveform falls totally below the 0.0VDC line of the scope, the amplifier is turned OFF. See Figures 6-4 and 6-5 for drive waveforms.

NOTE

When measuring RF amplifier drive amplitudes or phasing, the amplifier to be measured must be turned “ON” to give a correct drive measurement. The drive waveform of an “OFF” amplifier will be below 0.0VDC and the peaks will probably be clipped. Place P1 on the Analog Input Board in the TEST position and depress the RAISE button until all PA Modules are “ON”.

e. Now that a measurement of the RF drive to RF33 has been made, the RF drive of any other RF amplifier that needs to be measured can be performed by repeating the above steps. Remember that the anode of CR3 is the RF drive on the “A” side of the amplifier and the anode of CR4 is the RF drive to the “B” side of the amplifier. Refer to SECTION V, Maintenance, for additional information on RF drive characteristics.

6.31.7 Measuring Drive Phasing

This procedure is used to measure the RF drive phase on the RF amplifiers. This should be done any time the frequency is changed or any time problems caused by improper RF drive phasing are suspected. There are two sections on each RF amplifier and each section has an individual drive signal. For proper transmitter operation, the drive phasing on the RF amplifiers should be within +/-5 degrees. Measure the RF drive phasing with all amplifiers ON as in “Measuring RF Drive Level.”

a. Set the oscilloscope to DC coupled, 5 Volts per division, and the trace at the center of the screen.

b. Set the oscilloscope sync to “external” and connect the input to J5 on the Oscillator.
c. Adjust the horizontal vernier on the scope so that one full RF cycle occupies 9 divisions on the screen. Each division now equals 40 degrees of phase shift.
d. Using the Horizontal positioning and triggering level on the scope, place the zero crossing of the waveform on the center crossing of the vertical and horizontal lines of the scope.
e. Increase the vertical sensitivity of the scope to expand the waveform. Switch the scope to the X10 position and readjust the horizontal position so that the RF transition again crosses the center line of the scope. This will be the reference for the phase measurements. If another RF amplifier transition occurs at the first large division on the left, this amplifier is operating at 4 degrees lagging from the reference. See Figure 6-6.
f. Now that a reference phase has been established, without changing any of the scope settings, move the scope probe to the desired RF amplifier to be measured. It is usually a good idea to first measure the drive phase of the Steps RF33-RF38. Then set your reference phase to the module that is typical of the six. Some modules may be operating at the same phase and the others may be a few degrees off. There will be some phase difference between the A side and B side of the same module, but typically the A sides of the RF amplifiers should all line up as well as all the B sides should be within specifications. Typically, there may be two to four degrees difference between A and B sides and there should not be more than +/-4 degrees difference between all the A sides when referenced to an A side. The same maximum difference should also be seen between B sides when referenced to a B side.

6.31.7.1 Excessive Drive Phase Difference

If a module is out of specifications on drive phasing, substitute in a new module. If the problem is on the module, it is most likely caused by a defective drive transformer, T1 or T2, a defective MOSFET, or associated circuitry. If a module has just been repaired, check the control components, including transistors and diodes. A poor solder connection can cause a drive phase problem on an RF amplifier. Substitution is the only way to troubleshoot this problem. If by changing the module the drive phase is still not correct, the problem may be the drive cable. The drive cable can be swapped with another temporarily to determine if it is the cable.

6.31.8 RF Amplifier Drain Phasing

Even though the drive phasing to a particular amp may be within limits, it is possible for the output phasing to be out of specification and cause problems such as module overheating and failure. Measurement of the drain phasing is only necessary when isolating a specific module problem. The drain phasing of the Binary Amplifiers can be adjusted. Refer to SECTION V, Maintenance, for this procedure.

RF amplifier drain phasing should be within +/-4 degrees of each other. Typical phasing is usually within +/-2 degrees. Measure the Drain phasing as follows.

WARNING

ENSURE ALL AC POWER IS REMOVED FROM TRANSMITTER AND THAT THE GROUNDING STICK HAS BEEN USED TO DISCHARGE ANY RESIDUAL POTENTIAL WHERE POWER HAS BEEN APPLIED ANY TIME THE INNER FRONT DOOR IS OPENED TO ACCESS THE RF AMPLIFIER MODULES.

a. Use a 10x scope probe with an extended tip, Harris part #610-1131-000, and connect it to TP1 (Q3 drain) on RF33. The probe can be attached through the interlocked inner door. Make sure the scope case is properly grounded and ground the probe to the door.
b. Set the scope on AC coupled, 50V per division, and the trace to center of the screen.
c. Connect the external sync of the scope to J5 on the Oscillator and make sure the scope sync is set to External.
d. Operate the transmitter at 25 kW with no modulation. Adjust the horizontal vernier on the scope so that a full RF cycle occupies 9 divisions on the screen. Each division now equals 40 degrees of phase shift.
e. Using the Horizontal positioning and triggering level on the scope, place the zero crossing of the waveform on the crossing between the center vertical and horizontal lines on the scope. Increase the vertical sensitivity of the scope to expand the waveform.
f. Switch the scope to the X10 position and readjust the horizontal position so that the RF transition again crosses the center line of the scope. This will be the reference for the phase measurements.
g. If another RF amplifier transition occurs at the first large division on the left, this amplifier is operating at 4 degrees lagging from the reference. See Figure 6-7.
h. Now that a reference phase has been established, without changing any of the scope settings, move the scope probe to the desired RF amplifier to be measured. It is usually a good idea to first measure the drain phase of steps RF33-RF38 then set your reference phase to the module that is typical of the six. Some modules may be operating at near the same phase and the others may a few degrees off. Set the reference to the most common phase. Note that there will be some phase difference between the A side and B side of the same module, but typically the A sides of the RF amplifiers should all line up as well as all the B sides should be within specifications. Typically there may be 2 to 4 degrees difference between A and B sides and there should not be more than +/-4 degrees difference between all the A sides when referenced to an A side and all the B sides when referenced to a B side.

6.31.8.1 Excessive Drive Phase Difference

If a module drain phasing is out of specifications, substitute a different module in that position.

a. If the problem follows the module, check the drive phasing, RF drive toroid transformers, and the MOSFET's.
b. If the phase problem remains at the same module position with different modules, investigate possible problems in the combiner toroid or efficiency coil tapping.

6.31.8.2 Measuring Steps 57-90: TEST SWITCH

To measure drain signals on RF amplifiers RF57 to RF90, the FlexPatch™ TEST SWITCH feature is used:

a. Remove the gold jumper from the FlexPatch™ plug for the RF amplifier step to be measured. The FlexPatch™ plug is located on the Modulation Encoder.
b. Remove any FlexPatch™ jumper cables from the holes in P8-1 and 2. P8 is located next to the RF amplifier TEST SWITCH S2 on the Modulation Encoder.
c. Insert one end of a FlexPatch™ cable into P8-1. Connect the other end of the jumper to the hole closest to the PA Modules of the jack where the gold jumper was removed.
d. Operate the transmitter at 25 kW. The reference phase should already have been set in the preceding steps. Note that the drive waveform zero crossing on the module to be measured will not be visible because the RF amplifier is not turned ON.
e. Depress TEST SWITCH S2 and note that the drain is now turned ON as indicated by a zero crossing now indicating drain phase. The drain phasing of this RF amplifier can now be measured.

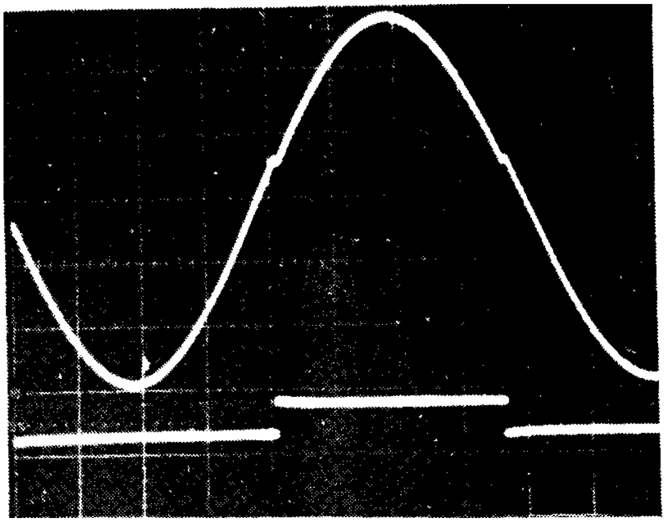

Figure 6-1
Upper Trace - Demodulated audio at 100Hz, 100% Modulation at 10kW showing missing step due to failed RF Amp.
Lower Trace - Modulation Encoder signal for missing step 10.

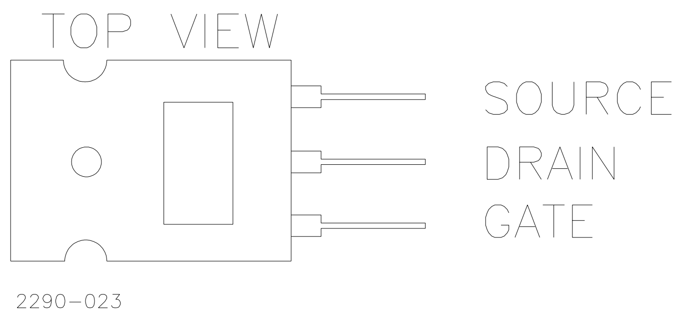

Figure 6-3
Pin Identification of MOSFET.

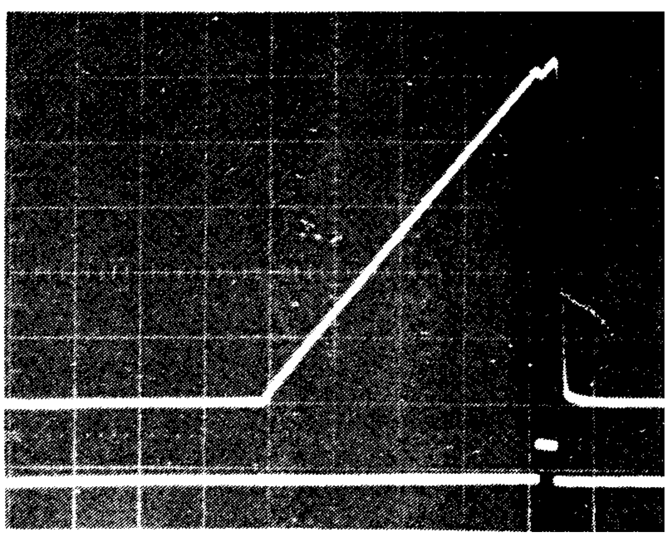

Figure 6-2
Upper Trace - Demodulated audio at 100Hz, 125% + peak, ramp modulation at 10kW showing missing step 56.
Lower Trace - Modulation Encoder signal for step 56.

WARNING: Disconnect primary power prior to servicing.

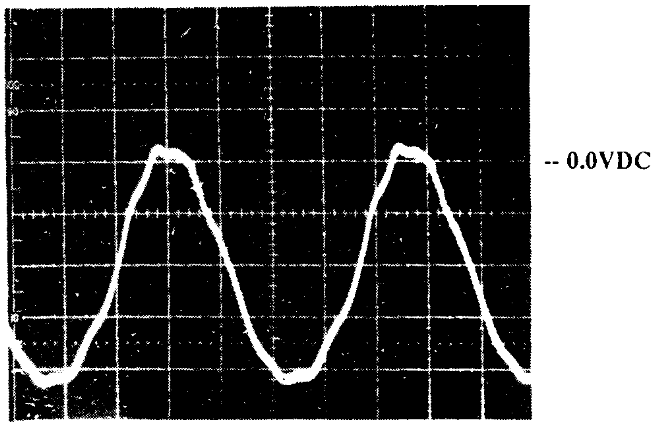

Figure 6-4
RF Drive Waveform at RF Amplifier, Gate of Q3 (anode of CR3). RF Amplifier turned OFF. (5Vp-p per division)

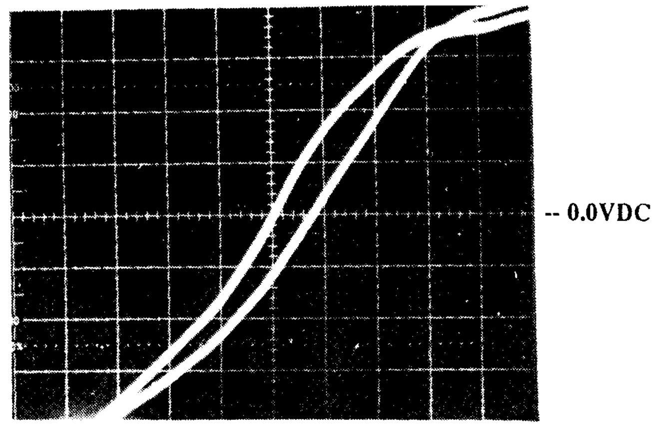

Figure 6-6
RF Drain Waveform as seen at RF Amp, Drain of Q3 (TP1) RF Amp turned ON. Shows zero crossing reference phase, and measured phase approximately 4 degrees lagging. (2Vp-p per division, X10 Magnification)

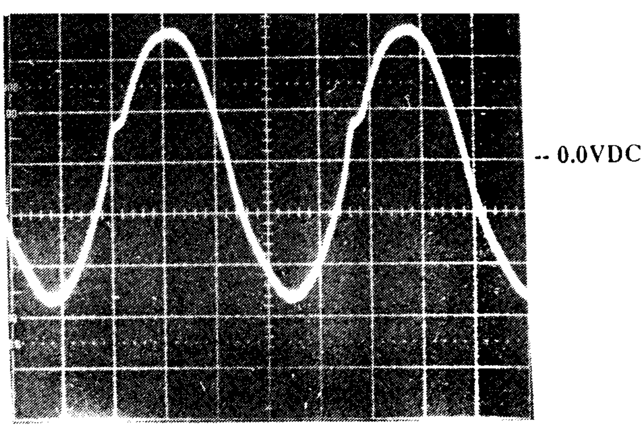

Figure 6-5
RF Drive Waveform as seen at RF Amp Gate of Q3 (anode of CR3). RF Amp turned ON. (5Vp-p per division)

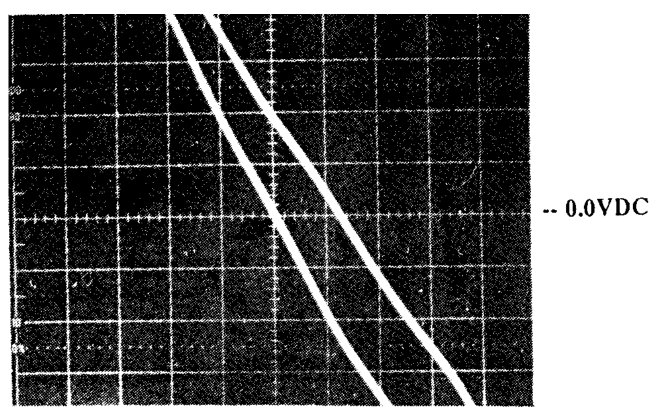

Figure 6-7
RF Drain Waveform as seen at RF Amp, Drain of Q3 (TP1) RF Amp turned ON. Shows zero crossing reference phase, and measured phase approximately 4 degrees lagging. (20Vp-p per division, X10 Magnification)

WARNING: Disconnect primary power prior to servicing.

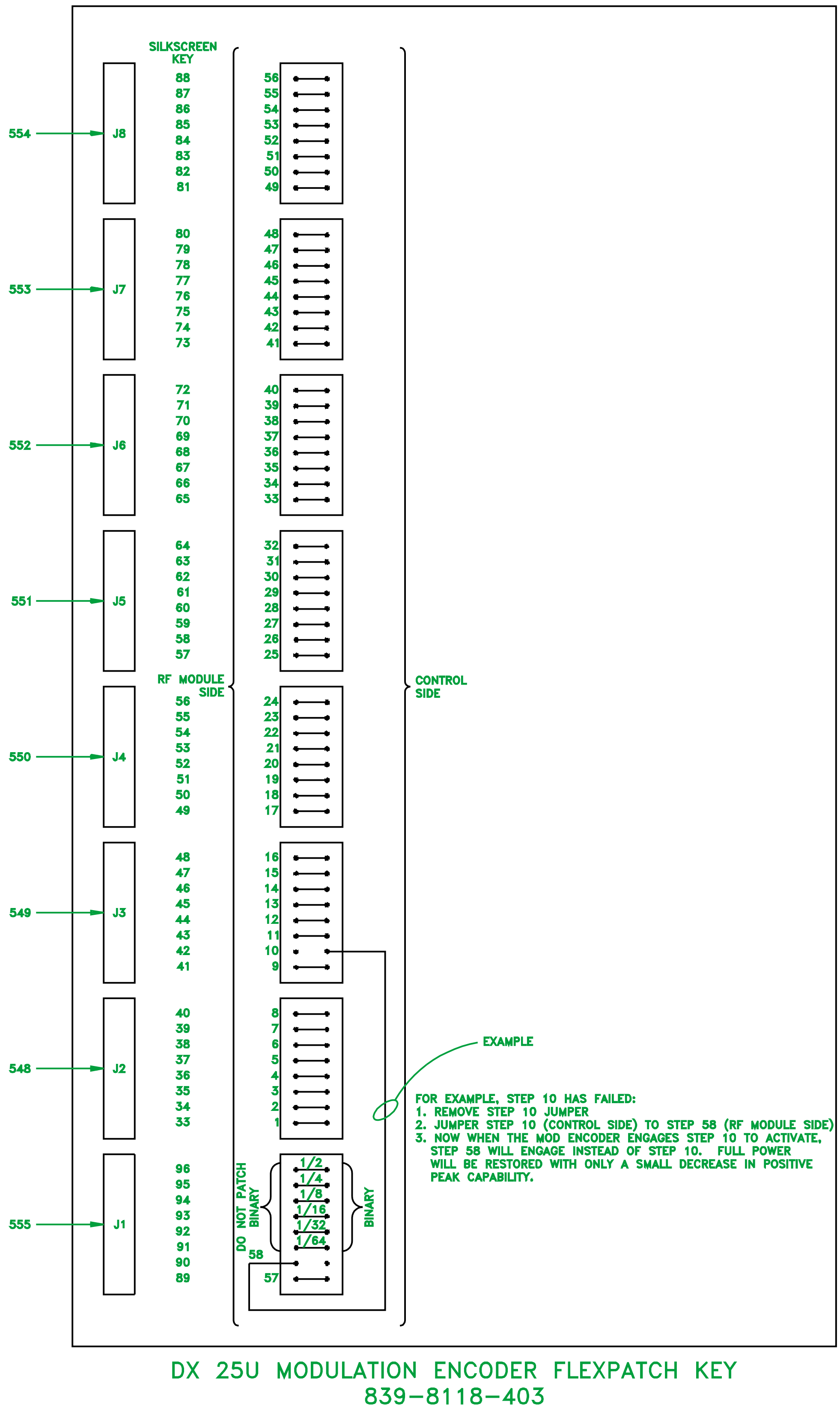

Figure 6-8. FlexPatch™ Operation

Section VII
Parts List

Introduction

This section of the technical manual contains a list of the replaceable parts for the DX-25U AM TRANSMITTER. Table 7-0 gives an index to the replaceable parts section.

Replaceable Parts Service

Refer to the Replaceable Parts Service paragraph on backside of technical manual title page.

Table 7-0. Replaceable Parts List Index

Table 7-1.	XMTR, DX 25U	994 9168 001	7-2
Table 7-2.	TEMP SENSOR REPLACEMENT	917 2099 017	7-3
Table 7-3.	RF AMPLIFIER MODULE	992 7095 001	7-3
Table 7-4.	PWA, ANALOG TO DIGITAL CONV	992 6730 002	7-4
Table 7-5.	* MOD ENCODER/BINARY	992 7089 013	7-7
Table 7-6.	DRIVER SUPPLY REGULATOR	992 8006 001	7-9
Table 7-7.	PWA, BUFFER AMP	992 8038 001	7-10
Table 7-8.	DRIVER ENC/TEMP	992 8048 001	7-11
Table 7-9.	OSCILLATOR	992 8069 002	7-13
Table 7-10.	CONTROLLER BOARD	992 8071 002	7-14
Table 7-11.	LED BOARD	992 8072 002	7-17
Table 7-12.	ANALOG INPUT	992 8077 001	7-21
Table 7-13.	OUTPUT SAMPLE	992 8203 003	7-23
Table 7-14.	DC REGULATOR	992 8468 002	7-23
Table 7-15.	OUTPUT MONITOR	992 9298 001	7-26
Table 7-16.	XMTR, BASIC DX 25U	994 9168 002	7-28
Table 7-17.	PA CABINET, DX 25U	992 7090 002	7-28
Table 7-18.	GROUND HOOK ASSY	938 4203 020	7-32
Table 7-19.	PWA, IPA PWR SPLITTER,ESD SAFE	992 5889 002	7-32
Table 7-20.	MULTIMETER W/O PROBE	992 6752 004	7-32
Table 7-21.	*PWA, DX SWITCH,	992 6784 002	7-32
Table 7-22.	PWA, PWR DISTRIBUTION,ESD SAFE	992 6916 001	7-34
Table 7-23.	PWA, RF SPLITTER, ESD SAFE	992 7085 001	7-34
Table 7-24.	* COMBINER MBD DRIVER *	992 7086 002	7-34
Table 7-25.	PWA, COMB MOTHERBD, ESD SAFE	992 7088 001	7-35
Table 7-26.	PWA, FUSE 1, ESD SAFE	992 8007 001	7-35
Table 7-27.	PWA, FUSE 2, ESD SAFE	992 8007 002	7-36
Table 7-28.	PA CAB CABLE PKG, DX 25U	992 8056 002	7-36
Table 7-29.	DX50 PA & OUTPUT CABINETS	943 5100 016	7-36
Table 7-30.	EXTERNAL INTERFACE	992 8070 001	7-37
Table 7-31.	PWA, NEUTRALIZATION, ESD SAFE	992 8079 002	7-38
Table 7-32.	XFMR PKG (PA CABINET)	992 8094 001	7-38
Table 7-33.	DX25U UNIQUE PARTS	992 8101 001	7-38
Table 7-34.	DX25U UNIQUE COMPONENTS	992 8164 001	7-39
Table 7-35.	COMB MOTHERBD BINARY, ESD SAFE	992 7087 003	7-39
Table 7-36.	PWA,COMB MTHBD BINARY,ESD SAFE	992 7087 001	7-39
Table 7-37.	XFMR PKG (BINARY MBD)	992 7096 001	7-40
Table 7-38.	POWER SUPPLY DISCHARGE	992 8684 003	7-40
Table 7-39.	OUTPUT CABINET	992 7091 001	7-40
Table 7-40.	GROUND HOOK ASSY	938 4203 021	7-42
Table 7-41.	STEP START PANEL	992 7092 001	7-42
Table 7-42.	XFMR KIT,STEPDOWN 480/240	994 9210 001	7-42

WARNING: Disconnect primary power prior to servicing.

Table 7-1. XMTR, DX 25U - 994 9168 001

HARRIS P/N	DESCRIPTION	QTY/UM	REF. SYMBOLS/EXPLANATIONS
041 1310 013	RUBBER SPONGE 3/8	16.80 FT	#SHIPPING TAPE FOR DOOR
358 3131 000	STUD, BRS 1/4-20 X 1	0.0 EA	#2C1B (18# EF) (12# GH) (6# JKL)
410 0025 000	INSULATOR ROUND NS5W 0416	0.0 EA	2L2 (1#FGHIJKL)
492 0743 000	COIL, AIR-WOUND 125UH	0.0 EA	2L2 (1#FGHIJKL)
504 0039 000	CAP 2000PF 5KV 5%	0.0 EA	1C1
504 0043 000	CAP .005UF 3KV 5%	0.0 EA	1C1
504 0238 000	CAP 1000PF 30KV 5%	0.0 EA	2C2B
504 0247 000	CAP 510PF 20KV 5%	0.0 EA	2C3B
504 0258 000	CAP 1000PF 20KV 5% (293)	0.0 EA	2C2C 2C4B
504 0353 000	CAP 3000PF 12KV 5% (293)	0.0 EA	2C2B
504 0364 000	CAP 100,000PF 3KV 5%	0.0 EA	1C3
504 0374 000	CAP 2000PF 15KV 5% (293)	0.0 EA	2C2B
504 0377 000	CAP 1500PF 15KV 5% (293)	0.0 EA	2C2B
504 0378 000	CAP 1200PF 15KV 5% (293)	0.0 EA	2C2B 2C2C
504 0382 000	CAP 2400PF 12KV 5% (293)	0.0 EA	2C2B
504 0383 000	CAP 1500PF 25KV 5% (294)	0.0 EA	2C1B 2C2C
504 0400 000	CAP .047UF 5KV	0.0 EA	1C3
504 0418 000	CAP 2700 PF 12KV 5% (293)	0.0 EA	2C1B
504 0419 000	CAP 3300 PF 12KV 5% (293)	0.0 EA	2C2B
504 0433 000	CAP 3600PF 12KV 5% (293)	0.0 EA	2C1B 2C2B
504 0435 000	CAP 5600PF 10KV 5% (293)	0.0 EA	1C4
504 0437 000	CAP 7500PF 10KV 5%	0.0 EA	1C4
504 0440 000	CAP 10,000PF 8KV 5% (293)	0.0 EA	1C4
504 0447 000	CAP 13,000PF 5KV 5% (293)	0.0 EA	1C4
504 0448 000	CAP 16,000PF 5KV 5% (293)	0.0 EA	1C3
504 0449 000	CAP 18,000PF 5KV 5% (293)	0.0 EA	1C3
504 0496 000	CAP 4700PF 10KV 5% (293)	0.0 EA	2C1B
504 0497 000	CAP 6200PF 10KV 5% (293)	0.0 EA	1C4
504 0509 000	CAPACITOR 330/293 20KV	0.0 EA	2C3B
504 0523 000	CAP 22000PF 5KV 5%	0.0 EA	1C003
512 0320 000	CAP 1000PF 40KV TEST	0.0 EA	2C1B
512 0350 000	CAP VAC 2000PF 15KV	0.0 EA	2C5 2C1B
514 0240 000	CAP, VAR 2300PF 15KV TEST	0.0 EA	2C1A
514 0264 000	CAP, VAR 1500PF 30KV TEST	0.0 EA	2C1A
813 5608 020	*NON STANDARD	0.0 EA	2L2 (1#FGHIJKL)
817 1280 025	SPEC, DX10 XMTR CRYSTAL	0.0 EA	A17Y1 A17Y2
817 2099 016	STDOFF, 3.35" X 0.50"	0.0 EA	#2C1B (18#EF 12#GH 6#JKL)
822 0922 084	STDOFF	0.0 EA	(12#ABCDEFGH 8#JKL)
822 0922 114	STDOFF 1 X 2 X 1/4-20	0.0 EA	2L2 (1#FGHJKL)
822 0922 140	STRAP	0.0 EA	2C5 (1#FGHJKL)
822 0922 174	STRAP	0.0 EA	#1C3 (1#DEFJKL)
822 0922 175	STRAP	0.0 EA	#1C3 (1#ABCGH)
822 0922 177	STRAP	0.0 EA	#2C2B (1#ABCDEFGHJKL)
822 0922 178	STRAP, 5.00" X 1.00"	0.0 EA	#2C2B #2C4B (7#ABC 9#DE 4#F 2#GHJKL)
822 0922 198	CAP PLATE	0.0 EA	#2C5 (1#FGHJKL)
829 9009 102	PLATE, COIL MTG	0.0 EA	2L2 (1#FGHIJKL)
839 7855 069	TOP CAP MTG PLATE	0.0 EA	#2C1A/B (1#JKL)
839 7855 071	CAP MTG PLATE	0.0 EA	#2C1A/B (1#JKL)
839 7855 104	CAP PLATE	0.0 EA	#1C4 (1#FGHJKL)
839 7855 125	ASSY INSTR, DX 25U	0.0 EA	
839 7855 138	FD CHART DX25U	0.0 EA	
839 7855 142	TUNING CHART DX25U	0.0 EA	
839 7855 152	CABINET OUTLINE, DX25U	0.0 EA	

839 7855 154	BTM CAP CONTACT PLT	0.0 EA	#2C1A/B (1#JKL)
839 7855 155	STRAP	0.0 EA	2C5 (1#FGHJKL)
839 7855 158	BTM CAP MTG PLATE	0.0 EA	#2C1A/B (1#ABCDE)
843 5100 079	CAP MTG PLATE	0.0 EA	#2C1A/B (1#E)
843 5100 080	TOP CONTACT PLT	0.0 EA	#2C1A/B (1#E)
843 5100 083	CAP MTG PLATE	0.0 EA	#2C1A/B (1#ABCD)
843 5100 084	TOP CONTACT PLATE	0.0 EA	#2C1A/B (1#ABCD)
922 0922 205	7 TURN RIBBON COIL	0.0 EA	(#1FGHIJKL)
922 0922 215	STRAP, #2C2B	0.0 EA	#2C2B (4#ABCDE) (6#FGHJKL)
922 0999 210	GROUND STRAP, .5 X 12.0LG	0.0 EA	#2C3A-L3 (2#ABCDE) (2 REQ'D)
939 7855 170	STRAP	0.0 EA	2L3-2C4A (1#ABCDE)
939 8183 001	BTM CAP MTG PLATE	0.0 EA	#2C1A/B (1#FGH)
943 5100 100	PLATE, CAP MTG	0.0 EA	#2C1A/B (1#FGH)
943 5100 101	PLATE, TOP CONTACT	0.0 EA	#2C1A/B (1#FGH)
988 2297 001	DP DX-25U	1.0 EA	
989 0076 001	PKG CK LIST DX50	0.0 EA	
990 1090 002	R-SK-DX25U REC S/C KIT	0.0 EA	
992 7095 001	RF AMPLIFIER MODULE	1.0 EA	
994 9165 002	R-BK-DX25U REC BDS KIT	0.0 EA	
994 9166 002	R-PK-DX25U REC PTS KIT	0.0 EA	
994 9168 002	XMTR, BASIC DX 25U	1.0 EA	
994 9210 001	XFMR KIT,STEPDOWN 480/240	0.0 EA	3T001
999 2622 001	HARDWARE LIST, DX50	1.0 EA	

Table 7-2. TEMP SENSOR REPLACEMENT - 917 2099 017

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
252 0002 000	WIRE, STRD 22AWG GRN	1.50 FT	
296 0260 000	TUBING, SHRINK 3/32 WHITE	0.30 FT	
296 0263 000	TUBING, SHRINK 3/8 WHITE	0.20 FT	
354 0287 000	LUG #10 RING N/INS 7-9AWG	1.0 EA	
354 0704 000	TERM, MALE FOR 18-22 AWG	3.0 EA	
382 1274 000	IC LM335AH ESD	1.0 EA	
610 0738 000	PLUG HOUSING	1.0 EA	
817 2099 017	ASSY INSTR, TEMP SENSOR	0.0 EA	

Table 7-3. RF AMPLIFIER MODULE - 992 7095 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
324 0281 000	NUT, CAPTIVE 4-40	2.0 EA	
328 0071 000	WASHER, STEEL COMPRESSION	4.0 EA	#Q001 #Q002 #Q003 #Q004
380 0653 000	XSTR, NPN MPS6602 ESD	2.0 EA	Q007 Q008
380 0681 000	XSTR IRFP350 ESD	8.0 EA	Q001 Q002 Q003 Q004 Q009 Q010 Q011 Q012
380 0708 000	XSTR MPS6652 40V 1A ESD	2.0 EA	Q005 Q006
380 0712 000	XSTR, NPN 2N6718 ESD	2.0 EA	Q013 Q014
384 0253 000	RECTIFIER 1N4007 ESD	2.0 EA	CR011 CR012
384 0612 000	DIODE 1N3070 ESD	2.0 EA	CR014 CR015
384 0661 000	LED, GRN, T 1-3/4, RT ANG ESD	1.0 EA	DS003
384 0802 000	TRANSZORB, BIPOLAR 18V 5% ESD	4.0 EA	CR001 CR002 CR003 CR004
384 0803 000	RECT MUR-110 100V ESD	4.0 EA	CR007 CR008 CR009 CR010
384 0810 000	LED RED ESD	2.0 EA	DS001 DS002
384 0817 000	RECT 1.7A 21DQ03 ESD	2.0 EA	CR005 CR006

386 0100 000	ZENER, 1N4747A 20V ESD	1.0 EA	CR013
398 0452 000	FUSE 1TIME MIDGET 5A 250V	2.0 EA	F001 F002
402 0194 000	CLIP FUSE BRONZE	4.0 EA	2#F001 2#F002
410 0413 000	INSULATOR PAD FOR TO-247	8.0 EA	#Q001 #Q002 #Q003 #Q004 #Q009 #Q010 #Q011 #Q012
414 0280 000	FERRITE TOROID, LINER	4.0 EA	#Q003 #Q004 #Q010 #Q011
494 0249 000	CHOKE RF 10UH	2.0 EA	L006 L007
494 0345 000	CHOKE, RF 1.2 UH	2.0 EA	L001 L002
494 0398 000	CHOKE RF 10.0UH	2.0 EA	L003 L004
494 0400 000	CHOKE RF 15.0UH	1.0 EA	L005
500 0754 000	CAP, MICA, 220PF 500V 5%	0.0 EA	C009 C010
500 0759 000	CAP, MICA, 100PF 500V 5%	0.0 EA	C009 C010
500 0784 000	CAP, MICA, 300PF 500V 5%	0.0 EA	C009 C010
500 0787 000	CAP, MICA, 200PF 500V 5%	0.0 EA	C009 C010
500 0834 000	CAP, MICA, 430PF 500V 5%	0.0 EA	C009 C010
500 0839 000	CAP, MICA, 620PF 300V 5%	0.0 EA	C009 C010
500 0842 000	CAP, MICA, 820PF 300V 5%	0.0 EA	C009 C010
500 0844 000	CAP, MICA, 1000PF 100V 5%	0.0 EA	C009 C010
500 0883 000	CAP, MICA, 4700PF 500V 5%	1.0 EA	C007
500 1164 000	CAP, MICA, 1800PF 500V 5%	2.0 EA	C012 C013
506 0234 000	CAP .0022UF 100V 5%	1.0 EA	C011
506 0237 000	CAP .0068UF 100V 5%	1.0 EA	C005
506 0238 000	CAP .015UF 100V 5%	1.0 EA	C006
508 0549 000	CAP .33UF 5% 400VDC	2.0 EA	C001 C002
508 0550 000	CAP .1UF 600V 5%	1.0 EA	C008
516 0419 000	CAP .05 UF 500V	2.0 EA	C003 C004
516 0453 000	CAP .1UF 100V 20% X7R	1.0 EA	C014
540 1491 000	RES 10 OHM 1/2W 2%	4.0 EA	R010 R011 R012 R013
540 1600 017	RES 4.7 OHM 3W 5%	2.0 EA	R019 R020
540 1600 412	RES 30K OHM 3W 5%	1.0 EA	R016
540 1600 419	RES 56K OHM 3W 5%	2.0 EA	R001 R002
546 0295 000	RES 50 OHM 3.25W 5%	2.0 EA	R005 R006
546 0311 000	RES 120 OHM 3W 5%	4.0 EA	R003 R004 R022 R023
548 2400 130	RES 20 OHM 1/2W 1%	1.0 EA	R009
548 2400 166	RES 47.5 OHM 1/2W 1%	2.0 EA	R007 R008
548 2400 201	RES 100 OHM 1/2W 1%	2.0 EA	R017 R018
548 2400 330	RES 2K OHM 1/2W 1%	2.0 EA	R014 R021
548 2400 566	RES 475K OHM 1/2W 1%	2.0 EA	R024 R025
610 0933 000	JUMPER, PWB TEST POINT	2.0 EA	TP001 TP002
839 7855 080	SCHEM, 2X RF AMP	0.0 EA	
843 4038 200	PWB, 2X RF AMP	1.0 EA	
922 0922 156	TRANSFORMER	2.0 EA	T001 T002
943 5155 064	HEATSINK SET	1.0 EA	
999 2561 001	HARDWARE LIST	1.0 EA	

Table 7-4. PWA, ANALOG TO DIGITAL CONV - 992 6730 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
354 0309 000	TERM SOLDER	22.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007 TP008 TP009 TP010 TP011 TP012 TP013 TP014 TP015 TP016 TP017 TP018 TP019 TP020 TP021 TP022
380 0189 000	XSTR, NPN 2N3904 ESD	1.0 EA	Q009
380 0190 000	XSTR, PNP 2N3906 ESD	1.0 EA	Q002
380 0587 000	XSTR, MJE210 ESD	1.0 EA	Q001

382 0081 000	IC, 7406 ESD	1.0 EA	U007
382 0159 000	IC, 7407 ESD	2.0 EA	U005 U006
382 0359 000	IC, 7815 ESD	1.0 EA	U002
382 0360 000	IC, 7915 ESD	1.0 EA	U018
382 0472 000	IC, LM318 ESD	5.0 EA	U009 U024 U026 U027 U028
382 0605 000	IC 7905C ESD	1.0 EA	U021
382 0648 000	IC, LM339A ESD	1.0 EA	U020
382 0749 000	IC NE5532A ESD	1.0 EA	U011
382 0770 000	IC, 74HC04 ESD	1.0 EA	U017
382 0771 000	IC 74HC08 ESD	1.0 EA	U015
382 0774 000	IC 74HC14 ESD	1.0 EA	U012
382 0800 000	IC, 74HC161 ESD	1.0 EA	U029
382 0882 000	IC, 78L05A ESD	1.0 EA	U019
382 0965 000	IC, D/A CONVERTER ESD	1.0 EA	U008
382 0990 000	*IC, LH0002CN ESD	2.0 EA	U010 U025
382 1065 000	IC 74HCT273 ESD	2.0 EA	U003 U004
382 1079 000	IC 74HC123 ESD	2.0 EA	U013 U014
382 1332 000	IC DAC-08 ESD	1.0 EA	U022
382 1414 000	IC, AD1671 A/D CONV ESD	1.0 EA	U001
382 1423 000	IC, LT1123 ESD	1.0 EA	U016
384 0205 000	DIODE SILICON 1N914/4148 ESD	4.0 EA	CR006 CR013 CR014 CR015
384 0321 000	DIODE 5082-2800/1N5711 ESD	2.0 EA	CR016 CR018
384 0431 000	RECT. 1N4001 ESD	5.0 EA	CR001 CR004 CR005 CR008 CR009
384 0719 000	TRANSZORB 1N6373 5V 5W ESD	1.0 EA	CR003
384 0720 000	TRANSZORB 1N6377 15V 5W ESD	2.0 EA	CR002 CR007
384 0733 000	LED, BI-COLOR RED/GRN ESD	1.0 EA	DS001
384 0817 000	RECT 1.7A 21DQ03 ESD	1.0 EA	CR011
386 0123 000	ZENER, 1N4732A 4.7V ESD	1.0 EA	CR010
398 0019 000	FUSE, FAST CART 2A 250V	3.0 EA	F001 F002 F003
402 0129 000	CLIP, 1/4 DIA FUSE	6.0 EA	2-XF001 2-XF002 2-XF003
404 0509 000	SOCKET IC 28 PIN	1.0 EA	XU001
404 0513 000	HEAT SINK PA1-1CB	4.0 EA	#Q001 #U002 #U018 #U021
404 0673 000	SOCKET 8 PIN DIP (DL)	6.0 EA	XU009 XU011 XU024 XU026 XU027 XU028
404 0674 000	SOCKET 14 PIN DIP (D-L)	7.0 EA	XU005 XU006 XU007 XU012 XU015 XU017 XU020
404 0675 000	SOCKET IC 16 CONT	4.0 EA	XU013 XU014 XU022 XU029
404 0767 000	SOCKET 20 PIN DIP (DL)	2.0 EA	XU003 XU004
404 0768 000	SOCKET 24 PIN DIP (DL)	1.0 EA	XU008
410 0405 000	INSULATOR XSTR TO220	1.0 EA	#Q001
484 0334 000	LINE,DELAY 60+/-2.0 NSEC	1.0 EA	DL003
484 0427 000	LINE, DELAY 450NS FIXED	1.0 EA	DL001
494 0238 000	CHOKE RF 39UH	2.0 EA	L009 L010
494 0393 000	CHOKE RF 5.60UH	1.0 EA	L005
494 0394 000	CHOKE 6.80UH	2.0 EA	L007 L008
494 0401 000	CHOKE RF 18.0UH	1.0 EA	L006
494 0411 000	CHOKE RF 220.0UH	1.0 EA	L001
494 0418 000	CHOKE RF 820.0UH	2.0 EA	L002 L003
500 0759 000	CAP, MICA, 100PF 500V 5%	1.0 EA	C106
500 0787 000	CAP, MICA, 200PF 500V 5%	3.0 EA	C014 C042 C050
500 0832 000	CAP, MICA, 360PF 500V 5%	1.0 EA	C103
500 0834 000	CAP, MICA, 430PF 500V 5%	1.0 EA	C047
500 0837 000	CAP, MICA, 510PF 500V 5%	2.0 EA	C111 C112
500 0841 000	CAP, 750PF 300V 5%	1.0 EA	C102
500 0844 000	CAP, MICA, 1000PF 100V 5%	1.0 EA	C105
516 0453 000	CAP .1UF 100V 20% X7R	44.0 EA	

WARNING: Disconnect primary power prior to servicing.

			C001 C002 C003 C005 C006 C009 C010 C012 C013 C015 C016 C017 C018 C019 C020 C021 C027 C028 C030 C031 C032 C035 C036 C037 C038 C039 C043 C045 C046 C054 C056 C059 C061 C062 C070 C077 C079 C080 C081 C082 C094 C104 C108 C109
516 0530 000	CAP .01UF 10% 100V X7R	16.0 EA	C025 C029 C033 C051 C052 C058 C060 C063 C066 C071 C072 C073 C074 C075 C076 C091
516 0556 000	CAP .33UF 100V 20%	2.0 EA	C026 C055
516 0736 000	CAP .001UF 10% 100V X7R	2.0 EA	C048 C049
516 0765 000	CAP 10PF 5% 100V C0G	5.0 EA	C044 C087 C088 C089 C090
516 0768 000	CAP 18PF 5% 100V C0G	1.0 EA	C057
516 0777 000	CAP 100PF 5% 100V C0G	1.0 EA	C092
516 0783 000	CAP 330PF 5% 100V C0G	1.0 EA	C093
516 0830 000	CAP 8200PF 10% 100V	1.0 EA	C110
516 0894 000	CAP 1500PF 5% 100V C0G	1.0 EA	C101
516 1001 000	CAP 3300PF 1% 100V C0G	1.0 EA	C100
522 0548 000	CAP 10UF 50V 20%	3.0 EA	C022 C023 C024
522 0561 000	CAP 100UF 63V 20%	7.0 EA	C004 C007 C008 C011 C034 C053 C064
522 0578 000	CAP 1.0UF 50V 20%	3.0 EA	C040 C041 C065
540 1600 118	RES 51 OHM 3W 5%	2.0 EA	R062 R083
540 1600 121	RES 68 OHM 3W 5%	1.0 EA	R084
540 1600 122	RES 75 OHM 3W 5%	1.0 EA	R086
540 1600 123	RES 82 OHM 3W 5%	1.0 EA	R087
540 1600 205	RES 150 OHM 3W 5%	1.0 EA	R085
540 1600 215	RES 390 OHM 3W 5%	1.0 EA	R043
540 1600 221	RES 680 OHM 3W 5%	1.0 EA	R026
548 2400 168	RES 49.9 OHM 1/2W 1%	1.0 EA	R012
548 2400 230	RES 200 OHM 1/2W 1%	1.0 EA	R019
548 2400 264	RES 453 OHM 1/2W 1%	1.0 EA	R072
548 2400 268	RES 499 OHM 1/2W 1%	1.0 EA	R079
548 2400 269	RES 511 OHM 1/2W 1%	5.0 EA	R010 R013 R035 R036 R069
548 2400 274	RES 576 OHM 1/2W 1%	1.0 EA	R046
548 2400 277	RES 619 OHM 1/2W 1%	3.0 EA	R021 R024 R025
548 2400 279	RES 649 OHM 1/2W 1%	1.0 EA	R040
548 2400 301	RES 1K OHM 1/2W 1%	4.0 EA	R020 R038 R047 R063
548 2400 312	RES 1.3K OHM 1/2W 1%	1.0 EA	R045
548 2400 326	RES 1.82K OHM 1/2W 1%	1.0 EA	R048
548 2400 330	RES 2K OHM 1/2W 1%	1.0 EA	R049
548 2400 332	RES 2.1K OHM 1/2W 1%	1.0 EA	R006
548 2400 335	RES 2.26K OHM 1/2W 1%	1.0 EA	R027
548 2400 337	RES 2.37K OHM 1/2W 1%	5.0 EA	R001 R029 R034 R037 R074
548 2400 347	RES 3.01K OHM 1/2W 1%	3.0 EA	R005 R053 R055
548 2400 351	RES 3.32K OHM 1/2W 1%	2.0 EA	R003 R018
548 2400 358	RES 3.92K OHM 1/2W 1%	1.0 EA	R071
548 2400 364	RES 4.53K OHM 1/2W 1%	1.0 EA	R039
548 2400 373	RES 5.62K OHM 1/2W 1%	6.0 EA	R011 R016 R022 R023 R050 R077
548 2400 385	RES 7.5K OHM 1/2W 1%	2.0 EA	R009 R015
548 2400 401	RES 10K OHM 1/2W 1%	6.0 EA	R032 R054 R065 R066 R067 R068
548 2400 411	RES 12.7K OHM 1/2W 1%	1.0 EA	R002
548 2400 425	RES 17.8K OHM 1/2W 1%	1.0 EA	R008
548 2400 426	RES 18.2K OHM 1/2W 1%	2.0 EA	R014 R017
548 2400 437	RES 23.7K OHM 1/2W 1%	4.0 EA	R028 R030 R031 R064
548 2400 467	RES 48.7K OHM 1/2W 1%	1.0 EA	R004

548 2400 469	RES 51.1K OHM 1/2W 1%	1.0 EA	R033
548 2400 501	RES 100K OHM 1/2W 1%	1.0 EA	R061
548 2400 578	RES 634K OHM 1/2W 1%	1.0 EA	R070
548 2400 601	RES 1MEG OHM 1/2W 1%	3.0 EA	R041 R042 R044
550 0956 000	POT 2000 OHM 1/2W 10%	1.0 EA	R078
550 0958 000	POT 10K OHM 1/2 W 10%	1.0 EA	R007
604 1064 000	SWITCH, ROCKER DIP 2-SPST	1.0 EA	S002
604 1093 000	SW, RKR DIP 6-SPST	1.0 EA	S001
610 0978 000	HDR 10C 2ROW RT ANG	1.0 EA	J007
610 0984 000	HDR 34C 2ROW VERTICAL	1.0 EA	J006
610 0999 000	HDR, 10 PIN, PC BD	2.0 EA	J001 J004
610 1053 000	HEADER, 4 PIN, PC BD	1.0 EA	J008
610 1070 000	HDR 6 PIN STRAIGHT	1.0 EA	JP010
610 1110 000	HDR 8C 2R STRT UNPOL	1.0 EA	JP001
610 1121 000	HDR 4C 2ROW STRAIGHT	1.0 EA	JP011
612 1184 000	SHUNT JUMPER 0.1" CENTERS	7.0 EA	#JP001, 2/#JP011
620 0515 000	RECP, SCREW ON SMC	1.0 EA	J003
620 1677 000	RECEPTACLE, PC MT, BNC	1.0 EA	J002
839 7855 177	SCH, A/D	0.0 EA	
843 5100 094	PWB, A/D	1.0 EA	
929 9009 198	XFMR	1.0 EA	T001
999 2760 001	HARDWARE LIST, ANALOG TO	1.0 EA	

Table 7-5. * MOD ENCODER/BINARY - 992 7089 013

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
382 0159 000	IC, 7407 ESD	1.0 EA	U059
382 0521 000	IC, 339 ESD	4.0 EA	U062 U063 U064 U065
382 0560 000	IC, 74LS27 ESD	1.0 EA	U053
382 0580 000	IC, 74LS32 ESD	2.0 EA	U060 U061
382 0622 000	IC, 74LS14N ESD	3.0 EA	U054 U055 U057
382 0637 000	IC, 74LS30 ESD	2.0 EA	U066 U067
382 0774 000	IC 74HC14 ESD	1.0 EA	U056
382 1010 000	IC, DS0026CN/MMH0026CP1 ESD	32.0 EA	U001 U002 U003 U004 U005 U006 U007 U008 U009 U010 U011 U012 U013 U014 U015 U016 U017 U018 U019 U020 U021 U022 U023 U024 U025 U026 U027 U028 U029 U030 U039 U040
382 1065 000	IC 74HCT273 ESD	11.0 EA	U031 U032 U033 U034 U035 U036 U037 U038 U049 U050 U051
384 0205 000	DIODE SILICON 1N914/4148 ESD	9.0 EA	CR001 CR004 CR005 CR006 CR007 CR008 CR009 CR010 CR011
384 0651 000	RECTIFIER 1N5401 ESD	1.0 EA	CR028
384 0719 000	TRANSZORB 1N6373 5V 5W ESD	2.0 EA	CR002 CR003
384 0823 000	LED 10 SEG BARGRAPH, RED ESD	1.0 EA	DS001
386 0082 000	ZENER, 1N4744A 15V 1W 5% ESD	8.0 EA	CR012 CR013 CR014 CR015 CR016 CR017 CR018 CR019
386 0100 000	ZENER, 1N4747A 20V ESD	8.0 EA	CR020 CR021 CR022 CR023 CR024 CR025 CR026 CR027
398 0019 000	FUSE, FAST CART 2A 250V	1.0 EA	F001
402 0129 000	CLIP, 1/4 DIA FUSE	2.0 EA	2#F001
404 0673 000	SOCKET 8 PIN DIP (DL)	32.0 EA	XU001 XU002 XU003 XU004 XU005 XU006 XU007 XU008 XU009 XU010 XU011 XU012 XU013 XU014 XU015 XU016

			XU017 XU018 XU019 XU020 XU021 XU022 XU023 XU024 XU025 XU026 XU027 XU028 XU029 XU030 XU039 XU040
404 0674 000	SOCKET 14 PIN DIP (D-L)	14.0 EA	XU053 XU054 XU055 XU056 XU057 XU059 XU060 XU061 XU062 XU063 XU064 XU065 XU066 XU067
404 0704 000	SOCKET IC 20 PIN	20.0 EA	XU031 XU032 XU033 XU034 XU035 XU036 XU037 XU038 XU041 XU042 XU043 XU044 XU045 XU046 XU047 XU048 XU049 XU050 XU051 XDS001
404 0790 000	HEATSINK, 8-PIN DIP	32.0 EA	#U001 #U002 #U003 #U004 #U005 #U006 #U007 #U008 #U009 #U010 #U011 #U012 #U013 #U014 #U015 #U016 #U017 #U018 #U019 #U020 #U021 #U022 #U023 #U024 #U025 #U026 #U027 #U028 #U029 #U030 #U039 #U040
516 0375 000	CAP .01UF 50V -20/+80% Z5U	16.0 EA	C400 C401 C402 C403 C404 C405 C406 C407 C408 C409 C410 C411 C412 C413 C414 C415
516 0453 000	CAP .1UF 100V 20% X7R	60.0 EA	C003 C031 C032 C033 C034 C035 C036 C037 C038 C049 C050 C051 C053 C054 C055 C056 C057 C059 C060 C061 C062 C063 C064 C065 C066 C067 C068 C070 C231 C232 C233 C235 C237 C239 C241 C243 C245 C247 C249 C251 C253 C255 C257 C259 C260 C261 C262 C263 C264 C265 C266 C267 C268 C269 C270 C271 C272 C273 C274 C275
516 0814 000	CAP NETWORK .0033UF 10%	16.0 EA	C100 C101 C102 C103 C104 C105 C106 C107 C108 C109 C110 C111 C112 C113 C114 C115
516 0815 000	CAP NETWORK .001UF 10%	16.0 EA	C099 C116 C117 C118 C119 C120 C121 C122 C123 C124 C125 C126 C127 C128 C129 C130
522 0531 000	CAP 1UF 50V 20%	24.0 EA	C041 C042 C043 C044 C045 C046 C047 C048 C201 C202 C203 C205 C207 C209 C211 C213 C215 C217 C219 C221 C223 C225 C227 C229
522 0541 000	CAP 220UF 50V 20%	2.0 EA	C001 C002
526 0108 000	CAP 4.7UF 35V 20%	1.0 EA	C004
540 1375 000	RES NETWORK 1000 OHM 2%	16.0 EA	R099 R116 R117 R118 R119 R120 R121 R122 R123 R124 R125 R126 R127 R128 R129 R130
540 1376 000	RES NETWORK 1000 OHM 2%	2.0 EA	R029 R030
540 1380 000	RES NETWORK 10K OHM 2%	8.0 EA	R012 R013 R014 R015 R016 R017 R018 R019
540 1383 000	RES NETWORK 100K OHM 2%	8.0 EA	R020 R021 R022 R023 R024 R025 R026 R027
540 1386 000	RES NETWORK 10K OHM 2%	8.0 EA	R131 R132 R133 R134 R135 R136 R137 R138
540 1393 000	RES NETWORK 180/390 OHM	2.0 EA	R010 R011
540 1410 000	RES NETWORK 330 OHM 2%	1.0 EA	R037
540 1466 000	RES NETWORK 39 OHM 2%	16.0 EA	R100 R101 R102 R103 R104 R105 R106 R107 R108 R109 R110 R111 R112 R113 R114 R115
548 2400 193	RES 90.9 OHM 1/2W 1%	1.0 EA	R234
548 2400 201	RES 100 OHM 1/2W 1%	60.0 EA	R028 R227 R228 R233

WARNING: Disconnect primary power prior to servicing.

			R235 R236 R237 R238 R239 R240 R241 R242 R243 R244 R245 R246 R247 R248 R249 R250 R251 R252 R253 R254 R255 R256 R257 R258 R259 R260 R261 R262 R263 R264 R265 R266 R267 R268 R269 R270 R271 R272 R273 R274 R275 R276 R277 R278 R279 R280 R281 R282 R283 R284 R285 R286 R287 R288 R289 R290
548 2400 205	RES 110 OHM 1/2W 1%	1.0 EA	R232
548 2400 212	RES 130 OHM 1/2W 1%	1.0 EA	R231
548 2400 218	RES 150 OHM 1/2W 1%	2.0 EA	R229 R230
548 2400 251	RES 332 OHM 1/2W 1%	1.0 EA	R039
548 2400 269	RES 511 OHM 1/2W 1%	1.0 EA	R038
548 2400 301	RES 1K OHM 1/2W 1%	13.0 EA	R040 R041 R042 R043 R044 R045 R046 R047 R048 R049 R050 R051 R052
548 2400 334	RES 2.21K OHM 1/2W 1%	2.0 EA	R036 R053
548 2400 369	RES 5.11K OHM 1/2W 1%	1.0 EA	R035
548 2400 451	RES 33.2K OHM 1/2W 1%	8.0 EA	R001 R002 R003 R004 R005 R006 R007 R008
548 2400 530	RES 200K OHM 1/2W 1%	1.0 EA	R054
604 0905 000	SW, PB MOMENTARY	1.0 EA	S002
610 0679 000	PLUG, SHORTING, .25" CTRS	2.0 EA	P020 P021
610 0870 000	PLUG, NON-INS SHORTING	64.0 EA	
610 0933 000	JUMPER, PWB TEST POINT	15.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007 TP008 TP009 TP010 TP011 TP012 TP013 TP014 TP015
610 0981 000	HDR 20C 2ROW VERTICAL	8.0 EA	J001 J002 J003 J004 J005 J006 J007 J008
610 0984 000	HDR 34C 2ROW VERTICAL	1.0 EA	J017
610 0999 000	HDR, 10 PIN, PC BD	1.0 EA	J019
610 1027 000	HEADER, MALE 12 PIN	1.0 EA	J018
612 0904 000	JACK, PC MT GOLD PLATED	10.0 EA	P010 P011 P012 P015 3#J020 #3J021
612 1176 000	DIP STRIP, FEMALE 10 POS	10.0 EA	
839 7855 174	SCHEM, MOD ENCODER	0.0 EA	
843 5100 092	PWB, MOD ENCODER	1.0 EA	A014
917 2099 051	FIRMWARE, MOD ENCODER, DX25U	1.0 EA	

Table 7-6. DRIVER SUPPLY REGULATOR - 992 8006 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
328 0071 000	WASHER, STEEL COMPRESSION	7.0 EA	#Q002 #Q003 #Q004 #Q005 #Q006 #Q007 #Q008
358 1929 000	JUMPER 1/2 LG 1/8H	1.0 EA	P001
358 3314 000	STANDOFF 4-40 X .250 L	6.0 EA	
380 0414 000	XSTR, 2N3799 ESD	1.0 EA	Q001
380 0681 000	XSTR IRFP350 ESD	7.0 EA	Q002 Q003 Q004 Q005 Q006 Q007 Q008
382 0368 000	IC, 78L15AWC VOLTAGE REG. ESD	1.0 EA	U001
382 0593 000	IC TL072ACP ESD	1.0 EA	U002
384 0205 000	DIODE SILICON 1N914/4148 ESD	2.0 EA	CR005 CR006
384 0731 000	* DIODE, SWITCHING 1N4607 ESD	4.0 EA	CR001 CR002 CR003 CR004
384 0782 000	RECT, MR754 400V 6A ESD	2.0 EA	CR013 CR015
386 0085 000	ZENER, 1N4740A 10V ESD	6.0 EA	CR008 CR011 CR012 CR014 CR016 CR017
386 0090 000	ZENER 1N4756A 47V 5% 1W ESD	2.0 EA	CR009 CR010
386 0164 000	ZENER, 1N4754A 39V ESD	1.0 EA	CR007
404 0673 000	SOCKET 8 PIN DIP (DL)	1.0 EA	#U002
410 0413 000	INSULATOR PAD FOR TO-247	7.0 EA	

			#Q002 #Q003 #Q004 #Q005 #Q006 #Q007 #Q008
494 0398 000	CHOKE RF 10.0UH	1.0 EA	L001
494 0402 000	CHOKE RF 22.0UH	1.0 EA	L002
500 0852 000	CAP, MICA, 1000PF 500V 5%	2.0 EA	C013 C014
500 0902 000	CAP, MICA, 3300PF 500V 5%	2.0 EA	C004 C005
506 0245 000	CAP.33UF 63V 5%	1.0 EA	C001
516 0375 000	CAP .01UF 50V -20/+80% Z5U	3.0 EA	C002 C006 C007
516 0453 000	CAP .1UF 100V 20% X7R	6.0 EA	C003 C008 C009 C010 C011 C012
540 1600 209	RES 220 OHM 3W 5%	2.0 EA	R005 R067
542 0005 000	RES 5 OHM 5% 8W	6.0 EA	R058 R059 R060 R061 R064 R065
546 0295 000	RES 50 OHM 3.25W 5%	1.0 EA	R006
548 2400 166	RES 47.5 OHM 1/2W 1%	1.0 EA	R021
548 2400 201	RES 100 OHM 1/2W 1%	8.0 EA	R023 R026 R027 R032 R035 R036 R062 R063
548 2400 269	RES 511 OHM 1/2W 1%	1.0 EA	R066
548 2400 293	RES 909 OHM 1/2W 1%	1.0 EA	R003
548 2400 301	RES 1K OHM 1/2W 1%	2.0 EA	R009 R016
548 2400 347	RES 3.01K OHM 1/2W 1%	1.0 EA	R001
548 2400 365	RES 4.64K OHM 1/2W 1%	2.0 EA	R044 R045
548 2400 368	RES 4.99K OHM 1/2W 1%	2.0 EA	R008 R010
548 2400 401	RES 10K OHM 1/2W 1%	3.0 EA	R020 R022 R033
548 2400 426	RES 18.2K OHM 1/2W 1%	1.0 EA	R013
548 2400 466	RES 47.5K OHM 1/2W 1%	1.0 EA	R014
548 2400 485	RES 75K OHM 1/2W 1%	1.0 EA	R011
548 2400 501	RES 100K OHM 1/2W 1%	3.0 EA	R004 R025 R034
548 2400 542	RES 267K OHM 1/2W 1%	2.0 EA	R041 R042
548 2400 566	RES 475K OHM 1/2W 1%	2.0 EA	R019 R024
548 2400 601	RES 1MEG OHM 1/2W 1%	13.0 EA	R015 R046 R047 R048 R049 R050 R051 R052 R053 R054 R055 R056 R057
550 0858 000	POT 5K OHM .5W 10%	1.0 EA	R002
550 0958 000	POT 10K OHM 1/2 W 10%	1.0 EA	R012
604 1066 000	SW, PC MT SLIDE SPDT	1.0 EA	
610 0933 000	JUMPER, PWB TEST POINT	7.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007
610 0980 000	HDR 20C 2ROW RT ANG	1.0 EA	J004
610 1001 000	HDR, 10 PIN RTANG	2.0 EA	J002 J003
620 0515 000	RECP, SCREW ON SMC	1.0 EA	J001
839 7855 004	SCHEM, DRIVER SUPPLY REG	0.0 EA	
839 7855 030	HEATSINK	1.0 EA	
843 5100 018	PWB, DRIVER SUPPLY REG	1.0 EA	
922 0922 156	TRANSFORMER	1.0 EA	T001
999 2566 001	HARDWARE LIST	1.0 EA	

Table 7-7. PWA, BUFFER AMP - 992 8038 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
380 0586 000	XSTR, MJE200 ESD	1.0 EA	Q001
380 0587 000	XSTR, MJE210 ESD	1.0 EA	Q002
380 0665 000	XSTR, MOS FET MTP15N06V ESD	2.0 EA	Q003 Q004
382 1010 000	IC, DS0026CN/MMH0026CP1 ESD	1.0 EA	U001
384 0612 000	DIODE 1N3070 ESD	2.0 EA	CR001 CR002
384 0662 000	LED RED ESD	3.0 EA	DS001 DS002 DS003
384 0802 000	TRANSZORB, BIPOLAR 18V 5% ESD	2.0 EA	CR003 CR004

WARNING: Disconnect primary power prior to servicing.

386 0169 000	ZENER, 1N5352A 15V ESD	1.0 EA	CR005
398 0019 000	FUSE, FAST CART 2A 250V	1.0 EA	F003
398 0020 000	FUSE, FAST CART 3A 250V	2.0 EA	F001 F002
402 0129 000	CLIP, 1/4 DIA FUSE	6.0 EA	2#F001 2#F002 2#F003
404 0733 000	HEAT SINK	2.0 EA	
404 0745 000	HEAT SINK FOR DIP IC'S	1.0 EA	#U001
494 0377 000	CHOKE RF 0.27UH	1.0 EA	L001
494 0386 000	CHOKE RF 1.50UH	1.0 EA	L002
506 0230 000	CAP .001UF 100VAC 5%	1.0 EA	C001
506 0233 000	CAP .1UF 63V 5%	1.0 EA	C002
506 0246 000	CAP .47UF 63V 5%	4.0 EA	C008 C009 C018 C020
508 0378 000	CAP .22 UF 100V 10%	1.0 EA	C003
516 0081 000	CAP, DISC .01UF 1KV 20%	2.0 EA	C019 C021
522 0255 000	CAP 15 UF 50V	1.0 EA	C010
526 0342 000	CAP 2.7UF 35V 10%	1.0 EA	C007
540 1600 011	RES 2.7 OHM 3W 5%	1.0 EA	R022
540 1600 017	RES 4.7 OHM 3W 5%	5.0 EA	R005 R008 R009 R010 R011
540 1600 201	RES 100 OHM 3W 5%	2.0 EA	R001 R002
540 1600 312	RES 3K OHM 3W 5%	1.0 EA	R020
540 1600 320	RES 6.2K OHM 3W 5%	2.0 EA	R023 R024
542 0060 000	RES 100 OHM 5% 12W	1.0 EA	R021
548 2400 101	RES 10 OHM 1/2W 1%	2.0 EA	R006 R007
548 2400 230	RES 200 OHM 1/2W 1%	1.0 EA	R004
548 2400 301	RES 1K OHM 1/2W 1%	1.0 EA	R003
839 7855 099	SCHEMATIC, BUFFER AMP	0.0 EA	
843 5100 046	PWB, BUFFER AMP	1.0 EA	
929 9009 198	XFMR	1.0 EA	T001

Table 7-8. DRIVER ENC/TEMP - 992 8048 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
354 0309 000	TERM SOLDER	14.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007 TP008 TP009 TP010 TP011 TP012 TP013 TP014
380 0125 000	XSTR, NPN 2N4401 ESD	1.0 EA	Q014
380 0126 000	XSTR, PNP 2N4403 ESD	1.0 EA	Q015
380 0653 000	XSTR, NPN MPS6602 ESD	6.0 EA	Q001 Q002 Q003 Q004 Q005 Q006
380 0708 000	XSTR MPS6652 40V 1A ESD	6.0 EA	Q007 Q008 Q009 Q010 Q011 Q012
382 0171 000	IC 3-TERM POS REG ESD	1.0 EA	U013
382 0184 000	IC, 340T-5/7805 +5V REG ESD	1.0 EA	U014
382 0291 000	IC, 75188/1488 ESD	2.0 EA	U001 U002
382 0415 000	IC, 324 ESD	2.0 EA	U009 U010
382 0428 000	IC, LM358 ESD	1.0 EA	U018
382 0605 000	IC 7905C ESD	1.0 EA	U015
382 0768 000	IC, 74HC00 ESD	1.0 EA	U008
382 0781 000	IC, 74HC74 ESD	1.0 EA	U004
382 1082 000	*IC, 74HC423 ESD	1.0 EA	U012
382 1084 000	IC, LP339N ESD	4.0 EA	U003 U007 U011 U019
382 1199 000	IC, LM35 ESD	2.0 EA	U016 U017
384 0321 000	DIODE 5082-2800/1N5711 ESD	3.0 EA	CR015 CR016 CR019
384 0431 000	RECT. 1N4001 ESD	4.0 EA	CR008 CR009 CR011 CR013
384 0610 000	LED, GREEN ESD	3.0 EA	DS004 DS005 DS006
384 0611 000	LED, RED ESD	3.0 EA	DS002 DS007 DS008
384 0612 000	DIODE 1N3070 ESD	3.0 EA	CR001 CR002 CR012

384 0679 000	LED, YELLOW ESD	2.0 EA	DS001 DS003
384 0719 000	TRANSZORB 1N6373 5V 5W ESD	2.0 EA	CR017 CR018
386 0082 000	ZENER, 1N4744A 15V 1W 5% ESD	4.0 EA	CR003 CR004 CR005 CR006
386 0135 000	ZENER, 1N4733A 5.1V ESD	1.0 EA	CR014
386 0419 000	ZENER, LM236H 2.5V ESD	1.0 EA	CR007
398 0019 000	FUSE, FAST CART 2A 250V	3.0 EA	F001 F002 F003
402 0129 000	CLIP, 1/4 DIA FUSE	6.0 EA	XF001 XF002 XF003
404 0513 000	HEAT SINK PA1-1CB	3.0 EA	#U013 #U014 #U015
404 0673 000	SOCKET 8 PIN DIP (DL)	1.0 EA	XU018
404 0674 000	SOCKET 14 PIN DIP (D-L)	10.0 EA	XU001 XU002 XU003 XU004 XU007 XU008 XU009 XU010 XU011 XU019
404 0675 000	SOCKET IC 16 CONT	1.0 EA	XU012
516 0453 000	CAP .1UF 100V 20% X7R	27.0 EA	C002 C003 C004 C005 C006 C007 C009 C012 C013 C020 C021 C022 C023 C024 C025 C026 C029 C030 C032 C033 C035 C037 C038 C039 C040 C041 C042
516 0530 000	CAP .01UF 10% 100V X7R	1.0 EA	C036
522 0531 000	CAP 1UF 50V 20%	3.0 EA	C014 C015 C016
522 0548 000	CAP 10UF 50V 20%	4.0 EA	C011 C017 C018 C019
526 0050 000	CAP 1UF 35V 20%	4.0 EA	C010 C028 C031 C034
526 0308 000	CAP 22UF 10V 20%	1.0 EA	C001
526 0359 000	CAP 47UF 25V 10%	1.0 EA	C027
540 1380 000	RES NETWORK 10K OHM 2%	2.0 EA	R100 R107
540 1443 000	RES NETWORK 27 OHM 2%	1.0 EA	R106
544 1662 000	RES 30 OHM 20W 2% TO-220	1.0 EA	R091
548 2400 142	RES 26.7 OHM 1/2W 1%	1.0 EA	R083
548 2400 185	RES 75 OHM 1/2W 1%	2.0 EA	R093 R096
548 2400 201	RES 100 OHM 1/2W 1%	2.0 EA	R044 R045
548 2400 209	RES 121 OHM 1/2W 1%	18.0 EA	R001 R002 R003 R004 R005 R006 R007 R008 R009 R010 R011 R012 R013 R014 R015 R200 R201 R202
548 2400 247	RES 301 OHM 1/2W 1%	5.0 EA	R023 R024 R063 R072 R073
548 2400 268	RES 499 OHM 1/2W 1%	1.0 EA	R062
548 2400 269	RES 511 OHM 1/2W 1%	6.0 EA	R081 R086 R087 R088 R099 R108
548 2400 301	RES 1K OHM 1/2W 1%	18.0 EA	R018 R021 R029 R033 R040 R043 R047 R052 R053 R056 R057 R065 R066 R067 R077 R078 R079 R080
548 2400 318	RES 1.5K OHM 1/2W 1%	2.0 EA	R061 R084
548 2400 359	RES 4.02K OHM 1/2W 1%	1.0 EA	R064
548 2400 366	RES 4.75K OHM 1/2W 1%	1.0 EA	R102
548 2400 377	RES 6.19K OHM 1/2W 1%	1.0 EA	R046
548 2400 390	RES 8.45K OHM 1/2W 1%	1.0 EA	R048
548 2400 401	RES 10K OHM 1/2W 1%	14.0 EA	R026 R027 R031 R037 R038 R041 R054 R055 R058 R059 R069 R082 R089 R101
548 2400 409	RES 12.1K OHM 1/2W 1%	2.0 EA	R075 R076
548 2400 426	RES 18.2K OHM 1/2W 1%	1.0 EA	R103
548 2400 430	RES 20K OHM 1/2W 1%	1.0 EA	R016
548 2400 451	RES 33.2K OHM 1/2W 1%	2.0 EA	R025 R036
548 2400 469	RES 51.1K OHM 1/2W 1%	2.0 EA	R068 R070
548 2400 501	RES 100K OHM 1/2W 1%	9.0 EA	R020 R028 R032 R034 R035 R039 R042 R085 R090
548 2400 530	RES 200K OHM 1/2W 1%	2.0 EA	R092 R095
548 2400 589	RES 825K OHM 1/2W 1%	2.0 EA	R094 R097
548 2400 601	RES 1MEG OHM 1/2W 1%	2.0 EA	R104 R105

WARNING: Disconnect primary power prior to servicing.

550 0858 000	POT 5K OHM .5W 10%	2.0 EA	R049 R060
550 0956 000	POT 2000 OHM 1/2W 10%	1.0 EA	R098
550 0958 000	POT 10K OHM 1/2 W 10%	4.0 EA	R017 R019 R050 R051
604 0904 000	SW, TGL SPDT	2.0 EA	S001 S002
604 0905 000	SW, PB MOMENTARY	1.0 EA	S003
610 0679 000	PLUG, SHORTING, .25" CTRS	1.0 EA	P005
610 0900 000	HEADER 3 CKT STRAIGHT	3.0 EA	JP001 JP002 JP003
610 0981 000	HDR 20C 2ROW VERTICAL	2.0 EA	J001 J002
610 0998 000	HDR, 6 PIN, PC BD	1.0 EA	J004
610 1027 000	HEADER, MALE 12 PIN	1.0 EA	J003
612 0904 000	JACK, PC MT GOLD PLATED	3.0 EA	3#J5
612 1184 000	SHUNT JUMPER 0.1" CENTERS	3.0 EA	#JP001 #JP002 #JP003
817 2150 007	AIR SENSE ANGLE	1.0 EA	#R091
839 7855 175	SCHEM, DRIVER ENCODER	0.0 EA	
843 5100 093	PWB, DRIVER ENCODER	1.0 EA	
999 2569 001	HARDWARE LIST	1.0 EA	

Table 7-9. OSCILLATOR - 992 8069 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
354 0309 000	TERM SOLDER	11.0 EA	E001 E002 E003 E004 TP001 TP002 TP003 TP004 TP005 TP006 TP007
358 2399 000	STUD, PC BD 4-40 X 1/2	2.0 EA	#Y001 #Y002
380 0083 000	XSTR, 2N2369 ESD	6.0 EA	Q001 Q002 Q003 Q004 Q005 Q006
382 0360 000	IC, 7915 ESD	1.0 EA	U006
382 0783 000	IC, 74HC76 ESD	2.0 EA	U001 U002
382 1010 000	IC, DS0026CN/MMH0026CP1 ESD	2.0 EA	U003 U005
382 1077 000	IC 301 ANALOG SWITCH SPDT ESD	1.0 EA	U004
384 0205 000	DIODE SILICON 1N914/4148 ESD	7.0 EA	CR002 CR003 CR006 CR007 CR008 CR009 CR010
384 0431 000	RECT. 1N4001 ESD	1.0 EA	CR005
386 0082 000	ZENER, 1N4744A 15V 1W 5% ESD	1.0 EA	CR001
386 0093 000	ZENER, 1N4728A 3.3V ESD	2.0 EA	CR011 CR012
386 0135 000	ZENER, 1N4733A 5.1V ESD	1.0 EA	CR004
386 0429 000	ZENER 1N5346A 9.1V 5W 10% ESD	1.0 EA	CR013
398 0015 000	FUSE,FAST CART .500A 250V	2.0 EA	F001 F002
402 0129 000	CLIP, 1/4 DIA FUSE	4.0 EA	#F001 #F002
404 0513 000	HEAT SINK PA1-1CB	1.0 EA	#U006
404 0673 000	SOCKET 8 PIN DIP (DL)	3.0 EA	#S001 #U003 #U005
404 0674 000	SOCKET 14 PIN DIP (D-L)	1.0 EA	XU004
404 0675 000	SOCKET IC 16 CONT	2.0 EA	XU001 XU002
404 0790 000	HEATSINK, 8-PIN DIP	1.0 EA	#U003
414 0087 000	BEAD FERRITE SHIELD	2.0 EA	L001 L002
492 0639 000	COIL, VAR 1.44-2.94UH	1.0 EA	L004
494 0196 000	CHOKE RF 100UH	1.0 EA	L003
500 0812 000	CAP, MICA, 30PF 500V 5%	2.0 EA	C002 C004
500 0822 000	CAP, MICA, 75PF 500V 5%	1.0 EA	C007
500 0831 000	CAP MICA 250UUF 500V	1.0 EA	C005
500 0888 000	CAP, MICA, 3900PF 500V 5%	1.0 EA	C037
506 0230 000	CAP .001UF 100VAC 5%	7.0 EA	C013 C014 C017 C018 C027 C029 C030
506 0232 000	CAP .01UF 100V 5%	2.0 EA	C009 C019
506 0234 000	CAP .0022UF 100V 5%	1.0 EA	C031
506 0236 000	CAP .0047UF 100/63V 5%	1.0 EA	C032
506 0237 000	CAP .0068UF 100V 5%	1.0 EA	C033

WARNING: Disconnect primary power prior to servicing.

506 0246 000	CAP .47UF 63V 5%	1.0 EA	C006
516 0375 000	CAP .01UF 50V -20/+80% Z5U	2.0 EA	C023 C024
516 0453 000	CAP .1UF 100V 20% X7R	10.0 EA	C011 C012 C015 C016 C020 C021 C026 C028 C034 C038
516 0736 000	CAP .001UF 10% 100V X7R	1.0 EA	C039
520 0439 000	CAP, AIR VAR 2.4-24.5PF	2.0 EA	C001 C003
522 0531 000	CAP 1UF 50V 20%	2.0 EA	C022 C025
526 0342 000	CAP 2.7UF 35V 10%	2.0 EA	C008 C036
526 0358 000	CAP 22UF 35V 10%	1.0 EA	C010
540 1600 111	RES 27 OHM 3W 5%	1.0 EA	R039
540 1600 211	RES 270 OHM 3W 5%	2.0 EA	R011 R012
540 1600 212	RES 300 OHM 3W 5%	2.0 EA	R006 R007
546 0295 000	RES 50 OHM 3.25W 5%	5.0 EA	R013 R017 R031 R037 R038
548 2400 158	RES 39.2 OHM 1/2W 1%	1.0 EA	R003
548 2400 169	RES 51.1 OHM 1/2W 1%	3.0 EA	R029 R040 R041
548 2400 201	RES 100 OHM 1/2W 1%	2.0 EA	R022 R025
548 2400 230	RES 200 OHM 1/2W 1%	1.0 EA	R036
548 2400 242	RES 267 OHM 1/2W 1%	1.0 EA	R004
548 2400 285	RES 750 OHM 1/2W 1%	2.0 EA	R009 R035
548 2400 301	RES 1K OHM 1/2W 1%	10.0 EA	R005 R015 R016 R026 R027 R028 R030 R032 R042 R044
548 2400 334	RES 2.21K OHM 1/2W 1%	2.0 EA	R008 R023
548 2400 366	RES 4.75K OHM 1/2W 1%	2.0 EA	R010 R034
548 2400 373	RES 5.62K OHM 1/2W 1%	1.0 EA	R024
548 2400 401	RES 10K OHM 1/2W 1%	5.0 EA	R019 R021 R033 R043 R045
548 2400 426	RES 18.2K OHM 1/2W 1%	1.0 EA	R002
548 2400 430	RES 20K OHM 1/2W 1%	1.0 EA	R014
548 2400 458	RES 39.2K OHM 1/2W 1%	1.0 EA	R001
548 2400 501	RES 100K OHM 1/2W 1%	1.0 EA	R046
548 2400 601	RES 1MEG OHM 1/2W 1%	2.0 EA	R018 R020
558 0041 000	OVEN, XTAL HC6/U 19VDC	2.0 EA	#Y001 #Y002
604 0852 000	SW, RKR DIP 4-SPST	1.0 EA	S001
610 0679 000	PLUG, SHORTING, .25" CTRS	6.0 EA	P001 P002 P003 P004 P005 P006
610 0777 000	HDR 3C 1ROW STRAIGHT	1.0 EA	J003
610 0979 000	HDR 10C 2ROW VERTICAL	1.0 EA	J007
610 0999 000	HDR, 10 PIN, PC BD	2.0 EA	J001 J004
612 0904 000	JACK, PC MT GOLD PLATED	18.0 EA	3XP001 3XP002 3XP003 3XP004 3XP005 3XP006
612 1206 000	JACK, PC MT FOR .050 PINS	4.0 EA	#Y001 #Y002
620 1677 000	RECEPTACLE, PC MT, BNC	2.0 EA	J002 J005
829 9009 051	BRACKET, OSC. HEATER	2.0 EA	
839 7930 032	SCHEM, OSCILLATOR	0.0 EA	
843 5155 032	PWB, OSCILLATOR	1.0 EA	
999 2450 002	HARDWARE LIST	1.0 EA	

Table 7-10. CONTROLLER BOARD - 992 8071 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
354 0309 000	TERM SOLDER	8.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007 TP008
358 1928 000	JUMPER 1/4 LG 1/8H	6.0 EA	JP001 JP002 JP007 JP008 JP009 JP010
358 3052 000	HOLDER, AA SIZE BATTERY	3.0 EA	BT1 BT2 BT3
380 0125 000	XSTR, NPN 2N4401 ESD	1.0 EA	Q008
380 0672 000	XSTR, D45H8 ESD	2.0 EA	Q001 Q002

380 0673 000	XSTR, NPN D44H8 ESD	1.0 EA	Q004
380 0678 000	XSTR, ARRAY QUAD 2222 ESD	6.0 EA	Q003 Q005 Q006 Q007 Q009 Q010
382 0082 000	* IC 7420	4.0 EA	U002 U014 U026 U057
382 0309 000	IC, SN74LS08N ESD	2.0 EA	U001 U039
382 0594 000	IC TL074ACN ESD	3.0 EA	U063 U064 U065
382 0637 000	IC, 74LS30 ESD	4.0 EA	U003 U013 U015 U027
382 0676 000	IC, 74LS05N ESD	6.0 EA	U004 U005 U016 U017 U028 U029
382 0769 000	IC 74HC02 ESD	1.0 EA	U060
382 0770 000	IC, 74HC04 ESD	2.0 EA	U025 U041
382 0771 000	IC 74HC08 ESD	1.0 EA	U053
382 0774 000	IC 74HC14 ESD	5.0 EA	U049 U050 U055 U059 U062
382 0776 000	IC, 74HC27 ESD	1.0 EA	U052
382 0778 000	IC, 74HC32 ESD	2.0 EA	U051 U058
382 0781 000	IC, 74HC74 ESD	2.0 EA	U024 U038
382 0791 000	IC, 74HC138 ESD	1.0 EA	U042
382 0807 000	IC, 74HC175 ESD	1.0 EA	U040
382 0808 000	IC, 74HC192 ESD	9.0 EA	U006 U007 U008 U018 U019 U020 U030 U031 U032
382 0853 000	IC, 74HC4050 ESD	3.0 EA	U046 U047 U054
382 0974 000	IC, 74LS148 ESD	1.0 EA	U044
382 0976 000	IC, 14490 ESD	1.0 EA	U045
382 1048 000	* IC, UC3834N ESD	3.0 EA	U012 U036 U048
382 1079 000	IC 74HC123 ESD	1.0 EA	U056
382 1080 000	IC 74HCT04 HEX INVERTER ESD	1.0 EA	U043
382 1082 000	*IC, 74HC423 ESD	1.0 EA	U061
382 1084 000	IC, LP339N ESD	1.0 EA	U037
382 1098 000	IC 74LS126AN ESD	9.0 EA	U009 U010 U011 U021 U022 U023 U033 U034 U035
384 0205 000	DIODE SILICON 1N914/4148 ESD	6.0 EA	CR012 CR013 CR015 CR016 CR017 CR018
384 0321 000	DIODE 5082-2800/1N5711 ESD	1.0 EA	CR011
384 0431 000	RECT. 1N4001 ESD	3.0 EA	CR001 CR004 CR009
384 0611 000	LED, RED ESD	1.0 EA	DS001
384 0719 000	TRANSZORB 1N6373 5V 5W ESD	1.0 EA	CR002
384 0720 000	TRANSZORB 1N6377 15V 5W ESD	2.0 EA	CR005 CR010
384 0805 000	RECTIFIER 1N5391 ESD	3.0 EA	CR003 CR006 CR007
386 0082 000	ZENER, 1N4744A 15V 1W 5% ESD	1.0 EA	CR019
386 0297 000	ZENER 1N5338B 5.1V 5W 5% ESD	1.0 EA	CR014
386 0428 000	DIODE LM385-1.2 1.235V 1% ESD	1.0 EA	CR008
398 0015 000	FUSE,FAST CART .500A 250V	2.0 EA	F001 F002
398 0019 000	FUSE, FAST CART 2A 250V	1.0 EA	F003
402 0129 000	CLIP, 1/4 DIA FUSE	6.0 EA	#F001 #F002 #F003
404 0513 000	HEAT SINK PA1-1CB	3.0 EA	#Q001 #Q002 #Q004
404 0674 000	SOCKET 14 PIN DIP (D-L)	50.0 EA	#U001 #U002 #U003 #U004 #U005 #U009 #U010 #U011 #U013 #U014 #U015 #U016 #U017 #U021 #U022 #U023 #U024 #U025 #U026 #U027 #U028 #U029 #U033 #U034 #U035 #U037 #U038 #U039 #U041 #U043 #U049 #U050 #U051 #U052 #U053 #U055 #U057 #U058 #U059 #U060 #U062 #U063 #U064 #U065 #Q003 #Q005 #Q006 #Q007 #Q009 #Q010
404 0675 000	SOCKET IC 16 CONT	21.0 EA	#U006 #U007 #U008 #U012 #U018 #U019 #U020 #U030 #U031 #U032 #U036 #U040 #U042 #U044

			#U045 #U046 #U047 #U048 #U054 #U056 #U061
410 0405 000	INSULATOR XSTR TO220	3.0 EA	#Q001 #Q002 #Q004
506 0242 000	CAP .068UF 63V 5%	1.0 EA	C025
506 0246 000	CAP .47UF 63V 5%	1.0 EA	C041
516 0453 000	CAP .1UF 100V 20% X7R	67.0 EA	C001 C002 C003 C004 C005 C006 C007 C008 C009 C010 C011 C014 C015 C016 C017 C018 C019 C020 C021 C022 C023 C024 C027 C028 C029 C030 C031 C032 C033 C034 C035 C036 C037 C038 C045 C046 C047 C048 C049 C050 C051 C052 C053 C054 C055 C056 C060 C061 C062 C063 C064 C065 C066 C067 C068 C069 C076 C091 C092 C093 C095 C096 C110 C111 C112 C113 C114
516 0530 000	CAP .01UF 10% 100V X7R	11.0 EA	C013 C039 C042 C043 C058 C059 C070 C074 C075 C109 C119
516 0774 000	CAP 56PF 5% 100V C0G	8.0 EA	C099 C100 C101 C102 C120 C121 C122 C123
516 0777 000	CAP 100PF 5% 100V C0G	3.0 EA	C085 C087 C089
516 0792 000	CAP NETWORK .1UF 10%	4.0 EA	C078 C079 C116 C117
516 0891 000	CAP 0.100UF 10% 50V	2.0 EA	C124 C125
522 0531 000	CAP 1UF 50V 20%	5.0 EA	C073 C081 C103 C104 C105
522 0548 000	CAP 10UF 50V 20%	10.0 EA	C026 C080 C083 C090 C094 C097 C098 C108 C115 C118
522 0554 000	CAP 4.7UF 50V 20%	9.0 EA	C012 C040 C057 C082 C084 C086 C088 C106 C107
522 0570 000	CAP 2.2UF 50V 20%	1.0 EA	C077
526 0311 000	CAP 2.2UF 35V 10%	2.0 EA	C126 C127
526 0314 000	CAP 33UF 10V 20%	1.0 EA	C072
526 0333 000	CAP 15UF 20V 20%	1.0 EA	C071
526 0374 000	CAP 1.0F 5.5V	1.0 EA	C044
540 1356 000	RES NETWORK 10K OHM 2%	2.0 EA	R080 R081
540 1377 000	RES NETWORK 3300 OHM 2%	1.0 EA	R025
540 1380 000	RES NETWORK 10K OHM 2%	8.0 EA	R001 R002 R010 R013 R022 R077 R078 R079
540 1387 000	RES NETWORK 10K OHM 2%	3.0 EA	R044 R083 R084
540 1434 000	RES NETWORK 330 OHM 2%	2.0 EA	R023 R024
540 1530 000	RES NETWORK 10 OHM 2%	2.0 EA	R054 R082
540 1600 108	RES 20 OHM 3W 5%	1.0 EA	R017
540 1600 211	RES 270 OHM 3W 5%	3.0 EA	R003 R014 R026
540 1600 215	RES 390 OHM 3W 5%	2.0 EA	R060 R061
548 2400 169	RES 51.1 OHM 1/2W 1%	1.0 EA	R018
548 2400 201	RES 100 OHM 1/2W 1%	11.0 EA	R005 R012 R015 R037 R045 R050 R051 R053 R097 R102 R103
548 2400 215	RES 140 OHM 1/2W 1%	1.0 EA	R034
548 2400 230	RES 200 OHM 1/2W 1%	1.0 EA	R004
548 2400 234	RES 221 OHM 1/2W 1%	1.0 EA	R039
548 2400 293	RES 909 OHM 1/2W 1%	2.0 EA	R011 R027
548 2400 301	RES 1K OHM 1/2W 1%	5.0 EA	R055 R056 R087 R093 R095
548 2400 307	RES 1.15K OHM 1/2W 1%	1.0 EA	R008
548 2400 330	RES 2K OHM 1/2W 1%	5.0 EA	R009 R071 R098 R100 R101
548 2400 347	RES 3.01K OHM 1/2W 1%	2.0 EA	R069 R099
548 2400 350	RES 3.24K OHM 1/2W 1%	1.0 EA	R007
548 2400 351	RES 3.32K OHM 1/2W 1%	1.0 EA	R052
548 2400 354	RES 3.57K OHM 1/2W 1%	1.0 EA	R105

548 2400 366	RES 4.75K OHM 1/2W 1%	1.0 EA	R070
548 2400 369	RES 5.11K OHM 1/2W 1%	4.0 EA	R042 R049 R057 R058
548 2400 377	RES 6.19K OHM 1/2W 1%	3.0 EA	R064 R092 R104
548 2400 385	RES 7.5K OHM 1/2W 1%	2.0 EA	R091 R094
548 2400 401	RES 10K OHM 1/2W 1%	3.0 EA	R035 R036 R066
548 2400 418	RES 15K OHM 1/2W 1%	2.0 EA	R047 R074
548 2400 446	RES 29.4K OHM 1/2W 1%	2.0 EA	R067 R068
548 2400 447	RES 30.1K OHM 1/2W 1%	5.0 EA	R063 R088 R089 R090 R096
548 2400 468	RES 49.9K OHM 1/2W 1%	2.0 EA	R073 R086
548 2400 469	RES 51.1K OHM 1/2W 1%	5.0 EA	R040 R048 R062 R075 R076
548 2400 477	RES 61.9K OHM 1/2W 1%	1.0 EA	R033
548 2400 488	RES 80.6K OHM 1/2W 1%	1.0 EA	R038
548 2400 489	RES 82.5K OHM 1/2W 1%	1.0 EA	R065
548 2400 501	RES 100K OHM 1/2W 1%	6.0 EA	R021 R029 R031 R041 R043 R059
548 2400 509	RES 121K OHM 1/2W 1%	2.0 EA	R072 R085
548 2400 530	RES 200K OHM 1/2W 1%	1.0 EA	R019
548 2400 547	RES 301K OHM 1/2W 1%	2.0 EA	R028 R030
548 2400 562	RES 432K OHM 1/2W 1%	1.0 EA	R020
548 2400 566	RES 475K OHM 1/2W 1%	1.0 EA	R006
548 2400 585	RES 750K OHM 1/2W 1%	1.0 EA	R016
548 2400 601	RES 1MEG OHM 1/2W 1%	1.0 EA	R046
548 2400 612	RES 1.3MEG OHM 1/2W 1%	1.0 EA	R032
604 0866 000	SW, PB SNAP ACTION SPDT	1.0 EA	S001
604 1089 000	SW, TGL SPDT PC MOUNT	1.0 EA	S002
610 0980 000	HDR 20C 2ROW RT ANG	1.0 EA	J005
610 0986 000	HDR 40C 2ROW RT ANG	3.0 EA	J002 J007 J008
610 0987 000	HDR 40C 2 ROW STRAIGHT	2.0 EA	J001 J003
610 0999 000	HDR, 10 PIN, PC BD	2.0 EA	J004 J006
610 1112 000	HDR 4C 2R STRT NP	4.0 EA	JP003 JP004 JP005 JP006
612 1184 000	SHUNT JUMPER 0.1" CENTERS	4.0 EA	P001 P002 P003 P004
843 5400 091	SCH, CONTROLLER	0.0 EA	
843 5400 093	PWB, CONTROLLER	1.0 EA	

Table 7-11. LED BOARD - 992 8072 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
358 1928 000	JUMPER 1/4 LG 1/8H	6.0 EA	JP001 JP002 JP003 JP004 JP005 JP006
358 2177 000	SPACER, LED MOUNT .380 LG	2.0 EA	#DS019 #DS020
358 2827 000	SPACER, LED MOUNT .25 LG	26.0 EA	#DS001 #DS002 #DS003 #DS004 #DS005 #DS006 #DS007 #DS008 #DS009 #DS010 #DS011 #DS012 #DS013 #DS014 #DS015 #DS016 #DS017 #DS018 #DS021 #DS022 #DS023 #DS024 #DS025 #DS026 #DS027 #DS028
380 0125 000	XSTR, NPN 2N4401 ESD	1.0 EA	Q001
382 0309 000	IC, SN74LS08N ESD	2.0 EA	U038 U059
382 0452 000	IC, LM311/CA311 ESD	1.0 EA	U043
382 0556 000	IC, 74LS00N ESD	1.0 EA	U062
382 0557 000	IC, 74LS02 ESD	1.0 EA	U060
382 0558 000	IC, 74LS04N TTL INV ESD	6.0 EA	U017 U033 U036 U047 U054 U058
382 0580 000	IC, 74LS32 ESD	1.0 EA	U037
382 0594 000	IC TL074ACN ESD	3.0 EA	U001 U027 U057
382 0648 000	IC, LM339A ESD	5.0 EA	U002 U005 U061 U067 U068
382 0768 000	IC, 74HC00 ESD	2.0 EA	U008 U063
382 0769 000	IC 74HC02 ESD	1.0 EA	U003

WARNING: Disconnect primary power prior to servicing.

382 0770 000	IC, 74HC04 ESD	5.0 EA	U007 U039 U041 U048 U049
382 0771 000	IC 74HC08 ESD	12.0 EA	U006 U009 U016 U020 U022 U023 U025 U031 U034 U045 U064 U065
382 0774 000	IC 74HC14 ESD	5.0 EA	U004 U021 U026 U046 U066
382 0777 000	IC, 74HC30 ESD	1.0 EA	U040
382 0778 000	IC, 74HC32 ESD	3.0 EA	U015 U019 U050
382 0781 000	IC, 74HC74 ESD	8.0 EA	U018 U024 U035 U042 U044 U051 U052 U053
382 0853 000	IC, 74HC4050 ESD	4.0 EA	U013 U014 U055 U056
382 0856 000	IC 74HC4078 ESD	1.0 EA	U032
382 1082 000	*IC, 74HC423 ESD	6.0 EA	U010 U011 U012 U028 U029 U030
384 0205 000	DIODE SILICON 1N914/4148 ESD	9.0 EA	CR003 CR005 CR006 CR007 CR009 CR010 CR011 CR014 CR016
384 0321 000	DIODE 5082-2800/1N5711 ESD	8.0 EA	CR001 CR002 CR008 CR013 CR015 CR017 CR018 CR019
384 0610 000	LED, GREEN ESD	1.0 EA	DS020
384 0611 000	LED, RED ESD	1.0 EA	DS019
384 0612 000	DIODE 1N3070 ESD	1.0 EA	CR012
384 0719 000	TRANSZORB 1N6373 5V 5W ESD	1.0 EA	CR004
384 0808 000	LED, BICOLOR, RED-GREEN ESD	26.0 EA	DS001 DS002 DS003 DS004 DS005 DS006 DS007 DS008 DS009 DS010 DS011 DS012 DS013 DS014 DS015 DS016 DS017 DS018 DS021 DS022 DS023 DS024 DS025 DS026 DS027 DS028
404 0673 000	SOCKET 8 PIN DIP (DL)	1.0 EA	#U043
404 0674 000	SOCKET 14 PIN DIP (D-L)	57.0 EA	#U001 #U002 #U003 #U004 #U005 #U006 #U007 #U008 #U009 #U015 #U016 #U017 #U018 #U019 #U020 #U021 #U022 #U023 #U024 #U025 #U026 #U027 #U031 #U032 #U033 #U034 #U035 #U036 #U037 #U038 #U039 #U040 #U041 #U042 #U044 #U045 #U046 #U047 #U048 #U049 #U050 #U051 #U052 #U053 #U054 #U057 #U058 #U059 #U060 #U061 #U062 #U063 #U064 #U065 #U066 #U067 #U068
404 0675 000	SOCKET IC 16 CONT	10.0 EA	#U010 #U011 #U012 #U013 #U014 #U028 #U029 #U030 #U055 #U056
484 0351 000	LINE DELAY 100+/-NSEC	1.0 EA	DL001
494 0398 000	CHOKE RF 10.0UH	1.0 EA	L001
494 0402 000	CHOKE RF 22.0UH	1.0 EA	L002
500 0753 000	CAP, MICA, 56PF 500V 5%	3.0 EA	C128 C129 C143
500 0756 000	CAP, MICA, 330PF 500V 5%	1.0 EA	C009
500 0844 000	CAP, MICA, 1000PF 100V 5%	1.0 EA	C079
500 0902 000	CAP, MICA, 3300PF 500V 5%	2.0 EA	C005 C010
506 0239 000	CAP .022UF 100V 5%	1.0 EA	C061
508 0543 000	CAP .1UF 160V 1%	6.0 EA	C040 C049 C059 C060 C099 C106
516 0063 000	CAP, DISC .002UF 1KV 20%	1.0 EA	C123
516 0453 000	CAP .1UF 100V 20% X7R	72.0 EA	C001 C003 C004 C006 C008 C015 C016 C019 C025 C031 C034 C035 C036 C037 C038 C041 C043 C045 C046 C051 C055 C056 C065 C067 C068 C087 C088 C089 C091 C092 C094 C095 C102 C105 C107 C111 C112 C113 C114 C115 C116 C117 C118 C119 C120 C121

WARNING: Disconnect primary power prior to servicing.

			C122 C124 C126 C127 C130 C134 C135 C136 C137 C138 C139 C140 C141 C142 C144 C145 C147 C149 C150 C152 C153 C154 C155 C156 C157 C159
516 0511 000	CAP 0.47UF 100V 20%	39.0 EA	C013 C014 C018 C021 C022 C023 C026 C027 C029 C032 C033 C039 C044 C047 C048 C052 C053 C057 C058 C063 C064 C066 C070 C072 C073 C075 C077 C078 C081 C082 C083 C084 C086 C096 C097 C098 C100 C104 C132
516 0530 000	CAP .01UF 10% 100V X7R	4.0 EA	C002 C146 C148 C158
526 0048 000	CAP 10UF 20V 20%	5.0 EA	C020 C030 C069 C131 C133
526 0050 000	CAP 1UF 35V 20%	4.0 EA	C062 C074 C093 C110
526 0093 000	CAP 15UF 35V 20%	1.0 EA	C007
526 0096 000	CAP 100UF 10V 20%	1.0 EA	C080
526 0108 000	CAP 4.7UF 35V 20%	2.0 EA	C085 C125
526 0109 000	CAP 22UF 25V 20%	4.0 EA	C011 C012 C042 C090
526 0125 000	CAP 68UF 6V 20%	1.0 EA	C071
526 0314 000	CAP 33UF 10V 20%	1.0 EA	C076
526 0321 000	CAP 3.3UF 15/16V 20%	3.0 EA	C017 C024 C028
526 0333 000	CAP 15UF 20V 20%	1.0 EA	C050
526 0351 000	CAP 6.8UF 50V 20%	1.0 EA	C151
526 0359 000	CAP 47UF 25V 10%	5.0 EA	C054 C101 C103 C108 C109
540 1370 000	RES NETWORK 220 OHM 2%	5.0 EA	R052 R150 R151 R152 R153
540 1380 000	RES NETWORK 10K OHM 2%	3.0 EA	R155 R186 R187
540 1391 000	RES NETWORK 220 OHM 2%	1.0 EA	R196
540 1421 000	RES NETWORK 4700 OHM 2%	1.0 EA	R156
540 1430 000	RES NETWORK, 10K OHM 2%	2.0 EA	R100 R147
540 1444 000	RES NETWORK 150 OHM 2%	6.0 EA	R098 R120 R122 R148 R160 R163
540 1457 000	RES NETWORK 330 OHM 2%	1.0 EA	R154
540 1484 000	RES, NETWORK 15K OHM 2%	1.0 EA	R185
540 1600 209	RES 220 OHM 3W 5%	2.0 EA	R011 R025
546 0295 000	RES 50 OHM 3.25W 5%	1.0 EA	R006
548 2400 101	RES 10 OHM 1/2W 1%	4.0 EA	R075 R127 R172 R180
548 2400 201	RES 100 OHM 1/2W 1%	5.0 EA	R001 R016 R080 R106 R113
548 2400 218	RES 150 OHM 1/2W 1%	4.0 EA	R083 R164 R166 R168
548 2400 219	RES 154 OHM 1/2W 1%	1.0 EA	R073
548 2400 234	RES 221 OHM 1/2W 1%	13.0 EA	R055 R065 R070 R074 R078 R094 R102 R109 R115 R134 R140 R165 R183
548 2400 251	RES 332 OHM 1/2W 1%	11.0 EA	R027 R039 R071 R079 R084 R105 R110 R112 R117 R124 R149
548 2400 266	RES 475 OHM 1/2W 1%	2.0 EA	R002 R003
548 2400 301	RES 1K OHM 1/2W 1%	3.0 EA	R061 R077 R189
548 2400 330	RES 2K OHM 1/2W 1%	7.0 EA	R010 R014 R017 R092 R096 R108 R193
548 2400 333	RES 2.15K OHM 1/2W 1%	1.0 EA	R028
548 2400 337	RES 2.37K OHM 1/2W 1%	2.0 EA	R126 R132
548 2400 347	RES 3.01K OHM 1/2W 1%	2.0 EA	R049 R121
548 2400 351	RES 3.32K OHM 1/2W 1%	1.0 EA	R023
548 2400 354	RES 3.57K OHM 1/2W 1%	2.0 EA	R135 R162
548 2400 362	RES 4.32K OHM 1/2W 1%	1.0 EA	R034
548 2400 366	RES 4.75K OHM 1/2W 1%	1.0 EA	R136
548 2400 369	RES 5.11K OHM 1/2W 1%	8.0 EA	R051 R057 R088 R130 R138 R167 R173 R190
548 2400 377	RES 6.19K OHM 1/2W 1%	1.0 EA	R009

548 2400 381	RES 6.81K OHM 1/2W 1%	1.0 EA	R033
548 2400 394	RES 9.31K OHM 1/2W 1%	1.0 EA	R107
548 2400 401	RES 10K OHM 1/2W 1%	41.0 EA	R020 R021 R022 R026 R031 R032 R036 R044 R048 R050 R056 R059 R064 R069 R089 R091 R095 R097 R111 R123 R128 R129 R131 R133 R139 R143 R144 R145 R157 R159 R171 R174 R175 R176 R177 R181 R182 R184 R191 R192 R195
548 2400 406	RES 11.3K OHM 1/2W 1%	1.0 EA	R013
548 2400 407	RES 11.5K OHM 1/2W 1%	1.0 EA	R054
548 2400 411	RES 12.7K OHM 1/2W 1%	1.0 EA	R060
548 2400 418	RES 15K OHM 1/2W 1%	4.0 EA	R141 R169 R179 R194
548 2400 430	RES 20K OHM 1/2W 1%	4.0 EA	R005 R035 R072 R104
548 2400 436	RES 23.2K OHM 1/2W 1%	1.0 EA	R085
548 2400 437	RES 23.7K OHM 1/2W 1%	2.0 EA	R170 R188
548 2400 443	RES 27.4K OHM 1/2W 1%	1.0 EA	R037
548 2400 451	RES 33.2K OHM 1/2W 1%	1.0 EA	R142
548 2400 461	RES 42.2K OHM 1/2W 1%	1.0 EA	R093
548 2400 462	RES 43.2K OHM 1/2W 1%	2.0 EA	R087 R101
548 2400 464	RES 45.3K OHM 1/2W 1%	1.0 EA	R043
548 2400 466	RES 47.5K OHM 1/2W 1%	2.0 EA	R015 R178
548 2400 469	RES 51.1K OHM 1/2W 1%	9.0 EA	R038 R040 R045 R062 R076 R090 R119 R125 R137
548 2400 473	RES 56.2K OHM 1/2W 1%	2.0 EA	R053 R058
548 2400 478	RES 63.4K OHM 1/2W 1%	1.0 EA	R029
548 2400 485	RES 75K OHM 1/2W 1%	2.0 EA	R066 R082
548 2400 487	RES 78.7K OHM 1/2W 1%	1.0 EA	R114
548 2400 493	RES 90.9K OHM 1/2W 1%	1.0 EA	R146
548 2400 501	RES 100K OHM 1/2W 1%	9.0 EA	R004 R008 R012 R024 R030 R046 R047 R063 R116
548 2400 518	RES 150K OHM 1/2W 1%	1.0 EA	R158
548 2400 530	RES 200K OHM 1/2W 1%	2.0 EA	R018 R019
548 2400 547	RES 301K OHM 1/2W 1%	1.0 EA	R099
548 2400 554	RES 357K OHM 1/2W 1%	1.0 EA	R118
548 2400 566	RES 475K OHM 1/2W 1%	1.0 EA	R081
548 2400 581	RES 681K OHM 1/2W 1%	2.0 EA	R007 R161
548 2400 638	RES 2.43MEG OHM 1/2W 1%	1.0 EA	
550 0949 000	POT 100K OHM 1/2W 10%	1.0 EA	R086
550 0958 000	POT 10K OHM 1/2 W 10%	3.0 EA	R041 R042 R068
550 1059 000	POT, 200 OHM 1/2W 10%	1.0 EA	R067
604 0904 000	SW, TGL SPDT	1.0 EA	S004
604 0905 000	SW, PB MOMENTARY	3.0 EA	S001 S002 S003
610 0933 000	JUMPER, PWB TEST POINT	15.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007 TP008 TP009 TP010 TP011 TP012 TP013 TP014 TP015
610 0978 000	HDR 10C 2ROW RT ANG	2.0 EA	J001 J009
610 0983 000	HDR 26C 2ROW RT ANG	1.0 EA	J003
610 0986 000	HDR 40C 2ROW RT ANG	2.0 EA	J007 J008
610 0987 000	HDR 40C 2 ROW STRAIGHT	1.0 EA	J011
610 0999 000	HDR, 10 PIN, PC BD	5.0 EA	J002 J004 J005 J006 J010
839 7855 184	SCH, LED	0.0 EA	
843 5100 099	PWB, LED	1.0 EA	
922 0922 156	TRANSFORMER	1.0 EA	T001

Table 7-12. ANALOG INPUT - 992 8077 001

HARRIS P/N	DESCRIPTION	QTY/UM	REF. SYMBOLS/EXPLANATIONS
335 0262 000	DF137A INSULATING WASHER	2.0 EA	#Q005 #Q006
380 0126 000	XSTR, PNP 2N4403 ESD	2.0 EA	Q001 Q002
380 0481 000	XSTR, NJFET 2N4092 ESD	2.0 EA	Q007 Q008
380 0672 000	XSTR, D45H8 ESD	1.0 EA	Q006
380 0673 000	XSTR, NPN D44H8 ESD	1.0 EA	Q005
382 0472 000	IC, LM318 ESD	2.0 EA	U003 U019
382 0711 000	PRECISION IC MULTIPLIER ESD	1.0 EA	U010
382 0718 000	IC, AD7525KN ESD	1.0 EA	U008
382 0721 000	IC, MC14504BCP ESD	2.0 EA	U014 U016
382 0749 000	IC NE5532A ESD	6.0 EA	U004 U005 U006 U007 U009 U012
382 0757 000	IC OP-27 ESD	1.0 EA	U011
382 0774 000	IC 74HC14 ESD	1.0 EA	U013
382 1048 000	* IC, UC3834N ESD	2.0 EA	U001 U002
382 1065 000	IC 74HCT273 ESD	2.0 EA	U017 U018
384 0205 000	DIODE SILICON 1N914/4148 ESD	2.0 EA	CR009 CR010
384 0321 000	DIODE 5082-2800/1N5711 ESD	3.0 EA	CR003 CR021 CR022
384 0431 000	RECT. 1N4001 ESD	2.0 EA	CR017 CR019
384 0612 000	DIODE 1N3070 ESD	1.0 EA	CR020
384 0720 000	TRANSZORB 1N6377 15V 5W ESD	2.0 EA	CR016 CR018
384 0799 000	DIODE, BIPOLAR ESD	3.0 EA	CR001 CR002 CR007
386 0135 000	ZENER, 1N4733A 5.1V ESD	4.0 EA	CR006 CR011 CR012 CR015
398 0015 000	FUSE,FAST CART .500A 250V	2.0 EA	F002 F003
402 0129 000	CLIP, 1/4 DIA FUSE	4.0 EA	XF002 XF003
404 0303 000	SOCKET IC 10 PIN	1.0 EA	XU010
404 0507 000	SOCKET IC 18 PIN	1.0 EA	XU008
404 0673 000	SOCKET 8 PIN DIP (DL)	9.0 EA	XU003 XU004 XU005 XU006 XU007 XU009 XU011 XU012 XU019
404 0674 000	SOCKET 14 PIN DIP (D-L)	1.0 EA	XU013
404 0675 000	SOCKET IC 16 CONT	4.0 EA	XU001 XU002 XU014 XU016
404 0704 000	SOCKET IC 20 PIN	2.0 EA	XU017 XU018
404 0758 000	HEAT SINK FOR TO-220	1.0 EA	#Q005 #Q006
410 0405 000	INSULATOR XSTR TO220	2.0 EA	#Q005 #Q006
494 0395 000	CHOKE 40UH 2 AMP	2.0 EA	L006 L007
494 0415 000	CHOKE RF 470.0UH	2.0 EA	L001 L003
494 0418 000	CHOKE RF 820.0UH	2.0 EA	L002 L004
500 0759 000	CAP, MICA, 100PF 500V 5%	2.0 EA	C077 C080
500 1064 000	CAP, MICA, 5100PF 500V 5%	2.0 EA	C001 C002
506 0232 000	CAP .01UF 100V 5%	1.0 EA	C052
506 0240 000	CAP .033UF 100/63V 5%	2.0 EA	C003 C004
506 0243 000	CAP .15UF 63V 5%	1.0 EA	C076
506 0246 000	CAP .47UF 63V 5%	7.0 EA	C005 C006 C007 C008 C046 C051 C053
506 0262 000	CAP .047UF 100V 5%	1.0 EA	C083
508 0547 000	CAP .01UF 160V 1%	1.0 EA	C062
516 0375 000	CAP .01UF 50V -20/+80% Z5U	20.0 EA	C010 C012 C016 C019 C023 C024 C028 C030 C031 C033 C035 C037 C040 C043 C049 C056 C059 C074 C082 C085
516 0453 000	CAP .1UF 100V 20% X7R	28.0 EA	C009 C011 C017 C018 C022 C025 C027 C029 C032 C036 C038 C041 C044 C047 C050 C057 C058 C060 C061 C063 C064 C066 C067 C068 C069 C070 C071 C087
516 0765 000	CAP 10PF 5% 100V C0G	6.0 EA	C021 C026

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			C039 C042 C055 C065
516 0774 000	CAP 56PF 5% 100V C0G	5.0 EA	C013 C014 C015 C020 C034
516 0891 000	CAP 0.100UF 10% 50V	2.0 EA	C091 C093
522 0554 000	CAP 4.7UF 50V 20%	4.0 EA	C073 C078 C079 C081
526 0048 000	CAP 10UF 20V 20%	2.0 EA	C075 C084
526 0108 000	CAP 4.7UF 35V 20%	3.0 EA	C048 C054 C072
526 0109 000	CAP 22UF 25V 20%	2.0 EA	C086 C088
526 0311 000	CAP 2.2UF 35V 10%	2.0 EA	C090 C092
526 0318 000	CAP 10UF 35V 20%	1.0 EA	C089
540 1380 000	RES NETWORK 10K OHM 2%	5.0 EA	R068 R069 R070
			R071 R072
540 1440 000	RES NETWORK 2000 OHM 2%	2.0 EA	R047 R048
540 1600 208	RES 200 OHM 3W 5%	1.0 EA	R066
540 1600 211	RES 270 OHM 3W 5%	2.0 EA	R055 R063
548 2400 101	RES 10 OHM 1/2W 1%	1.0 EA	R034
548 2400 201	RES 100 OHM 1/2W 1%	5.0 EA	R050 R051 R056 R064 R067
548 2400 205	RES 110 OHM 1/2W 1%	4.0 EA	R001 R004 R008 R009
548 2400 215	RES 140 OHM 1/2W 1%	1.0 EA	R060
548 2400 247	RES 301 OHM 1/2W 1%	1.0 EA	R028
548 2400 251	RES 332 OHM 1/2W 1%	2.0 EA	R002 R005
548 2400 258	RES 392 OHM 1/2W 1%	2.0 EA	R003 R006
548 2400 269	RES 511 OHM 1/2W 1%	1.0 EA	R075
548 2400 277	RES 619 OHM 1/2W 1%	1.0 EA	R019
548 2400 281	RES 681 OHM 1/2W 1%	2.0 EA	R007 R010
548 2400 285	RES 750 OHM 1/2W 1%	1.0 EA	R016
548 2400 293	RES 909 OHM 1/2W 1%	2.0 EA	R057 R061
548 2400 301	RES 1K OHM 1/2W 1%	3.0 EA	R024 R030 R038
548 2400 330	RES 2K OHM 1/2W 1%	6.0 EA	R032 R036 R037 R040 R065 R078
548 2400 342	RES 2.67K OHM 1/2W 1%	3.0 EA	R011 R012 R089
548 2400 347	RES 3.01K OHM 1/2W 1%	1.0 EA	R076
548 2400 354	RES 3.57K OHM 1/2W 1%	1.0 EA	R033
548 2400 368	RES 4.99K OHM 1/2W 1%	1.0 EA	R044
548 2400 369	RES 5.11K OHM 1/2W 1%	4.0 EA	R020 R021 R035 R062
548 2400 373	RES 5.62K OHM 1/2W 1%	1.0 EA	R086
548 2400 389	RES 8.25K OHM 1/2W 1%	1.0 EA	R018
548 2400 401	RES 10K OHM 1/2W 1%	4.0 EA	R017 R073 R077 R082
548 2400 405	RES 11K OHM 1/2W 1%	1.0 EA	R046
548 2400 407	RES 11.5K OHM 1/2W 1%	1.0 EA	R039
548 2400 409	RES 12.1K OHM 1/2W 1%	2.0 EA	R079 R080
548 2400 418	RES 15K OHM 1/2W 1%	3.0 EA	R026 R045 R074
548 2400 430	RES 20K OHM 1/2W 1%	4.0 EA	R022 R023 R025 R081
548 2400 439	RES 24.9K OHM 1/2W 1%	1.0 EA	R087
548 2400 466	RES 47.5K OHM 1/2W 1%	1.0 EA	R083
548 2400 469	RES 51.1K OHM 1/2W 1%	1.0 EA	R031
548 2400 481	RES 68.1K OHM 1/2W 1%	1.0 EA	R049
548 2400 485	RES 75K OHM 1/2W 1%	1.0 EA	R085
548 2400 491	RES 86.6K OHM 1/2W 1%	1.0 EA	R029
548 2400 501	RES 100K OHM 1/2W 1%	1.0 EA	R042
548 2400 509	RES 121K OHM 1/2W 1%	1.0 EA	R088
548 2400 601	RES 1MEG OHM 1/2W 1%	2.0 EA	R013 R014
550 0858 000	POT 5K OHM .5W 10%	1.0 EA	R027
550 0949 000	POT 100K OHM 1/2W 10%	1.0 EA	R015
550 0956 000	POT 2000 OHM 1/2W 10%	1.0 EA	R041
550 0959 000	POT 20K OHM 1/2 W 10%	1.0 EA	R084
550 0962 000	POT 200K OHM 1/2W 10%	1.0 EA	R052

WARNING: Disconnect primary power prior to servicing.

550 1070 000	POT 100 OHM 1/2 W 10%	1.0 EA	R043
610 0777 000	HDR 3C 1ROW STRAIGHT	3.0 EA	J001 J002 J003
610 0933 000	JUMPER, PWB TEST POINT	17.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007 TP008 TP009 TP010 TP011 TP012 TP013 TP014 TP015 TP016 TP017
610 0986 000	HDR 40C 2ROW RT ANG	1.0 EA	J004
610 0999 000	HDR, 10 PIN, PC BD	2.0 EA	J005 J006
610 1146 000	PLUG, SHORTING, .4" CTRS	1.0 EA	P001
612 0904 000	JACK, PC MT GOLD PLATED	3.0 EA	XP001
839 7855 100	SCHEMATIC, ANALOG INPUT	0.0 EA	
843 5100 067	PWB, ANALOG INPUT	1.0 EA	
999 2610 001	HARDWARE LIST	1.0 EA	

Table 7-13. OUTPUT SAMPLE - 992 8203 003

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
358 1928 000	JUMPER 1/4 LG 1/8H	1.0 EA	JP004
358 3092 000	STUD, BRS 6-32 X 3/8	4.0 EA	#2C007 2C008 #C009 C010 #C011 C012 #C013 C014
500 0835 000	CAP, MICA, 470PF 500V 5%	2.0 EA	C015 C016
500 0852 000	CAP, MICA, 1000PF 500V 5%	2.0 EA	C008 C017
516 0413 000	CAP 10 PF 7.5KV 10%	8.0 EA	C009 C010 C011 C012 C013 C014 2C007 2C008
546 0316 000	RES 62 OHM 5W 5%	4.0 EA	R001 R002 R003 R004
546 0317 000	RES 120 OHM 5W 5%	8.0 EA	R010 R011 R012 R013 R014 R015 R016 R017
610 0679 000	PLUG, SHORTING, .25" CTRS	2.0 EA	P001 P002
610 0980 000	HDR 20C 2ROW RT ANG	1.0 EA	J001
612 1012 000	JACK PC MT .040 PINS	6.0 EA	3#P001 3#P002
620 1677 000	RECEPTACLE, PC MT, BNC	1.0 EA	J002
817 2150 049	CAP PLATE	1.0 EA	#C012 #C013 #C014
839 7930 018	SCHEMATIC, OUTPUT SAMPLE	0.0 EA	
843 5155 018	PWB, OUTPUT SAMPLE	1.0 EA	
922 0922 025	TRANSFORMER	2.0 EA	T001 T002
922 0922 211	STRAP	1.0 EA	
999 2563 001	HARDWARE LIST	1.0 EA	

Table 7-14. DC REGULATOR - 992 8468 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
354 0309 000	TERM SOLDER	34.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007 TP008 TP009 TP010 TP011 TP012 TP013 TP014 TP015 TP016 TP017 TP018 TP019 TP020 TP021 TP022 TP023 TP024 TP025 TP026 TP027 TP028 TP029 TP030 TP031 TP032 TP033 TP034
358 1928 000	JUMPER 1/4 LG 1/8H	3.0 EA	JP002 JP005 JP006
380 0676 000	*XSTR, NPN 2N5629 ESD	1.0 EA	Q004
380 0677 000	XSTR, 2N6029 ESD	1.0 EA	Q003
382 0184 000	IC, 340T-5/7805 +5V REG ESD	1.0 EA	U011
382 0443 000	IC, CD4053BE ESD	1.0 EA	U002
382 0605 000	IC 7905C ESD	1.0 EA	U012
382 0749 000	IC NE5532A ESD	1.0 EA	U010
382 0789 000	IC 74HC132 ESD	1.0 EA	U008

382 0856 000	IC 74HC4078 ESD	1.0 EA	U009
382 1048 000	* IC, UC3834N ESD	2.0 EA	U013 U015
382 1084 000	IC, LP339N ESD	2.0 EA	U014 U016
382 1171 000	IC 74HC540 (ESD)	1.0 EA	U007
382 1211 000	IC ICL7136 ESD	1.0 EA	U001
384 0321 000	DIODE 5082-2800/1N5711 ESD	5.0 EA	CR006 CR009 CR015 CR029 CR040
384 0431 000	RECT. 1N4001 ESD	6.0 EA	CR011 CR012 CR030 CR031 CR032 CR037
384 0612 000	DIODE 1N3070 ESD	11.0 EA	CR001 CR002 CR008 CR013 CR016 CR018 CR019 CR022 CR023 CR035 CR038
384 0661 000	LED, GRN, T 1-3/4, RT ANG ESD	1.0 EA	DS006
384 0662 000	LED RED ESD	5.0 EA	DS005 DS007 DS008 DS009 DS010
384 0719 000	TRANSZORB 1N6373 5V 5W ESD	2.0 EA	CR025 CR027
384 0731 000	* DIODE, SWITCHING 1N4607 ESD	5.0 EA	CR004 CR005 CR017 CR033 CR034
384 0782 000	RECT, MR754 400V 6A ESD	4.0 EA	CR003 CR010 CR024 CR039
386 0124 000	ZENER, 1N4736A 6.8V ESD	2.0 EA	CR026 CR036
386 0341 000	ZENER 1N5341B 6.2V 5% 5W ESD	2.0 EA	CR007 CR021
386 0345 000	ZENER, 1N5342B 6.8V 5% 5W ESD	2.0 EA	CR014 CR028
386 0427 000	ZENER LM-313H 1.22VDC ESD	1.0 EA	CR020
398 0017 000	FUSE, FAST CART 1A 250V	2.0 EA	F001 F004
398 0022 000	FUSE, FAST CART 5A 250V	2.0 EA	F003 F006
398 0453 000	FUSE, FAST CART 7A 250V	1.0 EA	F005
402 0129 000	CLIP, 1/4 DIA FUSE	12.0 EA	XF001 XF002 XF003 XF004 XF005 XF006
404 0513 000	HEAT SINK PA1-1CB	2.0 EA	#U011 #U012
404 0673 000	SOCKET 8 PIN DIP (DL)	2.0 EA	XS002 XU010
404 0674 000	SOCKET 14 PIN DIP (D-L)	6.0 EA	XU004 XU005 XU008 XU009 XU014 XU016
404 0675 000	SOCKET IC 16 CONT	5.0 EA	XU002 XU003 XU006 XU013 XU015
404 0738 000	SOCKET 20 PIN SINGLE ROW	2.0 EA	XLCD001
404 0767 000	SOCKET 20 PIN DIP (DL)	1.0 EA	XU007
404 0769 000	SOCKET 40 PIN DIP (DL)	1.0 EA	XU001
406 0514 000	LCD DISPLAY, 3-1/2 DIGIT	1.0 EA	LCD001
410 0382 000	INSULATOR #4 SCREW	8.0 EA	#Q001 #Q002 #Q003 #Q004
410 0385 000	INSULATOR TO-3 SILICON	2.0 EA	#Q003 #Q004
410 0405 000	INSULATOR XSTR TO220	2.0 EA	#U011 #U012
442 0116 000	THERMOSTAT, 70 DEG C +/-5	1.0 EA	S002
500 0759 000	CAP, MICA, 100PF 500V 5%	5.0 EA	C006 C017 C023 C049 C069
500 0835 000	CAP, MICA, 470PF 500V 5%	3.0 EA	C032 C037 C060
500 0844 000	CAP, MICA, 1000PF 100V 5%	1.0 EA	C035
500 0912 000	CAP, MICA, 820PF 500V 5%	2.0 EA	C010 C056
506 0244 000	CAP .22UF 63V 5%	1.0 EA	C008
506 0245 000	CAP.33UF 63V 5%	2.0 EA	C011 C012
516 0453 000	CAP .1UF 100V 20% X7R	30.0 EA	C001 C002 C004 C005 C007 C009 C019 C026 C030 C031 C036 C038 C039 C040 C041 C044 C047 C050 C051 C053 C054 C059 C063 C067 C072 C073 C080 C081 C082 C083
516 0511 000	CAP 0.47UF 100V 20%	6.0 EA	C074 C075 C076 C077 C078 C079
516 0530 000	CAP .01UF 10% 100V X7R	7.0 EA	C014 C027 C043 C057 C061 C064 C066
516 0774 000	CAP 56PF 5% 100V C0G	1.0 EA	C042
516 0834 000	CAP 0.047UF 10% 50V	1.0 EA	C003
516 0891 000	CAP 0.100UF 10% 50V	8.0 EA	C092 C093 C094 C095 C096 C097 C098 C099
522 0548 000	CAP 10UF 50V 20%	11.0 EA	C015 C016 C020 C022 C033 C045 C048 C052 C058 C065 C068
526 0108 000	CAP 4.7UF 35V 20%	3.0 EA	C013 C028 C070
526 0311 000	CAP 2.2UF 35V 10%	12.0 EA	

			C021 C029 C062 C071 C084 C085 C086 C087 C088 C089 C090 C091
526 0314 000	CAP 33UF 10V 20%	1.0 EA	C046
526 0378 000	CAP 1UF 50V 20%	2.0 EA	C034 C055
540 1380 000	RES NETWORK 10K OHM 2%	3.0 EA	R015 R069 R071
540 1386 000	RES NETWORK 10K OHM 2%	2.0 EA	R039 R089
540 1444 000	RES NETWORK 150 OHM 2%	1.0 EA	R090
540 1496 000	RES NETWORK 100 OHM	1.0 EA	R003
540 1600 101	RES 10 OHM 3W 5%	2.0 EA	R041 R091
540 1600 111	RES 27 OHM 3W 5%	2.0 EA	R014 R082
540 1600 301	RES 1K OHM 3W 5%	2.0 EA	R103 R104
540 1600 303	RES 1.2K OHM 3W 5%	2.0 EA	R068 R070
548 2400 001	RES 1 OHM 1/2W 1%	2.0 EA	R012 R073
548 2400 201	RES 100 OHM 1/2W 1%	6.0 EA	R017 R040 R047 R078 R088 R096
548 2400 218	RES 150 OHM 1/2W 1%	2.0 EA	R029 R031
548 2400 226	RES 182 OHM 1/2W 1%	3.0 EA	R020 R063 R081
548 2400 230	RES 200 OHM 1/2W 1%	1.0 EA	R058
548 2400 266	RES 475 OHM 1/2W 1%	2.0 EA	R050 R087
548 2400 290	RES 845 OHM 1/2W 1%	2.0 EA	R019 R074
548 2400 301	RES 1K OHM 1/2W 1%	6.0 EA	R045 R085 R100 R101 R102 R105
548 2400 307	RES 1.15K OHM 1/2W 1%	1.0 EA	R062
548 2400 312	RES 1.3K OHM 1/2W 1%	3.0 EA	R042 R046 R075
548 2400 330	RES 2K OHM 1/2W 1%	1.0 EA	R065
548 2400 341	RES 2.61K OHM 1/2W 1%	2.0 EA	R016 R072
548 2400 351	RES 3.32K OHM 1/2W 1%	2.0 EA	R043 R099
548 2400 355	RES 3.65K OHM 1/2W 1%	1.0 EA	R064
548 2400 358	RES 3.92K OHM 1/2W 1%	2.0 EA	R037 R076
548 2400 368	RES 4.99K OHM 1/2W 1%	2.0 EA	R002 R057
548 2400 382	RES 6.98K OHM 1/2W 1%	1.0 EA	R023
548 2400 384	RES 7.32K OHM 1/2W 1%	2.0 EA	R032 R080
548 2400 401	RES 10K OHM 1/2W 1%	13.0 EA	R018 R028 R044 R048 R049 R054 R055 R056 R059 R066 R083 R094 R098
548 2400 412	RES 13K OHM 1/2W 1%	2.0 EA	R022 R060
548 2400 413	RES 13.3K OHM 1/2W 1%	1.0 EA	R024
548 2400 423	RES 16.9K OHM 1/2W 1%	1.0 EA	R027
548 2400 430	RES 20K OHM 1/2W 1%	1.0 EA	R010
548 2400 438	RES 24.3K OHM 1/2W 1%	2.0 EA	R036 R077
548 2400 443	RES 27.4K OHM 1/2W 1%	1.0 EA	R053
548 2400 458	RES 39.2K OHM 1/2W 1%	1.0 EA	R061
548 2400 470	RES 52.3K OHM 1/2W 1%	2.0 EA	R052 R067
548 2400 501	RES 100K OHM 1/2W 1%	4.0 EA	R006 R011 R013 R021
548 2400 521	RES 162K OHM 1/2W 1%	1.0 EA	R004
548 2400 530	RES 200K OHM 1/2W 1%	1.0 EA	R008
548 2400 562	RES 432K OHM 1/2W 1%	1.0 EA	R009
548 2400 566	RES 475K OHM 1/2W 1%	1.0 EA	R005
548 2400 601	RES 1MEG OHM 1/2W 1%	11.0 EA	R007 R026 R030 R033 R034 R035 R079 R084 R086 R092 R095
548 2400 616	RES 1.43MEG OHM 1/2W 1%	2.0 EA	R038 R097
550 0959 000	POT 20K OHM 1/2 W 10%	1.0 EA	R001
550 1059 000	POT, 200 OHM 1/2W 10%	2.0 EA	R051 R093
604 0979 000	SW, THUMBWHEEL SP-16 POS	1.0 EA	S001
610 0679 000	PLUG, SHORTING, .25" CTRS	1.0 EA	P001
610 0980 000	HDR 20C 2ROW RT ANG	1.0 EA	J003

WARNING: Disconnect primary power prior to servicing.

610 0999 000	HDR, 10 PIN, PC BD	4.0 EA	J001 J002 J005 J006
610 1054 000	HEADER STRAIGHT MNT 8 PIN	2.0 EA	J004 J007
612 0904 000	JACK, PC MT GOLD PLATED	3.0 EA	XP001
612 1215 000	JACK, PC BD	8.0 EA	XQ001 XQ002 XQ003 XQ004
839 7855 056	DC REG HEATSINK	1.0 EA	
839 7855 163	SCHEM, DC REGULATOR	0.0 EA	
843 5100 091	PWB, DC REGULATOR	1.0 EA	
999 2681 002	HARDWARE LIST FOR DC	1.0 EA	

Table 7-15. OUTPUT MONITOR - 992 9298 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
000 0000 003	FREQUENCY DETERMINED PART	4.0 EA	C005 C041 L003 L009
335 0262 000	DF137A INSULATING WASHER	2.0 EA	#Q001 #Q002
354 0309 000	TERM SOLDER	10.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007 TP008 TP009 TP010
358 1928 000	JUMPER 1/4 LG 1/8H	12.0 EA	JP001 JP002 JP003 JP004 JP005 JP006 JP007 JP008 JP009 JP010 JP011 JP012
380 0125 000	XSTR, NPN 2N4401 ESD	2.0 EA	Q003 Q004
380 0190 000	XSTR, PNP 2N3906 ESD	2.0 EA	Q005 Q006
380 0672 000	XSTR, D45H8 ESD	1.0 EA	Q001
380 0673 000	XSTR, NPN D44H8 ESD	1.0 EA	Q002
382 0309 000	IC, SN74LS08N ESD	1.0 EA	U005
382 0581 000	IC, 74LS123 ESD	1.0 EA	U006
382 1048 000	* IC, UC3834N ESD	2.0 EA	U001 U004
382 1427 000	IC LM360N ESD	2.0 EA	U002 U003
384 0321 000	DIODE 5082-2800/1N5711 ESD	2.0 EA	CR003 CR032
384 0431 000	RECT. 1N4001 ESD	4.0 EA	CR014 CR015 CR021 CR022
384 0612 000	DIODE 1N3070 ESD	13.0 EA	CR005 CR006 CR007 CR009 CR010 CR011 CR012 CR016 CR018 CR019 CR023 CR028 CR033
384 0719 000	TRANSZORB 1N6373 5V 5W ESD	2.0 EA	CR008 CR026
384 0720 000	TRANSZORB 1N6377 15V 5W ESD	2.0 EA	CR024 CR025
384 0731 000	* DIODE, SWITCHING 1N4607 ESD	5.0 EA	CR001 CR002 CR029 CR030 CR031
386 0135 000	ZENER, 1N4733A 5.1V ESD	3.0 EA	CR013 CR017 CR027
386 0164 000	ZENER, 1N4754A 39V ESD	2.0 EA	CR004 CR020
398 0015 000	FUSE,FAST CART .500A 250V	2.0 EA	F001 F002
402 0129 000	CLIP, 1/4 DIA FUSE	4.0 EA	2/#F001 2/#F002
404 0513 000	HEAT SINK PA1-1CB	2.0 EA	#Q001 #Q002
404 0673 000	SOCKET 8 PIN DIP (DL)	2.0 EA	#U002 #U003
404 0674 000	SOCKET 14 PIN DIP (D-L)	1.0 EA	#U005
404 0675 000	SOCKET IC 16 CONT	3.0 EA	#U001 #U004 #U006
410 0405 000	INSULATOR XSTR TO220	2.0 EA	#Q001 #Q002
492 0741 000	COIL, ADJ RF 3.4-5.8 UH	1.0 EA	L007
492 0744 000	COIL ADJ RF 7.1-12.5 UH	1.0 EA	L012
492 0748 000	COIL ADJ RF 5.6-10. UH	1.0 EA	L008
492 0749 000	COIL ADJ RF .76-1.25 UH	1.0 EA	L005
492 0750 000	COIL ADJ RF 1.65-2.75 UH	1.0 EA	L006
494 0198 000	CHOKE RF 10MH	2.0 EA	L001 L004
494 0404 000	CHOKE RF 33.0UH	2.0 EA	L002 L010
500 0759 000	CAP, MICA, 100PF 500V 5%	2.0 EA	C007 C011
500 0818 000	CAP, MICA, 50PF 500V 5%	1.0 EA	C036
500 0832 000	CAP, MICA, 360PF 500V 5%	2.0 EA	C003 C042

500 0841 000	CAP, 750PF 300V 5%	1.0 EA	C020
500 0854 000	CAP, VAR, 300-1000PF 175V	6.0 EA	C006 C015 C016 C021 C029 C040
500 0878 000	CAP, MICA, 1500PF 500V 5%	2.0 EA	C028 C030
500 0903 000	CAP, MICA, 2700PF 500V 5%	2.0 EA	C004 C013
500 1187 000	CAP, MICA, 8200PF 100V 5%	1.0 EA	C012
500 1196 000	CAP, MICA, 15,000PF 500V 5%	1.0 EA	C039
506 0230 000	CAP .001UF 100VAC 5%	3.0 EA	C017 C033 C043
506 0232 000	CAP .01UF 100V 5%	3.0 EA	C001 C010 C027
506 0234 000	CAP .0022UF 100V 5%	1.0 EA	C044
506 0235 000	CAP .0033UF 100V 5%	1.0 EA	C045
506 0236 000	CAP .0047UF 100/63V 5%	1.0 EA	C046
506 0246 000	CAP .47UF 63V 5%	2.0 EA	C048 C049
508 0412 000	CAP .047UF 200V 5%	1.0 EA	C018
508 0420 000	CAP .22UF 100V 5%	1.0 EA	C014
508 0536 000	CAP .033UF 400VDC 5%	1.0 EA	C047
516 0453 000	CAP .1UF 100V 20% X7R	10.0 EA	C009 C023 C025 C031 C032 C034 C035 C037 C038 C051
516 0891 000	CAP 0.100UF 10% 50V	4.0 EA	C052 C053 C054 C055
522 0554 000	CAP 4.7UF 50V 20%	1.0 EA	C019
526 0048 000	CAP 10UF 20V 20%	3.0 EA	C002 C008 C050
526 0068 000	CAP 100UF 25V 10%	1.0 EA	C024
526 0108 000	CAP 4.7UF 35V 20%	2.0 EA	C022 C026
526 0311 000	CAP 2.2UF 35V 10%	4.0 EA	C056 C057 C058 C059
548 2400 162	RES 43.2 OHM 1/2W 1%	1.0 EA	R025
548 2400 169	RES 51.1 OHM 1/2W 1%	2.0 EA	R013 R015
548 2400 201	RES 100 OHM 1/2W 1%	4.0 EA	R002 R044 R048 R049
548 2400 226	RES 182 OHM 1/2W 1%	1.0 EA	R004
548 2400 230	RES 200 OHM 1/2W 1%	1.0 EA	R010
548 2400 242	RES 267 OHM 1/2W 1%	2.0 EA	R027 R043
548 2400 247	RES 301 OHM 1/2W 1%	1.0 EA	R009
548 2400 269	RES 511 OHM 1/2W 1%	1.0 EA	R003
548 2400 281	RES 681 OHM 1/2W 1%	2.0 EA	R018 R019
548 2400 282	RES 698 OHM 1/2W 1%	1.0 EA	R006
548 2400 301	RES 1K OHM 1/2W 1%	7.0 EA	R012 R016 R017 R021 R046 R053 R054
548 2400 318	RES 1.5K OHM 1/2W 1%	1.0 EA	R045
548 2400 330	RES 2K OHM 1/2W 1%	4.0 EA	R005 R011 R014 R047
548 2400 366	RES 4.75K OHM 1/2W 1%	5.0 EA	R036 R037 R039 R041 R042
548 2400 401	RES 10K OHM 1/2W 1%	10.0 EA	R001 R022 R026 R029 R030 R031 R032 R033 R038 R052
548 2400 458	RES 39.2K OHM 1/2W 1%	1.0 EA	R028
548 2400 469	RES 51.1K OHM 1/2W 1%	3.0 EA	R034 R035 R040
548 2400 485	RES 75K OHM 1/2W 1%	1.0 EA	R051
548 2400 501	RES 100K OHM 1/2W 1%	2.0 EA	R020 R050
550 0958 000	POT 10K OHM 1/2 W 10%	2.0 EA	R023 R024
552 0313 000	RHEO 100 OHM 25 W	2.0 EA	R007 R008
560 0035 000	MOV 4500A 35J 130 VAC	1.0 EA	RV001
574 0450 000	RELAY SPDT 5VDC 3A	2.0 EA	K001 K002
604 0852 000	SW, RKR DIP 4-SPST	3.0 EA	S001 S006 S009
604 0905 000	SW, PB MOMENTARY	2.0 EA	S003 S004
604 0977 000	SW, TGL DPDT PC MOUNT	1.0 EA	S008
604 1064 000	SWITCH, ROCKER DIP 2-SPST	1.0 EA	S002
604 1070 000	SWITCH, PB MOM 3P	1.0 EA	S005
604 1093 000	SW, RKR DIP 6-SPST	1.0 EA	S007
610 0679 000	PLUG, SHORTING, .25" CTRS	3.0 EA	P001 P002 P003
610 0980 000	HDR 20C 2ROW RT ANG	1.0 EA	J001

610 0983 000	HDR 26C 2ROW RT ANG	1.0 EA	J002
610 0998 000	HDR, 6 PIN, PC BD	1.0 EA	J003
610 0999 000	HDR, 10 PIN, PC BD	1.0 EA	J006
612 0904 000	JACK, PC MT GOLD PLATED	9.0 EA	#P001 #P002 #P003
620 1677 000	RECEPTACLE, PC MT, BNC	3.0 EA	J004 J005 J007
650 0028 000	KNOB RD SKIRT 1.135" DIA	2.0 EA	#R007 #R008
843 5400 101	SCH, OUTPUT MONITOR	0.0 EA	
843 5400 103	PWB, OUTPUT MONITOR	1.0 EA	
929 9009 216	XFMR	3.0 EA	T001 T002 T003
929 9009 257	XFMR	1.0 EA	L011
939 6208 260	SHIELD	1.0 EA	#A027
999 2496 001	HARDWARE LIST	1.0 EA	

Table 7-16. XMTR, BASIC DX 25U - 994 9168 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
917 2501 007	KIT, WIRE 162	1.0 EA	
992 7090 002	PA CABINET, DX 25U	1.0 EA	
992 7091 001	OUTPUT CABINET	1.0 EA	
992 7092 001	STEP START PANEL	1.0 EA	
992 8102 001	DX50 INSTALLATION KIT	1.0 EA	
992 8203 003	OUTPUT SAMPLE	1.0 EA	A001

Table 7-17. PA CABINET, DX 25U - 992 7090 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
302 0411 000	SCR, 6-32 X 3/8	44.0 EA	
302 0551 000	SCR, SOC HD SHOULDER	3.0 EA	
302 0693 000	SCREW, 1/4-28 X .625	11.0 EA	
328 0073 000	WASHER, RETAINER	40.0 EA	
335 0252 000	WASHER, TEFLON	6.0 EA	#CR017 #CR019 #CR021
354 0760 000	TAB ADAPTOR 250 SERIES	4.0 EA	
356 0208 000	CLAMP, FLAT CABLE 2"	2.0 EA	
356 0214 000	CLAMP, FLAT CABLE 1 IN.	1.0 EA	
358 0003 000	BRACKET RESISTOR MTG	12.0 EA	
358 0437 000	BUSHING PANEL .252 ID	1.0 EA	#L001
358 0498 000	CLAMP, HOSE	21.0 EA	
358 0960 000	COUPLING W/4 SET SCR	1.0 EA	#L001
358 2511 000	STANDOFF, 10-32 X 3/4	18.0 EA	8#A24 8#A25 2#L1
358 3109 000	STUD, BRS 8-32 X 1	1.0 EA	#T010
358 3121 000	STUD, BRS 10-32 X 1	18.0 EA	#C010 #C019 #C020 #C021 #C022 #C023 #C024 #C025 #C026 #C027 #C028 #C037 #C042 4#A015 E102
358 3123 000	STUD, BRS 10-32 X 1-1/2	4.0 EA	
358 3131 000	STUD, BRS 1/4-20 X 1	2.0 EA	
358 3133 000	STUD, BRS 1/4-20 X 1-1/2	2.0 EA	
358 3172 000	STUD 1/4 TURN PHILLIPS HD	30.0 EA	
358 3185 000	PLUG WHT 1.093/1.125 HOLE	2.0 EA	
358 3246 000	STUD 1/4 TURN PHILLIPS HD	10.0 EA	
358 3247 000	PLUG, WHITE 1" HOLE	12.0 EA	
384 0702 000	RECT FW BRIDGE 600V 35A ESD	3.0 EA	CR013 CR014 CR015
384 0705 000	RECT 85A 1000V PIV ESD	8.0 EA	CR016 CR017 CR018 CR019 CR020 CR021 CR022 CR024

384 0839 000	RECT 1000PIV 300A 1N4056 ESD	12.0 EA	CR001A CR003A CR005A CR007A CR009A CR011A CR001B CR003B CR005B CR007B CR009B CR011B
384 0840 000	RECT 1000PIV 275A 1N4056R ESD	12.0 EA	CR002A CR004A CR006A CR008A CR010A CR012A CR002B CR004B CR006B CR008B CR010B CR012B
398 0433 000	FUSE 1 TIME 6A 250VAC	1.0 EA	F021
398 0441 000	FUSE 1 TIME 25A 250V	1.0 EA	F020
398 0455 000	FUSE, TIME DELAY 15A 500V	3.0 EA	F017 F018 F019
398 0456 000	FUSE, TIME DELAY 1A 500V	2.0 EA	F024 SPARE
398 0457 000	FUSE, RECTIFIER 250A 250V	12.0 EA	F001 F002 F003 F004 F005 F006 F007 F008 F009 F010 F011 F012
398 0458 000	FUSE, 35A 250V CRTG.	3.0 EA	F013 F014 F015
402 0014 000	FUSE HOLDER, 2 POLE	1.0 EA	#F020 #F021
402 0087 000	FUSE HOLDER, 60A 250V	1.0 EA	#F013 #F014 #F015
402 0107 000	CLIP, FUSE 9/16	2.0 EA	
402 0130 000	FUSE HOLDER, 3 POLE	1.0 EA	#F017 #F018 #F019
402 0177 000	FUSE BLOCK, 2 POLE, 600V	1.0 EA	#F024
410 0010 000	INSULATOR ROUND NS5W 0208	2.0 EA	#S012
410 0023 000	INSULATOR ROUND NS5W 0410	2.0 EA	
424 0360 000	GROMMET 1-3/4 MTG DIA	8.0 EA	
448 0224 000	HANDLE ALUM	6.0 EA	
448 0729 000	STRIKE MAGNETIC CATCH	6.0 EA	
448 0776 000	CATCH MAGNETIC	6.0 EA	
448 0938 000	HANDLE, CONCEALED PULL	3.0 EA	
456 0144 000	SPRING, EJECTOR	40.0 EA	
464 0169 000	TOOL, TRIMMER ADJUSTMENT	1.0 EA	
472 1660 000	XFMR, PWR	1.0 EA	T001
472 1666 000	XFMR, INTERPHASE	1.0 EA	T003
472 1668 000	XFMR,PWR, 817-2099-009	1.0 EA	T002
476 0416 000	CHOKE, FLTR 10MHY 12.5ADC	1.0 EA	L003
492 0309 000	INDUCTOR VAR 28UH	1.0 EA	L001
494 0424 000	CHOKE RF 8.8UH	1.0 EA	T006
508 0539 000	CAP 2 UF 400VDC 10%	2.0 EA	C040
524 0142 000	CAP 5500 UF 25V	2.0 EA	C035A C035B
524 0219 000	CAP 5500 UF 200V	3.0 EA	C007 C008 C019
524 0322 000	CAP 15000UF 100WVDC	2.0 EA	C010 C042
524 0341 000	CAP 5100 UF 350WVDC	9.0 EA	C021 C022 C023 C024 C025 C026 C027 C028 C038
524 0342 000	CAP 76000UF 40WVDC	1.0 EA	C037
524 0380 000	CAP 120, 000UF 50WVDC	3.0 EA	C032 C033 C034
530 0092 000	BRACKET, CAP, 3" ID	1.0 EA	#C010
530 0094 000	BRACKET, CAP, 1.375"ID	2.0 EA	#C035A #C035B
540 1600 108	RES 20 OHM 3W 5%	4.0 EA	R069
540 1600 201	RES 100 OHM 3W 5%	2.0 EA	R032 R033
540 1600 219	RES 560 OHM 3W 5%	3.0 EA	R034 R035A R035B
540 1600 301	RES 1K OHM 3W 5%	1.0 EA	R037
540 1600 316	RES 4.3K OHM 3W 5%	1.0 EA	R010
540 1600 405	RES 15K OHM 3W 5%	2.0 EA	R038 R040
540 1600 422	RES 75K OHM 3W 5%	8.0 EA	R021 R022 R023 R024 R025 R026 R027 R028
542 0287 000	RES 10 OHM 5% 100W	4.0 EA	R101 R102 R103 R104
542 0293 000	RES 250 OHM 5% 100W	2.0 EA	R105 R106
548 1487 000	RES 0.1 OHM 10W 1%	3.0 EA	R003A R003B R003C

552 0358 000	RHEO 25 OHM 75 W	1.0 EA	R002
552 0402 000	RHEO 5 OHM 150 W	1.0 EA	R001
560 0077 000	VARISTOR 275VRMS 30KA	2.0 EA	RV001 RV002
574 0461 000	RELAY DPDT 10A 24VAC COIL	1.0 EA	K003
604 1079 000	SW DPST 15A 125/250 VAC	3.0 EA	S001 S002 S003
606 0829 000	CKT BREAKER 2 POLE 5A	1.0 EA	CB001
606 0836 000	CKT BREAKER 2 POLE	1.0 EA	CB002
614 0050 000	TERM BD 6 TERM	2.0 EA	TB004 TB005
614 0062 000	TERM BD 18 TERM	1.0 EA	TB003
614 0774 000	*INTERFACE, 40 PIN, TB/HDR	2.0 EA	TB001 TB002
620 0455 000	ADPT BNC UG492A/U	1.0 EA	J001
632 1133 000	MTR 0-3/0-10, 4-1/2", W	1.0 EA	M001
646 0726 000	MARKER STRIP MS-6-141	2.0 EA	#TB004 #TB005
646 1353 000	NAMEPLATE, XMTR EQUIPMENT	1.0 EA	
646 1404 000	MARKER STRIP, 18 TERM	1.0 EA	#TB003
646 1430 000	NAMEPLATE, PATENT	1.0 EA	
646 1461 000	NAMEPLATE, FRAME 7.75 LG	1.0 EA	
650 0020 000	KNOB RD SKIRT .911" DIA	2.0 EA	
650 0028 000	KNOB RD SKIRT 1.135" DIA	2.0 EA	
813 4999 021	STDOFF 6-32X3/16 1/4 HEX	3.0 EA	
813 5000 011	STDOFF 6-32X1 5/16 HEX	1.0 EA	#T9 #R69
813 5604 011	STUD BRS 6-32 X 1	2.0 EA	#T009
814 7796 002	HANDLE	1.0 EA	
814 7917 001	HOOK, 1/2IN RADIUS	1.0 EA	
817 1335 119	PLATE, GROUNDING	2.0 EA	
817 2099 062	RUNNING LIST, PA CABINET DX25	0.0 EA	
822 0922 033	FRT DOOR HINGE PLATE	3.0 EA	
822 0922 153	STRAPS	1.0 EA	
822 0922 158	DRIVE CABLE SUPPORT RING	1.0 EA	
822 0922 159	DRIVE CABLE MTG CHNL	4.0 EA	
822 0922 165	SHAFT 3.3"	1.0 EA	
822 0922 172	CABLE MTG CHNL	1.0 EA	
822 0922 186	STRAP, 1.75" X 0.50"	11.0 EA	#C019 #C021 #C022 #C023 #C024 #C025 #C026 #C027 #C028 #C038 #C042
822 0922 188	STRAP	2.0 EA	#C009
822 0922 195	STRAP	1.0 EA	#C037
839 7855 024	RECT HEATSINK	4.0 EA	
839 7855 101	DRVR PIPE HEATSINK	1.0 EA	
839 7855 151	SCHEM OVERALL DX25U	0.0 EA	
917 2099 017	TEMP SENSOR REPLACEMENT	2.0 EA	
917 2099 043	PATCH CORD	3.0 EA	#A037
917 2244 001	SPACER, 1.0 LG .75 DIA	6.0 EA	#R003 #S009 #S010
917 2332 049	INSULATOR, 3/8 D. X 1 LG.	1.0 EA	#T9 #R69
922 0922 046	SWITCH HOT PLATE ASSY	2.0 EA	
922 0922 047	SW SPRING CONTACT ASSY	2.0 EA	
922 0922 098	SW SPRING CONTACT ASSY	1.0 EA	
922 0922 100	SW CONTACT PLATE ASSY	1.0 EA	
922 0922 149	XFMR MTG PLATE	1.0 EA	
922 0922 208	GND STRAP	1.0 EA	
922 0922 212	INSULATION, DOOR 21 X 48	5.0 EA	
922 0922 213	INSULATION, DOOR 21 X 21	2.0 EA	
922 0922 214	INSULATION, DOOR 21 X 6	3.0 EA	
922 1295 006	GUARD COVER	1.0 EA	
922 1295 007	GUARD, FAN (4)	1.0 EA	

WARNING: Disconnect primary power prior to servicing.

938 4203 020	GROUND HOOK ASSY	1.0 EA	
939 7855 055	FUSE BD BUSS BAR	1.0 EA	
943 5100 034	RT FRT DOOR	1.0 EA	
943 5100 066	LT & CTR FRT DOOR	2.0 EA	
992 5889 002	PWA, IPA PWR SPLITTER,ESD SAFE	1.0 EA	A018
992 6730 002	PWA, ANALOG TO DIGITAL CONV	1.0 EA	A034
992 6752 004	MULTIMETER W/O PROBE	1.0 EA	A023
992 6784 002	*PWA, DX SWITCH,	1.0 EA	A031
992 6916 001	PWA, PWR DISTRIBUTION,ESD SAFE	1.0 EA	A039
992 7085 001	PWA, RF SPLITTER, ESD SAFE	1.0 EA	A015
992 7086 002	* COMBINER MBD DRIVER *	1.0 EA	A014
992 7088 001	PWA, COMB MOTHERBD, ESD SAFE	3.0 EA	A005 A006 A007
992 7095 001	RF AMPLIFIER MODULE	79.0 EA	RF033 RF034 RF035 RF036 RF037 RF038 RF039 RF040 RF041 RF042 RF043 RF044 RF045 RF046 RF047 RF048 RF049 RF050 RF051 RF052 RF053 RF054 RF055 RF056 RF057 RF058 RF059 RF060 RF061 RF062 RF063 RF064 RF065 RF066 RF067 RF068 RF069 RF070 RF071 RF072 RF073 RF074 RF075 RF076 RF077 RF078 RF079 RF080 RF081 RF082 RF083 RF084 RF085 RF086 RF087 RF088 RF089 RF090 RF091 RF092 RF093 RF094 RF095 RF096 RF129 RF130 RF131 RF132 RF133 RF134 RF135 RF136 RF137 RF138 RF139 RF140 RF141 RF142 RF143
992 8006 001	DRIVER SUPPLY REGULATOR	1.0 EA	A022
992 8007 001	PWA, FUSE 1, ESD SAFE	1.0 EA	A024
992 8007 002	PWA, FUSE 2, ESD SAFE	1.0 EA	A025
992 8038 001	PWA, BUFFER AMP	1.0 EA	A016
992 8048 001	DRIVER ENC/TEMP	1.0 EA	A019
992 8056 002	PA CAB CABLE PKG, DX 25U	1.0 EA	
992 8058 001	CABINET PKG	1.0 EA	
992 8059 001	0.125 AL SM FAB PKG	1.0 EA	
992 8059 002	PKG, FAB, 0.090 AL SM	1.0 EA	
992 8059 003	0.064 AL SM FAB PKG	1.0 EA	
992 8059 004	MS LATHE FAB PKG	1.0 EA	
992 8059 005	MS MILLED AL FAB PKG	1.0 EA	
992 8059 008	HINGE FAB PKG	1.0 EA	
992 8059 009	MS GLS EPOXY FAB PKG	1.0 EA	
992 8059 010	SM GLS EPOXY FAB PKG	1.0 EA	
992 8059 011	SM LEXAN FAB PKG	1.0 EA	
992 8059 012	MS MILLED CU FAB PKG	1.0 EA	
992 8069 002	OSCILLATOR	1.0 EA	A017
992 8070 001	EXTERNAL INTERFACE	1.0 EA	A028
992 8071 002	CONTROLLER BOARD	1.0 EA	A038
992 8072 002	LED BOARD	1.0 EA	A032
992 8077 001	ANALOG INPUT	1.0 EA	A035
992 8079 002	PWA, NEUTRALIZATION, ESD SAFE	1.0 EA	A040
992 8092 001	EFFICIENCY COIL QUAD, ESD SAFE	20.0 EA	
992 8094 001	XFMR PKG (PA CABINET)	1.0 EA	
992 8101 001	DX25U UNIQUE PARTS	1.0 EA	
992 8164 001	DX25U UNIQUE COMPONENTS	1.0 EA	
992 8684 003	POWER SUPPLY DISCHARGE	1.0 EA	A029
992 9298 001	OUTPUT MONITOR	1.0 EA	A027

999 2589 002	HARDWARE LIST, PA CABINET	1.0 EA

Table 7-18. GROUND HOOK ASSY - 938 4203 020

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
254 0017 000	WIRE, ROPE 10AWG	0.950 FT	
296 0019 000	PLASTIC TUBE 4AWG CLEAR	0.850 FT	
306 0006 000	NUT, HEX 10-32	2.0 EA	
308 0007 000	10 FLAT WASHER BRASS	1.0 EA	
312 0007 000	WASHER, INT LOCK 10	1.0 EA	
312 0049 000	WASHER, SPLIT-LOCK 10	1.0 EA	
354 0287 000	LUG #10 RING N/INS 7-9AWG	2.0 EA	
814 7796 006	HANDLE, 18" X 1/2"	1.0 EA	
814 7917 001	HOOK, 1/2IN RADIUS	1.0 EA	
838 4203 001	ASSY INSTR, GROUND HOOK	0.0 EA	

Table 7-19. PWA, IPA PWR SPLITTER,ESD SAFE - 992 5889 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
610 0873 000	HEADER KIT, 20 PIN EJECT	4.0 EA	J001 J002 J003 J004
839 5695 273	PC BD, IPA PWR SPLITTER	1.0 EA	
843 5400 267	COMPONENT LOCATOR, IPA POWER	0.0 EA	

Table 7-20. MULTIMETER W/O PROBE - 992 6752 004

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
384 0431 000	RECT. 1N4001 ESD	2.0 EA	CR004 CR005
384 0612 000	DIODE 1N3070 ESD	1.0 EA	CR001
516 0530 000	CAP .01UF 10% 100V X7R	1.0 EA	C003
516 0555 000	CAP .047UF 10% 100V X7R	1.0 EA	C001
548 2400 401	RES 10K OHM 1/2W 1%	1.0 EA	R004
548 2400 446	RES 29.4K OHM 1/2W 1%	1.0 EA	R005
548 2400 543	RES 274K OHM 1/2W 1%	1.0 EA	R002
548 2400 547	RES 301K OHM 1/2W 1%	1.0 EA	R003
548 2400 550	RES 324K OHM 1/2W 1%	1.0 EA	R001
600 0606 000	SW, ROTARY 2P 6 POS	2.0 EA	S001 S002
604 0605 000	SW, TGL DPDT ALT ACTION	1.0 EA	S003
610 0978 000	HDR 10C 2ROW RT ANG	1.0 EA	J005
610 0980 000	HDR 20C 2ROW RT ANG	1.0 EA	J004
610 1210 000	JUMPER, FLEX 10C X 2" LG	1.0 EA	FS001
632 1133 000	MTR 0-3/0-10, 4-1/2", W	1.0 EA	M001
839 6208 302	SCH, MULTIMETER	0.0 EA	
843 4038 202	PWB, MULTIMETER	1.0 EA	
999 2446 001	HARDWARE LIST	1.0 EA	

Table 7-21. *PWA, DX SWITCH, - 992 6784 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
358 1928 000	JUMPER 1/4 LG 1/8H	1.0 EA	JP001
358 3545 003	STANDOFF, PEM 3/8" H SNAP-TOP	4.0 EA	
380 0189 000	XSTR, NPN 2N3904 ESD	4.0 EA	Q002 Q003 Q004 Q005
380 0190 000	XSTR, PNP 2N3906 ESD	1.0 EA	Q001
382 0463 000	IC, 4051/14051 ESD	2.0 EA	U003 U010
382 0774 000	IC 74HC14 ESD	1.0 EA	U007

382 0781 000	IC, 74HC74 ESD	1.0 EA	U011
382 0791 000	IC, 74HC138 ESD	1.0 EA	U008
382 0800 000	IC, 74HC161 ESD	1.0 EA	U006
382 0882 000	IC, 78L05A ESD	1.0 EA	U012
382 1043 000	IC UDN2595 ESD	1.0 EA	U001
382 1210 000	IC CD4538B ESD	1.0 EA	U013
382 1387 000	IC MAX637 ESD	1.0 EA	U014
382 1542 000	IC, OP490 ESD	4.0 EA	U002 U004 U005 U009
384 0725 000	RECT 1N5818 ESD	1.0 EA	CR002
384 0827 000	LED LIGHT BAR, GREEN ESD	5.0 EA	DS001 DS002 DS003 DS004 DS005
384 0849 000	LED LIGHT BAR, GREEN ESD	1.0 EA	DS008
384 0854 000	DIODE ARRAY, 8 ISOLATED ESD	1.0 EA	CR001
384 0858 000	LED LIGHT BAR, YELLOW ESD	1.0 EA	DS009
384 0892 000	LED 4 SEG LIGHTBAR, GRN ESD	2.0 EA	DS006 DS007
404 0673 000	SOCKET 8 PIN DIP (DL)	1.0 EA	#U014
404 0674 000	SOCKET 14 PIN DIP (D-L)	6.0 EA	#U002 #U004 #U005 #U007 #U009 #U011
404 0675 000	SOCKET IC 16 CONT	8.0 EA	#CR001 #DS006 #DS007 #U003 #U006 #U008 #U010 #U013
404 0766 000	SOCKET 18 PIN DIP (DL)	1.0 EA	#U001
404 0829 000	SOCKET, SIP20, STRAIGHT	3.0 EA	#DS001 #DS002 #DS003 #DS004 #DS005 #DS008 #DS009
492 0839 000	IND 330 UH 10% 500MA	1.0 EA	L001
516 0453 000	CAP .1UF 100V 20% X7R	30.0 EA	C002 C003 C004 C007 C010 C011 C012 C013 C014 C015 C016 C017 C018 C019 C020 C021 C023 C024 C027 C028 C029 C030 C034 C035 C036 C037 C038 C039 C040 C041
516 0530 000	CAP .01UF 10% 100V X7R	1.0 EA	C022
516 0792 000	CAP NETWORK .1UF 10%	2.0 EA	C031 C032
516 0907 000	CAP 0.330UF 10% 50V	1.0 EA	C025
522 0548 000	CAP 10UF 50V 20%	6.0 EA	C001 C005 C006 C009 C026 C033
522 0569 000	CAP 100UF 50V 20%	1.0 EA	C008
540 1383 000	RES NETWORK 100K OHM 2%	2.0 EA	R006 R007
540 1387 000	RES NETWORK 10K OHM 2%	4.0 EA	R001 R005 R012 R023
540 1408 000	RES NETWORK 2000 OHM 2%	1.0 EA	R003
540 1440 000	RES NETWORK 2000 OHM 2%	1.0 EA	R002
540 1461 000	RES NETWORK 100 OHM 2%	9.0 EA	R004 R026 R027 R028 R029 R030 R032 R033 R034
540 1462 000	RES NETWORK 1000 OHM 2%	1.0 EA	R024
548 2400 401	RES 10K OHM 1/2W 1%	2.0 EA	R010 R016
548 2400 456	RES 37.4K OHM 1/2W 1%	2.0 EA	R011 R015
548 2400 477	RES 61.9K OHM 1/2W 1%	1.0 EA	R025
548 2400 530	RES 200K OHM 1/2W 1%	2.0 EA	R009 R017
550 0949 000	POT 100K OHM 1/2W 10%	2.0 EA	R013 R014
550 0958 000	POT 10K OHM 1/2 W 10%	1.0 EA	R008
604 1111 000	SW PB GRAY MOM W/O LED	2.0 EA	S007 S008
604 1119 000	SW PB RED MOM W/O LED	1.0 EA	S006
604 1121 000	SW PB BLUE MOM W/O LED	2.0 EA	S004 S005
604 1152 000	SW PB GRN MOM W/O LED	3.0 EA	S001 S002 S003
610 0933 000	JUMPER, PWB TEST POINT	8.0 EA	TP001 TP002 TP003 TP004 TP005 TP006 TP007 TP008
610 0991 000	HDR, STR, 6 PIN, 0.025 SQ	1.0 EA	J002
610 1043 000	HDR 40C 2ROW VERTICAL	1.0 EA	J001
610 1210 000	JUMPER, FLEX 10C X 2" LG	3.0 EA	FS001 FS002 FS003
839 6208 301	SCH, SWITCH/METER	0.0 EA	

843 4038 201	PWB, SWITCH/METER	1.0 EA	

Table 7-22. PWA, PWR DISTRIBUTION,ESD SAFE - 992 6916 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
610 1027 000	HEADER, MALE 12 PIN	7.0 EA	J001 J002 J003 J004 J005 J006 J007
843 4038 091	PWB, PWR DISTRIBUTION	1.0 EA	
999 2820 001	HARDWARE LIST, PWR	1.0 EA	

Table 7-23. PWA, RF SPLITTER, ESD SAFE - 992 7085 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
414 0310 000	TOROID, FERRITE	2.0 EA	
610 0998 000	HDR, 6 PIN, PC BD	1.0 EA	J017
610 1086 000	HDR 34 PIN/ACTION PINS	16.0 EA	J001 J002 J003 J004 J005 J006 J007 J008 J009 J010 J011 J012 J013 J014 J015 J016
610 1088 000	LATCH .576 FOR EJECTION	32.0 EA	2#J001 2#J002 2#J003 2#J004 2#J005 2#J006 2#J007 2#J008 2#J009 2#J010 2#J011 2#J012 2#J013 2#J014 2#J015 2#J016
817 2099 044	TRANSFORMER STAPLE	24.0 EA	
852 9170 001	PWB, SPLITTER	1.0 EA	

Table 7-24. * COMBINER MBD DRIVER * - 992 7086 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
358 2837 000	STUD, PC BD 4-40 X 5/16	6.0 EA	
358 3164 000	CARD GUIDE	32.0 EA	2#J001 2#J002 2#J003 2#J004 2#J005 2#J006 2#J007 2#J008 2#J009 2#J010 2#J011 2#J012 2#J013 2#J014 2#J015 2#J016
384 0612 000	DIODE 1N3070 ESD	2.0 EA	CR001 CR003
386 0083 000	ZENER, 1N4742A 12V ESD	1.0 EA	CR002
386 0138 000	ZENER, 1N4750A 27V ESD	1.0 EA	CR004
516 0453 000	CAP .1UF 100V 20% X7R	2.0 EA	C005 C006
522 0628 000	CAP 220UF 400V 20%	4.0 EA	C001 C002 C003 C004
540 1600 422	RES 75K OHM 3W 5%	4.0 EA	R001 R002 R003 R004
548 1487 000	RES 0.1 OHM 10W 1%	1.0 EA	R009
548 2400 383	RES 7.15K OHM 1/2W 1%	2.0 EA	R010 R011
548 2400 401	RES 10K OHM 1/2W 1%	2.0 EA	R006 R008
548 2400 501	RES 100K OHM 1/2W 1%	2.0 EA	R005 R007
548 2400 601	RES 1MEG OHM 1/2W 1%	1.0 EA	R012
610 0998 000	HDR, 6 PIN, PC BD	1.0 EA	J027
610 0999 000	HDR, 10 PIN, PC BD	1.0 EA	J028
610 1051 000	HOUSING 28 DUAL POSITIONS	15.0 EA	J002 J003 J004 J005 J006 J007 J008 J009 J010 J011 J012 J013 J014 J015 J016
610 1053 000	HEADER, 4 PIN, PC BD	1.0 EA	J029
610 1055 000	HOUSING 22 DUAL POSITIONS	1.0 EA	J001
610 1084 000	HDR 10 PIN/ACTION PINS	5.0 EA	J021 J022 J023 J024 J026
610 1085 000	HDR 20 PIN/ACTION PINS	4.0 EA	J017 J018 J019 J020
610 1088 000	LATCH .576 FOR EJECTION	18.0 EA	2#J017 2#J018 2#J019 2#J020 2#J021 2#J022 2#J023 2#J024 2#J026
612 0775 000	JACK, PC MT, .040 PINS	30.0 EA	
813 4999 005	STDOFF 4-40X3/8 1/4 HEX	4.0 EA	
822 0922 053	COMBINER COVER SUPPORT	2.0 EA	
822 0922 092	RF COND SUPPORT	2.0 EA	

822 0922 109	STDOFF,.25 X 5.35 X 4-40	2.0 EA	
839 7855 095	SCHEMATIC COMB MB DRIVER	0.0 EA	
843 5100 032	PWB, COMBINER DRIVER	1.0 EA	
922 0922 022	XFMR PAIR	7.0 EA	T2/T15 T3/T14 T4/T13 T5/T12 T6/T11 T7/T10 T8/T09
999 2571 001	HARDWARE LIST	1.0 EA	

Table 7-25. PWA, COMB MOTHERBD, ESD SAFE - 992 7088 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
324 0257 000	NUT, CAPTIVE 6-32	4.0 EA	
358 2837 000	STUD, PC BD 4-40 X 5/16	6.0 EA	
358 3164 000	CARD GUIDE	32.0 EA	2#J001 2#J002 2#J003 2#J004 2#J005 2#J006 2#J007 2#J008 2#J009 2#J010 2#J011 2#J012 2#J013 2#J014 2#J015 2#J016
522 0628 000	CAP 220UF 400V 20%	4.0 EA	C005 C006 C007 C008
540 1600 422	RES 75K OHM 3W 5%	4.0 EA	R001 R002 R003 R004
610 1051 000	HOUSING 28 DUAL POSITIONS	16.0 EA	J001 J002 J003 J004 J005 J006 J007 J008 J009 J010 J011 J012 J013 J014 J015 J016
610 1084 000	HDR 10 PIN/ACTION PINS	4.0 EA	J021 J022 J023 J024
610 1085 000	HDR 20 PIN/ACTION PINS	4.0 EA	J017 J018 J019 J020
610 1088 000	LATCH .576 FOR EJECTION	16.0 EA	2#J017 2#J018 2#J019 2#J020 2#J021 2#J022 2#J023 2#J024
612 0775 000	JACK, PC MT, .040 PINS	32.0 EA	
813 4999 005	STDOFF 4-40X3/8 1/4 HEX	4.0 EA	
822 0922 026	RF COND SUPPORT	2.0 EA	
822 0922 053	COMBINER COVER SUPPORT	2.0 EA	
822 0922 109	STDOFF,.25 X 5.35 X 4-40	2.0 EA	
839 7855 094	SCHEM, COMBINER MB MAIN	0.0 EA	
843 5100 030	PWB, COMBINER MAIN	1.0 EA	
922 0922 002	XFMR PAIR	8.0 EA	T1/T16 T2/T15 T3/T14 T4/T13 T5/T12 T6/T11 T7/T10 T8/T9
999 2570 001	HARDWARE LIST	1.0 EA	

Table 7-26. PWA, FUSE 1, ESD SAFE - 992 8007 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
324 0257 000	NUT, CAPTIVE 6-32	4.0 EA	2#F009 2#F010
324 0321 000	NUT, CAPTIVE 10-32	16.0 EA	2#F001 2#F002 2#F003 2#F004 2#F005 2#F006 2#F007 2#F008
384 0341 000	RECTIFIER 1N5404 ESD	10.0 EA	CR001 CR002 CR003 CR004 CR005 CR006 CR007 CR008 CR009 CR010
384 0802 000	TRANSZORB, BIPOLAR 18V 5% ESD	1.0 EA	CR011
398 0186 000	FUSE 1 TIME 30A 250V	1.0 EA	F010
398 0437 000	FUSE, 50A 250V CRTG	8.0 EA	F001 F002 F003 F004 F005 F006 F007 F008
398 0441 000	FUSE 1 TIME 25A 250V	1.0 EA	F009
402 0004 000	CLIP, FUSE .812 60A 250V	16.0 EA	#F001 #F002 #F003 #F004 #F005 #F006 #F007 #F008
402 0069 000	CLIP, FUSE BRONZE	4.0 EA	#F009 #F010
516 0419 000	CAP .05 UF 500V	1.0 EA	C002
540 1600 419	RES 56K OHM 3W 5%	2.0 EA	R025 R026
542 0121 000	RES 150 OHM 5% 20W	10.0 EA	R001 R002 R003 R004 R005 R006 R007 R008 R009 R010

548 2400 309	RES 1.21K OHM 1/2W 1%	1.0 EA	R014
548 2400 388	RES 8.06K OHM 1/2W 1%	2.0 EA	R018 R021
548 2400 526	RES 182K OHM 1/2W 1%	4.0 EA	R016 R017 R019 R020
610 0999 000	HDR, 10 PIN, PC BD	1.0 EA	J002
839 7855 068	SCHEM, OVERALL DX-50	0.0 EA	
839 7930 030	SCHEMATIC, FUSE BOARD	0.0 EA	
843 5100 029	PWB, FUSE	1.0 EA	
999 2576 001	HARDWARE LIST	1.0 EA	

Table 7-27. PWA, FUSE 2, ESD SAFE - 992 8007 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
324 0257 000	NUT, CAPTIVE 6-32	2.0 EA	2#F010
324 0321 000	NUT, CAPTIVE 10-32	16.0 EA	2#F001 2#F002 2#F003 2#F004 2#F005 2#F006 2#F007 2#F008
384 0341 000	RECTIFIER 1N5404 ESD	9.0 EA	CR001 CR002 CR003 CR004 CR005 CR006 CR007 CR008 CR010
398 0186 000	FUSE 1 TIME 30A 250V	1.0 EA	F010
398 0437 000	FUSE, 50A 250V CRTG	8.0 EA	F001 F002 F003 F004 F005 F006 F007 F008
402 0004 000	CLIP, FUSE .812 60A 250V	16.0 EA	#F001 #F002 #F003 #F004 #F005 #F006 #F007 #F008
402 0069 000	CLIP, FUSE BRONZE	2.0 EA	#F010
508 0549 000	CAP .33UF 5% 400VDC	1.0 EA	C003
542 0121 000	RES 150 OHM 5% 20W	9.0 EA	R001 R002 R003 R004 R005 R006 R007 R008 R010
548 2400 401	RES 10K OHM 1/2W 1%	1.0 EA	R024
548 2400 466	RES 47.5K OHM 1/2W 1%	2.0 EA	R022 R023
548 2400 547	RES 301K OHM 1/2W 1%	1.0 EA	R027
620 0515 000	RECP, SCREW ON SMC	1.0 EA	J001
839 7855 068	SCHEM, OVERALL DX-50	0.0 EA	
839 7930 030	SCHEMATIC, FUSE BOARD	0.0 EA	
843 5100 029	PWB, FUSE	1.0 EA	A025
999 2576 002	HARDWARE LIST	1.0 EA	

Table 7-28. PA CAB CABLE PKG, DX 25U - 992 8056 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
917 2099 003	MAIN CABLE DX-50	1.0 EA	
917 2099 005	DRIVE CABLES	8.0 EA	
917 2099 006	RIBBON CABLES	1.0 EA	
917 2099 007	CABLE PKG	1.0 EA	
917 2099 013	DRVR ENCODER CABLE	1.0 EA	
917 2099 014	DRVR DRIVE CABLE	4.0 EA	
917 2099 039	FILTER CAPACITOR CABLE	1.0 EA	
917 2501 014	CBL POWER SUPPLY DISCHARGE	1.0 EA	
939 7855 162	JUMPER CABLES	1.0 EA	
939 7930 174	CABLE ASSY, FRONT METER	1.0 EA	
952 9170 012	CABLE, DRIVER ENCODER	1.0 EA	

Table 7-29. DX50 PA & OUTPUT CABINETS - 943 5100 016

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
302 0316 000	SCR, 3/8-16 X 3/4	8.0 EA	
306 0064 000	NUT, WELD 10-32	6.0 EA	

306 0065 000	NUT, WELD 1/4-20	12.0 EA	
306 0067 000	NUT, WELD 3/8-16	16.0 EA	
310 0011 000	WASHER, FLAT 3/8	8.0 EA	
314 0011 000	WASHER, SPLIT-LOCK 3/8	8.0 EA	
822 0922 029	Z-BRACE	12.0 EA	
822 0922 030	XFMR BRACE	2.0 EA	
822 0922 031	XFMR MTG BRACE	2.0 EA	
822 0922 090	XFMR CTR BRACE	2.0 EA	
843 5100 005	PA CABINET BASE	1.0 EA	
843 5100 007	PA CAB TOP FRT CHNL	1.0 EA	
843 5100 008	PA CAB TOP REAR CHNL	1.0 EA	
843 5100 009	CABINET END PNL	1.0 EA	
843 5100 010	CABINET END PNL	1.0 EA	
843 5100 011	OUTPUT CABINET BASE	1.0 EA	
843 5100 012	OUTPUT CAB TOP FRT CHNL	1.0 EA	
843 5100 013	OUTPUT CAB TOP REAR CHNL	1.0 EA	
843 5100 014	CABINET END PNL	1.0 EA	
843 5100 015	CABINET END PNL	1.0 EA	
843 5100 016	ASSY INSTR, DX50 PA & OUT	0.0 EA	

Table 7-30. EXTERNAL INTERFACE - 992 8070 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
380 0678 000	XSTR, ARRAY QUAD 2222 ESD	9.0 EA	Q001 Q002 Q003 Q004 Q005 Q006 Q007 Q008 Q009
382 0359 000	IC, 7815 ESD	1.0 EA	U008
382 0360 000	IC, 7915 ESD	1.0 EA	U009
382 0510 000	* IC, ILQ-74 OPTO ISOL ESD	3.0 EA	U001 U002 U003
382 0749 000	IC NE5532A ESD	4.0 EA	U004 U005 U006 U007
384 0720 000	TRANSZORB 1N6377 15V 5W ESD	23.0 EA	CR008 CR009 CR010 CR011 CR012 CR013 CR014 CR015 CR016 CR017 CR018 CR019 CR020 CR021 CR022 CR023 CR024 CR025 CR026 CR027 CR028 CR029 CR030
384 0743 000	DIODE ARRAY DUAL 8 ESD	5.0 EA	CR001 CR002 CR003 CR004 CR005
384 0799 000	DIODE, BIPOLAR ESD	1.0 EA	CR031 CR032
384 0838 000	TRANSZORB 1N6380 36V 5W ESD	2.0 EA	CR033 CR034
386 0082 000	ZENER, 1N4744A 15V 1W 5% ESD	2.0 EA	CR006 CR007
404 0673 000	SOCKET 8 PIN DIP (DL)	4.0 EA	XU004 XU005 XU006 XU007
404 0674 000	SOCKET 14 PIN DIP (D-L)	14.0 EA	XCR001 XCR002 XCR003 XCR004 XCR005 XQ001 XQ002 XQ003 XQ004 XQ005 XQ006 XQ007 XQ008 XQ009
404 0675 000	SOCKET IC 16 CONT	3.0 EA	XU001 XU002 XU003
404 0733 000	HEAT SINK	2.0 EA	#U008 #U009
516 0375 000	CAP .01UF 50V -20/+80% Z5U	2.0 EA	C006 C008
516 0453 000	CAP .1UF 100V 20% X7R	35.0 EA	C007 C009 C014 C017 C018 C021 C022 C025 C026 C028 C029 C030 C031 C032 C033 C034 C035 C036 C037 C038 C039 C040 C041 C042 C043 C044 C045 C046 C047 C048 C049 C050 C051 C053 C054
516 0511 000	CAP 0.47UF 100V 20%	2.0 EA	C011 C013
516 0516 000	CAP 1UF 100V 20%	2.0 EA	C010 C012
516 0774 000	CAP 56PF 5% 100V C0G	8.0 EA	C015 C016 C019 C020 C023 C024 C027 C052
516 0792 000	CAP NETWORK .1UF 10%	5.0 EA	C001 C002 C003 C004 C005
540 1375 000	RES NETWORK 1000 OHM 2%	4.0 EA	R029 R030 R038 R039

540 1380 000	RES NETWORK 10K OHM 2%	2.0 EA	R028 R037
540 1434 000	RES NETWORK 330 OHM 2%	9.0 EA	R001 R003 R005 R007 R009 R011 R013 R015 R017
540 1443 000	RES NETWORK 27 OHM 2%	9.0 EA	R002 R004 R006 R008 R010 R012 R014 R016 R018
540 1446 000	RES NETWORK 220K OHM 2%	2.0 EA	R027 R036
540 1480 000	RES NETWORK 180 OHM 2%	18.0 EA	R048 R049 R050 R051 R052 R053 R054 R055 R056 R057 R058 R059 R060 R061 R062 R063 R064 R065
540 1600 001	RES 1 OHM 3W 5%	4.0 EA	R066 R067 R068 R069
542 1591 000	RES 100.0 OHM 5.25W 5%	6.0 EA	R021 R022 R023 R024 R025 R026
548 2400 101	RES 10 OHM 1/2W 1%	4.0 EA	R070 R071 R072 R073
548 2400 230	RES 200 OHM 1/2W 1%	2.0 EA	R019 R020
548 2400 326	RES 1.82K OHM 1/2W 1%	2.0 EA	R041 R043
548 2400 330	RES 2K OHM 1/2W 1%	2.0 EA	R045 R047
548 2400 343	RES 2.74K OHM 1/2W 1%	2.0 EA	R044 R046
548 2400 401	RES 10K OHM 1/2W 1%	2.0 EA	R040 R042
610 0780 000	HEADER 4C 1 ROW STRAIGHT	1.0 EA	J011
610 0854 000	HEADER, 40 PIN PC RIBBON	4.0 EA	J005 J006 J009 J010
610 0998 000	HDR, 6 PIN, PC BD	2.0 EA	J004 J012
610 0999 000	HDR, 10 PIN, PC BD	1.0 EA	J003
612 1131 000	RECEPTACLE 25 POS D	1.0 EA	J001
614 0715 000	TERM BD 4 TERM	1.0 EA	TB003
620 1677 000	RECEPTACLE, PC MT, BNC	2.0 EA	J007 J008
839 7855 090	SCHEM, EXTERNAL INTERFACE	0.0 EA	
843 5100 063	PWB, EXTERNAL INTERFACE	1.0 EA	
999 2455 002	HARDWARE LIST	1.0 EA	

Table 7-31. PWA, NEUTRALIZATION, ESD SAFE - 992 8079 002

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
051 0001 023	*ADHESIVE, DP-190 GRAY	0.0 EA	
546 0295 000	RES 50 OHM 3.25W 5%	10.0 EA	R001 R002 R003 R004 R005 R006 R007 R008 R009 R010
610 1054 000	HEADER STRAIGHT MNT 8 PIN	1.0 EA	J001
839 7930 031	SCHEM, NEUTRALIZATION	0.0 EA	
843 5155 031	PWB, NEUTRALIZATION	1.0 EA	
922 0999 128	TRANSFORMER	1.0 EA	T001

Table 7-32. XFMR PKG (PA CABINET) - 992 8094 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
922 0922 154	TRANSFORMER	1.0 EA	T010
922 0922 160	TRANSFORMER	1.0 EA	T008
922 0922 161	TRANSFORMER	1.0 EA	T009

Table 7-33. DX25U UNIQUE PARTS - 992 8101 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
822 0922 196	RF COND GND BAR	1.0 EA	
839 7855 070	INDUCTOR LEAD	1.0 EA	#2L1
839 7855 141	CTR COLUMN CLOSEOUT PLT	1.0 EA	
839 7855 148	RF COND GND PLATE	1.0 EA	
843 5100 081	CAP MTG ANGLE	1.0 EA	

Table 7-34. DX25U UNIQUE COMPONENTS - 992 8164 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
410 0018 000	INSULATOR ROUND NS5W 0312	2.0 EA	
414 0295 000	CORE, FERRITE,	1.0 EA	
632 1138 000	MTR, 250ADC, 4-1/2", W	1.0 EA	M002
632 1139 000	MTR O-50KW, 4-1/2", W	1.0 EA	M003
638 0025 000	SHUNT METER 250A 50MV	1.0 EA	SH001
646 1464 000	INSERT, DX 25U NAMEPLATE	1.0 EA	
922 0922 209	FILTER BRACKET	1.0 EA	
992 7087 003	COMB MOTHERBD BINARY, ESD SAFE	1.0 EA	A008
992 7089 013	* MOD ENCODER/BINARY	1.0 EA	A037
992 8468 002	DC REGULATOR	1.0 EA	

Table 7-35. COMB MOTHERBD BINARY, ESD SAFE - 992 7087 003

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
252 0408 000	WIRE, 20AWG, TEFLON YEL.	0.050 FT	
358 1928 000	JUMPER 1/4 LG 1/8H	5.0 EA	JP001 JP002 JP003 JP004 JP005
922 0922 006	XFMR PAIR	1.0 EA	T6/T11
992 7087 001	PWA,COMB MTHBD BINARY,ESD SAFE	1.0 EA	

Table 7-36. PWA,COMB MTHBD BINARY,ESD SAFE - 992 7087 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
358 2837 000	STUD, PC BD 4-40 X 5/16	6.0 EA	
358 3164 000	CARD GUIDE	32.0 EA	2#J001 2#J002 2#J003 2#J004 2#J005 2#J006 2#J007 2#J008 2#J009 2#J010 2#J011 2#J012 2#J013 2#J014 2#J015 2#J016
494 0345 000	CHOKE, RF 1.2 UH	1.0 EA	L017
522 0628 000	CAP 220UF 400V 20%	6.0 EA	C001 C002 C003 C004 C005 C006
540 1600 422	RES 75K OHM 3W 5%	6.0 EA	R001 R002 R003 R004 R005 R006
610 1005 000	PLUG, SHORTING .040 PINS	4.0 EA	P030 P031 P032 P033
610 1051 000	HOUSING 28 DUAL POSITIONS	16.0 EA	J001 J002 J003 J004 J005 J006 J007 J008 J009 J010 J011 J012 J013 J014 J015 J016
610 1084 000	HDR 10 PIN/ACTION PINS	4.0 EA	J021 J022 J023 J024
610 1085 000	HDR 20 PIN/ACTION PINS	4.0 EA	J017 J018 J019 J020
610 1088 000	LATCH .576 FOR EJECTION	16.0 EA	2#J017 2#J018 2#J019 2#J020 2#J021 2#J022 2#J023 2#J024
612 0775 000	JACK, PC MT, .040 PINS	32.0 EA	
612 1012 000	JACK PC MT .040 PINS	16.0 EA	4#J30 4#J31 4#J32 4#J33
813 4999 005	STDOFF 4-40X3/8 1/4 HEX	4.0 EA	
822 0922 026	RF COND SUPPORT	2.0 EA	
822 0922 053	COMBINER COVER SUPPORT	2.0 EA	
822 0922 109	STDOFF,.25 X 5.35 X 4-40	2.0 EA	
839 8118 043	SCHEM, COMBINER MB BINARY	0.0 EA	
843 5100 031	PWB, COMBINER BINARY	1.0 EA	
992 7096 001	XFMR PKG (BINARY MBD)	1.0 EA	T001 T002 T003 T004 T005 T007 T008 T009 T010 T012 T013 T014 T015 T016
999 2577 001	HARDWARE LIST	1.0 EA	

Table 7-37. XFMR PKG (BINARY MBD) - 992 7096 001

HARRIS P/N	DESCRIPTION	QTY/UM	REF. SYMBOLS/EXPLANATIONS
922 0922 002	XFMR PAIR	2.0 EA	T8/T9 T7/T10
922 0922 003	XFMR PAIR	1.0 EA	T1/T16
922 0922 004	XFMR PAIR	2.0 EA	T2/T15 T3/T14
922 0922 005	XFMR PAIR	1.0 EA	T4/T13
922 0922 007	XFMR PAIR	1.0 EA	T5/T12

Table 7-38. POWER SUPPLY DISCHARGE - 992 8684 003

HARRIS P/N	DESCRIPTION	QTY/UM	REF. SYMBOLS/EXPLANATIONS
328 0071 000	WASHER, STEEL COMPRESSION	4.0 EA	#Q001 #Q002 @Q003 #Q004
380 0681 000	XSTR IRFP350 ESD	4.0 EA	Q001 Q002 Q003 Q004
386 0094 000	ZENER, 1N4740 10V ESD	4.0 EA	CR004 CR005 CR008 CR009
410 0413 000	INSULATOR PAD FOR TO-247	4.0 EA	#Q001 #Q002 #Q003 #Q004
508 0539 000	CAP 2 UF 400VDC 10%	2.0 EA	C001 C003
540 1600 401	RES 10K OHM 3W 5%	4.0 EA	R006 R007 R011 R012
614 0727 000	TERM BD 8C 1ROW PC MT	2.0 EA	TB001 TB002
839 7930 518	SCHEM, PWR SUP DISCHARGE	0.0 EA	
843 5155 518	PWB, PWR SUPPLY DISCHARGE	1.0 EA	
917 2150 682	DISCHARGE HEATSINK	1.0 EA	
999 2781 003	HARDWARE LIST, PWR SUPPLY	1.0 EA	

Table 7-39. OUTPUT CABINET - 992 7091 001

HARRIS P/N	DESCRIPTION	QTY/UM	REF. SYMBOLS/EXPLANATIONS
328 0070 000	WASHER CUPPED BLACK WEAR	23.0 EA	
328 0073 000	WASHER, RETAINER	23.0 EA	
358 0437 000	BUSHING PANEL .252 ID	2.0 EA	
358 2635 000	CABLE TIE, PUSH MOUNT SNAP IN	12.0 EA	
358 3131 000	STUD, BRS 1/4-20 X 1	1.0 EA	#J002 GND
358 3172 000	STUD 1/4 TURN PHILLIPS HD	21.0 EA	
358 3236 000	DRIVE, RIGHT ANGLE GEAR	3.0 EA	
398 0456 000	FUSE, TIME DELAY 1A 500V	12.0 EA	F011 F012 F013 F021 F022 F023 F031 F032 F033 F041 F042 F043
402 0107 000	CLIP, FUSE 9/16	2.0 EA	
402 0130 000	FUSE HOLDER, 3 POLE	4.0 EA	XF001 XF002 XF003 XF004
410 0025 000	INSULATOR ROUND NS5W 0416	1.0 EA	
410 0028 000	INSULATOR ROUND NS5W 0432	1.0 EA	
430 0199 000	FAN BLADE, 12"DIA, 4 BLADE	4.0 EA	#B001 #B002 #B003 #B004
436 0289 000	MOTOR, 1/3HP 50/60 HZ 3PH	4.0 EA	B001 B002 B003 B004
448 0224 000	HANDLE ALUM	4.0 EA	
448 0869 000	AIR FILTER 20 X 25 X .88	4.0 EA	
452 0025 000	GEAR, MITER 16 TEETH	2.0 EA	
452 0026 000	GEAR, MITER 16 TEETH	2.0 EA	
456 0144 000	SPRING, EJECTOR	23.0 EA	
492 0743 000	COIL, AIR-WOUND 125UH	1.0 EA	L007
514 0240 000	CAP, VAR 2300PF 15KV TEST	2.0 EA	2C2A 2C4A
514 0339 000	CAP. VAR-12-500PF 15KV	1.0 EA	2C3A
530 0006 000	FLG MTG TERM FM2B	1.0 EA	#2C3A
530 0007 000	FLG MTG TERM FM2D	1.0 EA	#2C3A
614 0047 000	TERM BD 3 TERM	1.0 EA	TB001
620 0265 000	END TERMINAL, 2062	1.0 EA	J002

620 0455 000	ADPT BNC UG492A/U	1.0 EA	J001
646 1347 000	MARKER STRIP 3 TERM	1.0 EA	#TB001
646 1462 000	NAMEPLATE, HARRIS 10.5 LG	1.0 EA	
648 0051 000	* COUNTER CCW	2.0 EA	
650 0150 000	KNOB RD PLAIN SKIRT	2.0 EA	
813 5608 020	*NON STANDARD	1.0 EA	#2E2
817 1335 119	PLATE, GROUNDING	1.0 EA	
817 2099 021	STRAP	1.0 EA	#1A26C1/9-2C2B
817 2099 040	RUNNING LIST, OUTPUT CAB	0.0 EA	
817 2099 053	ANGLE	6.0 EA	
817 2099 054	PLATE	2.0 EA	
822 0922 064	COIL MTG CHNL	2.0 EA	
822 0922 067	LOAD KNOB SHAFT	1.0 EA	
822 0922 069	L/T DRIVE MTG PLT	2.0 EA	
822 0922 070	COUPLING 3/8-1/2	4.0 EA	
822 0922 071	COUPLING 1/4 - 3/8	2.0 EA	
822 0922 072	L/T PNL TRIM	2.0 EA	
822 0922 073	L/T PNL MTG BAR	2.0 EA	
822 0922 075	DOOR HINGE PIN	2.0 EA	
822 0922 079	TERMINAL MTG PLT	2.0 EA	
822 0922 081	SHELF SUPPORT BLOCK	2.0 EA	
822 0922 087	CONNECTION POST	1.0 EA	#CAP SHLF
822 0922 114	STDOFF 1 X 2 X 1/4-20	1.0 EA	#2L7
822 0922 123	STDOFF 1 X 4 X 1/4-20	1.0 EA	#2E2
822 0922 125	STUD 3/8-16 X 1.6	1.0 EA	
822 0922 126	STUD 3/8-16 X .8	1.0 EA	
822 0922 128	STUD 1/4-20 X 1.9	1.0 EA	#2E2
822 0922 129	SHAFT 5"	1.0 EA	
822 0922 130	SHAFT 14"	1.0 EA	
822 0922 133	SPARK BRKT	1.0 EA	
822 0922 134	SPARK BRKT	1.0 EA	
822 0922 138	STRAP	1.0 EA	#C4-STDOFF
822 0922 139	STRAP	1.0 EA	
822 0922 157	TUNE KNOB SHAFT	1.0 EA	
822 0922 166	CAP MTG PLATE	1.0 EA	1#C3A/B
822 0922 167	STDOFF	2.0 EA	2#C3A/B
822 0922 180	STRAP, 8.00" X 1.00"	6.0 EA	4#C2A-C1A1B 1#C4A-B 1#C2A-C3
822 0922 182	STRAP	3.0 EA	3#C2A-L3—(2 REQ'D)
822 0922 207	SHAFT 14.5 INCH LG	1.0 EA	
829 9009 102	PLATE, COIL MTG	2.0 EA	#2L7
839 7855 022	INDUCTOR	1.0 EA	L001
839 7855 070	INDUCTOR LEAD	1.0 EA	
839 7855 078	INDUCTOR LEAD	1.0 EA	
843 5100 072	COIL MTG PLATE	1.0 EA	
914 3468 002	COUPLING FLEXIBLE .5 X .5	2.0 EA	#C1A #C4A
922 0922 142	MODIFIED FAN FRAME	4.0 EA	
931 6372 001	COIL FXD TUBG 35FCT1	1.0 EA	
938 4203 021	GROUND HOOK ASSY	1.0 EA	
939 8187 022	PANEL, LEFT REAR ACCESS	1.0 EA	
939 8187 023	PANEL, RIGHT REAR ACCESS	1.0 EA	
943 5479 074	SUPPORT, DRIVE OUTPUT CAB	1.0 EA	
992 8060 001	0.125 AL SM FAB PKG	1.0 EA	
992 8060 003	0.064 AL SM FAB PKG	1.0 EA	
999 2588 001	HARDWARE LIST	1.0 EA	

Table 7-40. GROUND HOOK ASSY - 938 4203 021

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
252 0017 000	WIRE, STRD 26 AWG WHT	4.30 FT	
296 0019 000	PLASTIC TUBE 4AWG CLEAR	4.250 FT	
306 0006 000	NUT, HEX 10-32	2.0 EA	
308 0007 000	10 FLAT WASHER BRASS	1.0 EA	
312 0007 000	WASHER, INT LOCK 10	1.0 EA	
312 0049 000	WASHER, SPLIT-LOCK 10	1.0 EA	
354 0287 000	LUG #10 RING N/INS 7-9AWG	1.0 EA	
354 0289 000	LUG .25 RING N/INS 7-9AWG	1.0 EA	
814 7796 006	HANDLE, 18" X 1/2"	1.0 EA	
814 7917 001	HOOK, 1/2IN RADIUS	1.0 EA	
838 4203 001	ASSY INSTR, GROUND HOOK	0.0 EA	

Table 7-41. STEP START PANEL - 992 7092 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
358 3185 000	PLUG WHT 1.093/1.125 HOLE	10.0 EA	
410 0029 000	INSULATOR ROUND NS5W 0440	6.0 EA	#R001 #R002 #R003
448 0224 000	HANDLE ALUM	2.0 EA	
508 0554 000	CAP 3300PF 600WVDC	2.0 EA	
540 1600 015	RES 3.9 OHM 3W 5%	2.0 EA	
542 1006 000	RES 5.4 OHM 766W 10%	3.0 EA	R001 R002 R003
560 0049 000	MOV 4500A 75J 275VAC	2.0 EA	
560 0077 000	VARISTOR 275VRMS 30KA	8.0 EA	RV001 RV002 RV003 RV004 RV005 RV006 RV007 RV008
570 0124 000	CONTACTOR, 3P, 40A, 50/60HZ	1.0 EA	K001
570 0317 000	CONTACTOR 3 POLE 200A	1.0 EA	
574 0436 000	*RELAY, SS, AC, 10A, SPST	2.0 EA	
614 0062 000	TERM BD 18 TERM	1.0 EA	TB001
646 1404 000	MARKER STRIP, 18 TERM	1.0 EA	#TB001
817 1335 119	PLATE, GROUNDING	1.0 EA	
817 2099 023	RUNNING LIST, SSP DX50	0.0 EA	
822 0922 077	SSP GND STRAP	1.0 EA	
917 2099 055	CABLE, STEP START PANEL	1.0 EA	
917 2332 049	INSULATOR, 3/8 D. X 1 LG.	2.0 EA	
992 8061 001	0.125 AL SM FAB PKG	1.0 EA	
999 2587 001	HARDWARE LIST	1.0 EA	

Table 7-42. XFMR KIT,STEPDOWN 480/240 - 994 9210 001

HARRIS P/N	*DESCRIPTION*	*QTY/UM*	*REF. SYMBOLS/EXPLANATIONS*
398 0460 000	FUSE, TIME DELAY 3A 500V	2.0 EA	
402 0177 000	FUSE BLOCK, 2 POLE, 600V	1.0 EA	
472 1705 000	XFMR, STEP-DOWN 1KVA	1.0 EA	

Section VIII
Diagrams

8.1 Introduction

This section provides a list of the drawings provided in the separate drawing package.

Drawings Provided Under Separate Cover

Drawing Description	Drawing Number
Schematic, Switch Board/Meter Board	839 6208 301
Schematic, RF Multimeter	839 6208 302
Schematic, Driver Supply Regulator	839 7855 004
DX25 Overall Schematic	839 7855 151
Schematic, RF Amplifier	839 7855 080
Schematic, External Interface	839 7855 090
Schematic, Controller	843 5400 091
Schematic, LED Board	843 7855 184
Schematic, Combiner MB, Main	839 7855 094
Schematic, Driver Combiner/Motherboard	839 7855 095
Schematic, Buffer Amplifier	839 7855 099
Schematic, Analog Input Board	839 7855 100
DX50 Cabinet Outline	839 7855 152
FD Chart DX25	839 7855 138
Tuning Chart DX25	839 7855 142
Schematic, Output Monitor	843 5400 101
Schematic, DC Regulator	839 7855 163
Schematic, Modulation Encoder	839 7855 174
Schematic, Driver Encoder/Temp Sensor	839 7855 175
Schematic, Analog To Digital Converter	839 8755 177
Schematic, Output Sample	839 7930 018
Schematic, Neutralization Board	839 7930 031
Schematic, Oscillator	839 7930 032
Schematic, Power Supply Discharge	839 7930 518
Schematic, Combiner MB, Binary	839 8118 043
PA Cabinet Cable Package Running List	817 2099 002
Output Cabinet Running List	817 2099 040

A.1 Introduction

This section includes a description of the Oscillator and troubleshooting information.

A.2 Location

The Oscillator is located in the Center Control Compartment of the transmitter, on the inner right wall.

A.3 Principles of Operation

The Oscillator provides an RF signal at the transmitter operating frequency, and also allows for an external RF input. Refer to SECTION V, Maintenance, for adjustment and pc board maintenance procedures.

A.4 Circuit Description

Refer to schematic 839-7930-032 in the Drawing Package.

A.4.1 Supply Voltages and Voltage Regulators

Input voltages from the Low Voltage power supply are +22 VDC and -22 VDC through F1 and F2. Voltage regulator U6 provides -15 VDC for the crystal oven. All positive voltages are regulated by zener diodes, and include +15 VDC from CR1, +9 VDC from CR13, and +5 VDC from CR4.

A.4.2 Oscillator Stage

The crystal oscillator stage, Q1, is a standard Pierce circuit, operating at four or eight times the carrier frequency. The crystal operates in its parallel resonant mode. A jumper plug, P1, allows selecting either of two crystals. If one crystal should fail, this jumper allows quick selection of the backup crystal (the oven jumper P6 must also be changed). For each crystal, small frequency adjustments can be made with C1 (for crystal Y1) or C3 (for Y2).

For carrier frequencies of 1250 kHz and below, the crystal frequency is eight times the carrier frequency, and for carrier frequencies above 1250 kHz, the crystal frequency is four times the carrier frequency.

The +15 VDC supply voltage for the oscillator is derived from +22 VDC and is regulated by zener diode CR1. The oscillator supply voltage can be measured at TP1.

Each crystal is contained in a sleeve type oven, which maintains temperature at 70°C (+/-3°C, approximately). Oven jumper plug P6 supplies -15 VDC to either oven. Note that crystal jumper plug P1 and oven jumper plug P6 must both be in the upper or lower position.

A.4.3 Buffer/Squaring Amplifier

Buffer amplifier Q2 is coupled to the oscillator output, and operates as an overdriven amplifier, with a +5 VDC supply voltage. The output of Q2 is a TTL-level square wave which drives the frequency divider.

A.4.4 Frequency Divider

Integrated circuits U1 and U2 are dual J-K flip-flops, used as frequency dividers. Each IC section is connected as a divide-by-two circuit. The signal at P2-2 is one-fourth the crystal frequency and the signal at P2-3 is one-eighth the crystal frequency. Jumper plug P2 routes the selected frequency to buffer/driver U5-2. The output of U5-7 at TP-5 is a TTL level square wave at the transmitter operating frequency.

If the transmitter frequency is 1250 kHz or below, P2 is jumpered between 1 and 2. It the transmitter frequency is above 1250 Khz, P2 is jumpered between 1 and 3.

A.4.5 External Input

Jumper plug P3 is used to select either the internal oscillator or an external oscillator. An external input signal can be connected to BNC jack J2.

Jumper plug P5 selects an external input impedance of 50 Ohms or 20k Ohms. The high impedance input is for use with TTL level (4 to 4.5 Volt peak-to-peak square wave) inputs. The 50 Ohm input impedance is for use with RF input levels from 0 to +25 dbm. Amplifier Q3 and buffer/driver U5 provide a logic-level signal to P3-2.

A.4.6 Normal or Combined Transmitter Operation

Jumper plug P4 is used to select either normal or combined transmitter operation. For normal operation, P4-1 and P4-3 are jumpered, and the RF signal from buffer/driver U5 is fed to U4-4. For combined operation, P4-1 and P4-2 are connected. The RF signal is then routed through R29, J4-1, and the External Interface to the combiner control unit. When transmitters are combined, the oscillator from either transmitter can be used. The combiner control unit will provide two outputs from one oscillator; the selected RF signal is then returned to each transmitter's Oscillator at J4-4.

A.4.7 Frequency Monitor Output

Buffer/driver U3-5 provides an output signal for a frequency monitor or counter. Resistor R17 sets the driver output impedance at 50 Ohms. The frequency monitor output signal, at BNC connector J5, will be a 4-4.5 Vp-p square wave at the transmitter operating frequency when the monitor impedance is 50 Ohms. If the impedance is higher than 50 Ohms, the output signal level will be higher.

A.4.8 Oscillator Sync

"Oscillator Sync" synchronizes the RF drive phase to any ringing currents in the combiner/output network during VSWR protection. The circuit replaces the oscillator signal with a current sample from the output network. The oscillator sync is adjusted with DIP switch S1 and inductor L4.

The Output Current sample from T6 at the combiner output is brought into the Oscillator at J3-1. Resistor R37 provides a 50-Ohm input impedance, and zener diodes CR11 and CR12 protect Q4 from transient voltages. The signal phase is adjusted by DIP-switch selected capacitors C30 through C33 and L4. The signal is converted to TTL level by Q4 and fed to CMOS analog switch U4-11.

During normal operation, the Oscillator signal is routed through U4 to buffer-driver U3 and then to the Buffer Amplifier. During VSWR protection a logic HIGH signal from the LED Board turns on Q5 and switches U4 so that the output current sample is used as the transmitter's RF drive.

Because the air system does not operate until the Power Amplifier stage is energized, the Oscillator output to the Buffer Amplifier is muted to protect it from over-dissipation. The VSWR-H input is held HIGH by the LED Board when the transmitter is OFF.

A.4.9 Oscillator Output (Buffer-Driver)

The output of driver amplifier U3-7 is square wave at the carrier frequency. The signal is sent to the Driver Combiner Motherboard where it drives the input of Buffer Amplifier A16.

A.4.10 "RF Present" Output

The output from U3-7 is converted to positive and negative DC voltages by peak detectors CR7-C18 and CR6-C17. These voltages are used for the Oscillator RF Sense circuit on the LED Board.

A.5 Troubleshooting

A.5.1 Symptom: Oscillator LED on ColorStat™ panel is Red, transmitter will not operate.

A.5.1.1 Possible Cause: Power Supplies

Check for +22 VDC at both sides of F1. The +22 VDC unregulated voltage should be present when ac power is applied to the transmitter and Low Voltage Supply circuit breaker CB2 is turned on. The front panel multimeter will also indicate whether the low voltage power supply voltages are present.

If the +22 VDC is present and F1 is good, check the voltages at TP1, TP2, and TP3. If one voltage is missing, a zener diode may be shorted or there may be a short in a circuit supplied by that voltage.

A.5.1.2 Possible Cause: Oscillator Sync Circuit

Using an oscilloscope, check for RF voltage At TP5. A 4-4.5 Vp-p square wave at carrier frequency should be present.

If the RF voltage at TP5 is ok, check the output of CMOS switch U4.

NOTE

Remember that the output to the Buffer Amplifier is held off by CMOS switch U4 at the VSWR-H input J7-5 until the Power Amplifier stage is turned on. Use S4 on the LED Board to check the output of U4.

A.5.1.2.1 *CMOS switch U4*

Observe the DC voltage at U4-6 while depressing S4 on the LED Board. The voltage should change from LOW to HIGH.

- If the DC voltage changes from LOW to HIGH but there is no RF output at U4-2, replace U4.
- If the voltage changes from LOW to HIGH and there is RF output at U4-2, check U3.
- If the voltage is LOW and does not change, check the operation of Q5.
- Measure the DC voltage at the junction of R45 and R34. If the voltage changes from HIGH to LOW when S4 on the LED Board is depressed, Q5 is leaky or shorted, or U4-6 input is shorted internally.
- If the DC voltage at the junction of R45 and R34 does not change when S4 on the LED Board is depressed, check the operation of the VSWR circuitry on the LED Board.

A.5.1.2.2 *U3 Defective*

Using an oscilloscope, check for an RF signal at U3-2. If the RF signal is present at U3-2 but not at U3-7, replace U3. If there is RF present at U3-7, check the Oscillator output at J4-8.

A.5.1.2.3 *Short on Output*

Using an oscilloscope, check for RF output at J4-8 (a convenient place to check is at the end of R31 closest to BNC connector J5). A 4-4.5 Vp-p square wave at the transmitter carrier frequency should be present.

If RF voltage is present at U3-7 but not at J4-8, there is a short on the Oscillator output. This could be in the cable between the Oscillator and the Driver/Combiner motherboard, the input of the Buffer amplifier, or the RF detection circuitry.

A.5.1.3 Possible Cause: RF Not Present at TP5

A.5.1.3.1 *P3 or P4 Installed Incorrectly*

When the crystal oscillator on the Oscillator is used, the jumper plugs must be installed from P3-1 to P3-3, and from P4-1 to P4-3. When an external oscillator is used, the jumper plugs must be installed from P3-1 to P3-2, and from P4-1 to P4-2.

If P3 and P4 are installed correctly, and the crystal oscillator is used, continue with the list of possible causes below.

A.5.1.3.2 *Crystal Failure*

Move P1 to the other crystal position. If RF output returns, one crystal (or associated circuitry) is defective. If you operate with the alternate crystal, change the crystal oven plug P6 to the alternate crystal.

A.5.1.3.3 *Q1, Q2 faulty*

Using an oscilloscope, check the signals at Q1 and Q2 collectors. A sinewave of RF should be present at the output of Q1. The output of Q2 output should be a square wave at 4-4.5 Vp-p. RF frequency at these points should be at the crystal frequency.

A.5.1.3.4 *U1, U2 faulty*

Check the frequency divider outputs at P2-2 and P2-3 for a 4-4.5 Vp-p square wave. Each IC section should divide the frequency by two. Faults in a divider IC section will normally cause the IC output to go to ground or +Vcc supply voltage.

A.5.1.3.5 U5 faulty

The output of U5-7 should be 4-4.5 Vp-p square wave, and can be checked at P3-3.

A.5.2 Symptom: No RF Output, External Oscillator Used

A.5.2.1 Possible Cause: RF Input From External Oscillator

The fault could be either in the external oscillator or in coaxial cables carrying the signal. Check for output from the external oscillator, then trace the signal through each cable connection point.

A.5.2.2 Possible Cause: External Input Impedance

When P5 is jumpered from 1 to 3, the external input is terminated in 50 Ohms. For a 50 Ohm input, 0.23 Vrms to 4 Vrms should be present at P5-1. For a TTL input, 4-4.5 Vp-p should be present at P5-1 with P5 jumpered from 1 to 2.

A.5.2.3 Possible Cause: Q3 or U5 faulty

Using an oscilloscope, check the RF signal level at Q3 collector and at P3-2. Both should be 4-4.5 Vp-p.

A.5.3 Symptom: Frequency Instability.

A.5.3.1 Possible Cause: Plug P6.

Make certain that both P1 and P6 are in the same position (jumper from 1 to 3 on both, or from 1 to 2 on both).

A.5.3.2 Possible Cause: Crystal Oven Failure

The crystal oven which is operating should be hot.

A.5.3.3 Possible Cause: No -15 VDC Supply

Check for -15 VDC at P6-1. If not present, check both ends of F2 for -22 VDC. If F2 is open, replace it. If the fuse opens again, U6 is probably defective.

A.5.3.4 Possible Cause: Defective Crystal

Defective crystals may operate off frequency. If one crystal can be adjusted to the correct frequency but the other cannot, the off-frequency crystal is probably defective.

A.5.4 Symptom: Output At Incorrect Frequency

A.5.4.1 Possible Cause: Frequency Divider Jumper Plug P2

Check the position of the P2. The crystal frequency will be divided by four if P2 is from 1-2, and will be divided by eight if P2 is from 1-3. Check your crystal frequency and the jumper position.

A.5.4.2 Possible Cause: Frequency Divider Fault

Normally, a frequency divider fault will result in complete loss of RF at P2-1. The output of a frequency divider section will go to either 0 VDC or to +5 VDC. Using an oscilloscope, check the oscillator frequency at Q2 collector, and divider frequencies at P2. Frequency at P2-2 should be 1/4 the oscillator frequency and at P2-3, should be 1/8 the oscillator frequency.

A.5.5 Symptom: Oscillator LED on ColorStat™ panel is Red but transmitter operation is normal.

A.5.5.1 Possible Cause: RF Present circuit

CR6 and CR7 “RF Present Detectors.” Check for +4 to +5 VDC at CR7 cathode and for -4 to -5 VDC at CR6 anode. If a normal RF level is present at the Oscillator board output but one or both of these DC voltages are missing, check and/or replace the diode(s). Loss of one or both DC voltages will cause a RED “OSCILLATOR” status indication. If voltage is present at one side of R19 or R21 but not at the other side, a resistor failure or a short after J7 is indicated. (In this case, the transmitter will remain ON.)

If you measured correct DC voltages in the previous step, the red “OSCILLATOR” Status LED indication is caused by a problem on the LED Board or an open or short in an interconnecting cable. Refer to SECTION Q, LED Board, and SECTION VI, Troubleshooting, for additional information.

Table A-2. Oscillator Board A17, Controls and Indicators

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
C7	C1	Adjusts the frequency of crystal Y1.
C6	C3	Adjusts the frequency of crystal Y2.
F4	F1	Fuse in +22 Volt unregulated input for +15 Volt and +5 Volt regulators.
G6	F2	Protects -22 Volt supply if a -15 Volt regulator fault occurs.
G2	J2	Input for external frequency source (e.g. AM Stereo Exciter, Combiner Common Drive). Input level: TTL Level, or 0 to +25 dBm at 50 Ohms.
F1	J3	Input, from “Output Current Sample,” T6, used for Oscillator Sync.
A3	J5	Output for optional Frequency Monitor.
A2	J7	Input/Output connector between LED board and Oscillator. Oscillator Sync control signal input, RF present output.
E2	L4	Used for fine adjustment of oscillator sync phase.
D6	P1	Selects either crystal Y1 or Y2. For Y1, jumper 1-2; for Y2, jumper 1-3.
A5	P2	Selects the ratio of crystal frequency to transmitter carrier frequency. To divide by 4, jumper 1-2; to divide by 8, jumper 1-3.
C1	P3	Used to select onboard crystal oscillator (jumper 1-3) or external oscillator (jumper 1-2).
C1	P4	For normal operation, jumper 2-3. For combined transmitter operation, jumper 1-2.
F2	P5	Selects a 50 Ohm input impedance for external oscillator (jumper 1-3) or 20K Ohm input impedance for TTL input (jumper 1-2).
F7	P6	Selects the crystal oven which will be heated. For Y1 oven, jumper 1-2; for Y2 oven, jumper 1-3.
E1	S1	Used for coarse adjustment of oscillator sync phase.
B3	TP1	Test point for +15 Volt zener-regulated voltage.
E4	TP2	Test point for +5 Volt zener-regulated voltage.
A2	TP3	Test point for +9 Volt zener-regulated voltage.
D1	TP4	Test point, used during oscillator sync phase adjustment.
D1	TP5	Test point, used during oscillator sync adjustment.
E4	TP6	Used as a test equipment ground connection when making measurements on the oscillator board.
C7	TP7	Used as a test equipment ground connection when making measurements on the Oscillator board.

NOTE

Test points are small wire loops, for connecting clip-on oscilloscope or meter probes.

WARNING: Disconnect primary power prior to servicing.

B.1 Introduction

This section includes a description of the Buffer Amplifier, and troubleshooting information. The Buffer Amplifier plugs into the Driver Combiner/Motherboard, and is accessible from the front of the transmitter.

B.1.1 Principles of Operation

The Buffer Amplifier includes three amplifier stages. The buffer-driver U1 takes the TTL-level output from the Oscillator Board and drives the push-pull second stage, consisting of Q1, Q2 and associated components. The third stage consists of MOSFET's Q3 and Q4 which provide the RF output to drive the Predriver.

Refer to SECTION V, Maintenance, for pc board maintenance procedures. There are no adjustments on this module.

B.2 Circuit Description

Refer to the Buffer Amplifier Schematic, 849-7855-099, in the Drawing Package.

B.2.1 Buffer Amplifier Supply Voltage

The +30VDC supply is used for the Buffer Amplifier and is adjusted by the Buffer Voltage ADJ potentiometer R2 in the Driver Compartment. The DC input is fused by F3, filtered, and used for the third stage MOSFET transistors. Red LED DS3 will illuminate if F3 opens and will be visible through the interlocked door inside the Driver Control Compartment. The supply voltage is also regulated to +15VDC by zener diode CR5 for driver amplifier U1 and second stage transistors Q1 and Q2.

B.2.2 First RF Amplifier Stage (U1)

The first RF amplifier consists of a CMOS clock driver IC used as a buffer-driver stage to convert the TTL-level input from the Oscillator into a higher level signal to drive Q1-Q2.

B.2.3 Second RF Amplifier Stage (Q1 and Q2)

Transistors Q1 and Q2 operate as a high-efficiency switching amplifier, with square-wave input and output signals. The output, at the junction of Q1 and Q2 emitters, switches between ground and the supply voltage. This stage provides RF drive to the output transistors Q3 and Q4 through a series tuned coupling network C2, L1 and R5,and phase-splitting transformer T1.

B.2.4 Third RF Amplifier Stage (Q3 and Q4)

This RF amplifier stage drives the Predriver and consists of two power MOSFET's Q3 and Q4. The two RF drive signals to the MOSFET gates are 180° out of phase (note the dots, indicating phase of each secondary winding on T1). Transistors Q3 and Q4 switch between ground and the DC supply. Diodes CR3 and CR4 protect the MOSFET gates against overvoltages.

B.2.5 Output Coupling Network

The output of the Q3-Q4 amplifier stage is coupled to the Predriver input through broad-band coupling network C3, R8-R11 and L2.

B.2.6 Buffer Amplifier RF Sense

The "Buffer Amplifier" indicator LED on the ColorStat™ panel is driven by an RF detector on the Driver Combiner/Motherboard and logic circuits on the LED Board.

Refer to SECTION D, Driver Combiner/Motherboard, and SECTION Q, LED Board.

B.2.7 Predriver Supply

The +60 VDC supply is used for the Predriver amplifier and is adjusted by Predriver Voltage ADJ potentiometer R1 in the Driver Compartment.

The Predriver DC IN is fused on the Buffer Amplifier pc board by F1 and F2. Red LEDs DS1 and DS2 will illuminate if F1 or F2 opens. These can be observed through the interlocked door in the Driver Compartment.

Refer to SECTION D, Driver Combiner/Motherboard and to SECTION C, RF Amplifier Modules, for additional information on the Predriver.

B.3 Troubleshooting

Troubleshooting consists of isolating an RF drive problem to the Buffer Amplifier Board, using the LED indicators. The easiest way to check buffer amplifier operation is to substitute a spare board if one is available.

B.3.1 Symptom: Buffer Amplifier LED on ColorStat™ panel is Red, transmitter will not operate.

B.3.1.1 Possible Cause: Component failure

LED indicators will illuminate when a fuse is open, if the associated Low Voltage supply is present. Three indicators are visible through the interlocked RF Amp access door inside the Driver Compartment:

- DS1 (F1) - PREDRIVER A
- DS2 (F2) - PREDRIVER B
- DS3 (F3) - BUFFER AMP

If the Buffer Amp fuse indicator is illuminated, check the Buffer Amplifier Board for signs of overheated components, or damage to printed circuit board traces. Check the socket on the motherboard for damage.

Buffer Amplifier Board component checks can be made with the Buffer Amplifier Board removed from the transmitter. Refer to SECTION VI, Troubleshooting, for information on checking MOSFET's.

Back-to-back zener diodes CR3 and CR4 should indicate a low leakage current in either direction; if one of the diodes is shorted, they will look like a single diode with an ohmmeter check or “diode test” function on a digital multimeter. Note that CR3 and CR4 are each in parallel with a 10-Ohm resistor and low resistance toroidal transformer winding, so in-circuit checks are not possible. One end will have to be removed from the circuit to test.

B.3.1.2 Possible Cause: Coaxial Cable or Connector Fault

With all power removed from the transmitter, you can remove P4 from the Oscillator Board and check for a 50-Ohm resistance into P4-8 and 9; this indicates that the coaxial cable and connectors are good.

B.3.2 Symptom: Buffer Amplifier LED on ColorStat™ panel is Red, transmitter will operate.

If the transmitter will operate, but the ColorStat™ panel LED is red, there is a detector failure on the Driver Combiner/Motherboard or a fault circuit failure on the LED Board. Refer to SECTION D, Driver Combiner/Motherboard and SECTION Q, LED Board, for troubleshooting information.

Table B-1. Buffer Amplifier Controls and Indicators

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
D1	DS1	Pre-driver A, Fuse Indicator. When illuminated, indicates open fuse A16F1.
C1	DS2	Pre-driver B, Fuse Indicator. When illuminated, indicates open fuse A16F2.
B1	DS3	Buffer Amp Fuse Indicator. When illuminated, indicates open fuse A16F3.
D3	A16F1	Pre-driver Section A FUSE. Protects the +30 or +60 Volt supply from faults in the pre-driver.
C3	A16F2	Pre-driver Section B FUSE. Protects the +30 or +60 Volt supply from faults in the pre-driver.
A3	A16F3	Protects the +30 Volt supply from faults in the buffer amplifier.

WARNING: Disconnect primary power prior to servicing.

C.1 Introduction

This section includes a description of the RF amplifier module, and troubleshooting information.

The transmitter uses a total of 79 “plug-in” RF amplifier modules. One module is used in the Predriver stage, fourteen are used in the Driver stage (D1 through D14) and 64 are used in the Power Amplifier stage (RF33 through RF96).

Any RF amplifier module can be used in the Predriver, Driver, or Power Amplifier position. Modules can be exchanged with no effect on transmitter performance. If a PA Module fails, FlexPatch™ can be used to replace it with another PA Module without turning the transmitter OFF. Refer to “Using FlexPatch™ To Replace A Failed PA Amplifier” in SECTION VI, Troubleshooting, for more information.

CAUTION

ALL MOSFETs MUST BE IN PLACE ON ALL MODULES IN ALL POSITIONS (RF33-RF96, D1-D14 AND PREDRIVER), EVEN IF SOME MODULES HAVE SHORTED MOSFETs. FAILURE TO OBSERVE THIS PRECAUTION WILL RESULT IN DAMAGE TO COMBINER TRANSFORMER TOROIDAL CORES.

All RF amplifier modules plug into combiner/motherboards, and are accessible from the front of the transmitter. The Predriver and Driver Modules plug in to the Driver Combiner/Motherboard. Power Amplifier stage modules RF33 through RF96 plug in to the Binary Combiner/Motherboard and three Main Combiner/Motherboards. This section describes only the RF amplifier module.

Refer to SECTION V, Maintenance, for pc board maintenance procedures. There are no adjustments on this board.

The Driver section and Power Amplifier section are described in SECTION IV, Overall System Theory.

C.2 Principles of Operation

Refer to the simplified diagrams C-1 through C-5.

Each RF amplifier module is a class D switching amplifier, using four pairs of N-channel power MOSFETs in a bridge configuration. This configuration is referred to as a QUAD. The quad is made up of two sections: Section A includes Q1/Q12 and Q3/Q10; section B includes Q2/Q9 and Q4/Q11. Power MOSFETs are in flat plastic packages, and are mounted on heat sinks.

C.2.1 RF Amplifier: Basic Theory Of Operation

Figure C-1 is a simplified functional diagram of an RF amplifier module. Each section of the module consists of two pairs of MOSFETs in series. Each pair of MOSFETs is alternately driven into cutoff and into saturation, acting as a switch. The RF drive signals to the two pairs of MOSFETs in a section are 180° out of phase, so that when the upper pair is on (saturated) the lower pair is off (cut off). When the upper pair is off the lower pair is on. The output is switched between ground (about zero Volts) and the positive supply voltage at an RF rate.

Amplifier efficiency is high because each MOSFET switches between cutoff and saturation in a very short time. Dissipation is low in both states. The devices switch quickly through their linear operating region, where power dissipation is high, so that average power dissipation is low.

C.2.2 RF Amplifier: Half Quad Configuration

The RF amplifier was designed to have a separate supply voltage and RF drive inputs to allow the A half to operate independently of the B half. This feature of the RF module is utilized in section D8A and D8B of the Driver stage. Independent supply voltages for D8A and D8B are supplied by the Driver Supply Regulator.

Figure C-2 shows the MOSFETs as switches, for section A. Section B is identical in operation, except Q2/Q9 and Q4/Q11 are used. The square wave RF output waveform, at the junction of Q1/Q12 source and Q3/Q10 drain, is the carrier frequency of the transmitter.

C.2.3 RF Amplifier: Full Quad Configuration

All RF amplifier modules except Driver Module D8 operate in a full-quad configuration: section A output and section B output are connected to opposite ends of a combiner transformer primary winding. This is equivalent to the classical push-pull configuration.

Figure C-3 shows the four pairs of MOSFETs as switches. The phase of the RF drive signals is such that only two configurations are possible for the switches (unless a MOSFET is shorted). During one half of the RF cycle, Q1/Q12 and Q4/Q11 are both driven to cutoff and Q2/Q9 and Q3/Q10 are saturated. During the other half of the cycle, Q1/Q12 and Q4/Q11 are saturated, and Q2/Q9 and Q3/Q10 are cut off.

This switching action effectively applies the full supply voltage to the combiner transformer primary winding across C8. Each doubled push-pull amplifier produces a square wave output, but the two sets of amplifier square waves are 180° out of phase.

The square wave peak-to-peak amplitude across the transformer primary is about two times the supply voltage and will have some “ringing” because of the reactive load.

A capacitor is placed in series with the transformer winding to prevent a direct current path to ground if a MOSFET shorts.

C.2.4 RF Amplifier Module On/Off Control Circuit

In the Predriver and the Driver stage, the RF amplifier modules are always turned ON when the transmitter is operating. In the Power Amplifier stage, however, modules are turned ON and OFF to change the power and to modulate the carrier.

Figure C-4 is simplified diagram that explains the control circuit operation. The control section on the RF amplifier module affects RF drive to Q3/Q10 and Q4/Q11.

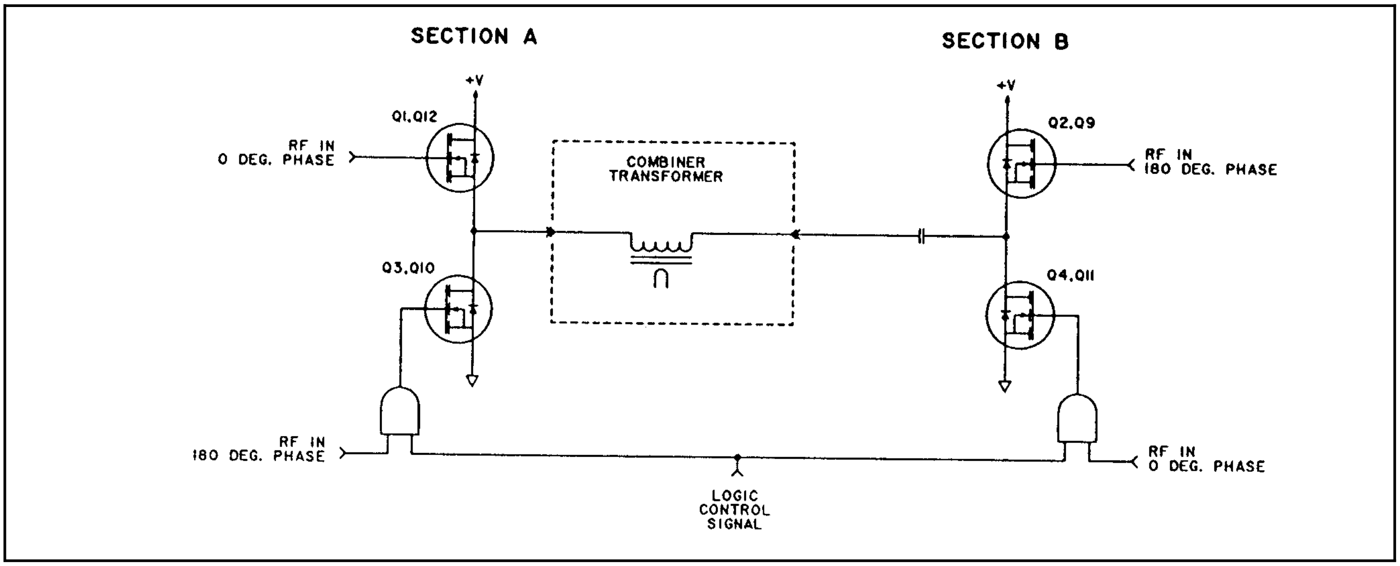

Figure C-1. RF Amplifier Module, Simplified Diagram
(817 2099 031)

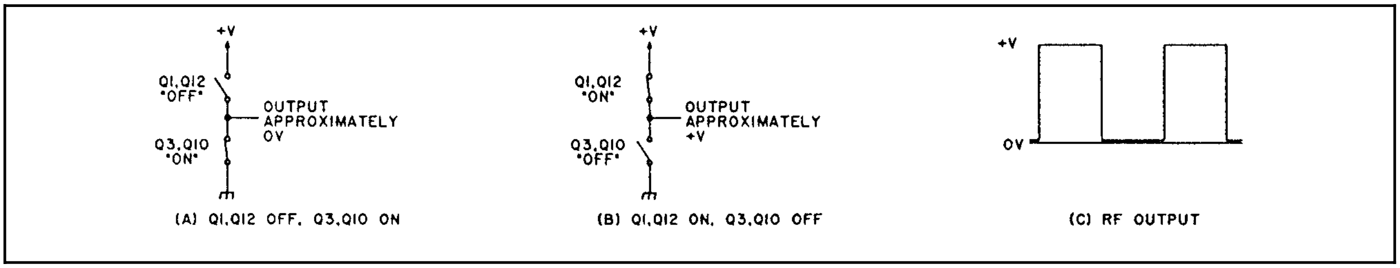

Figure C-2. RF Amplifier Operation, Half-Quad Configuration (817 2099 032)

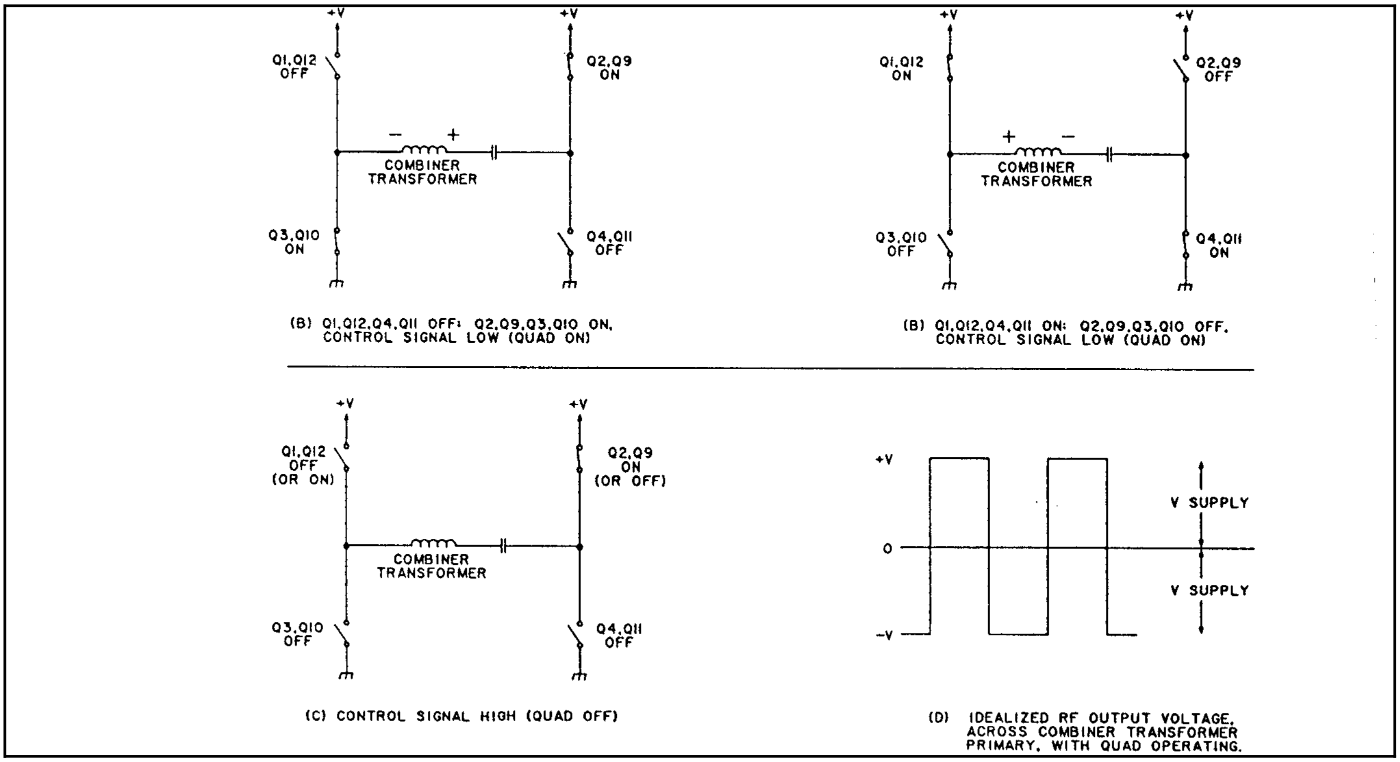

Figure C-3. RF Amplifier Operation, Full Quad Configuration (817 2099 033)

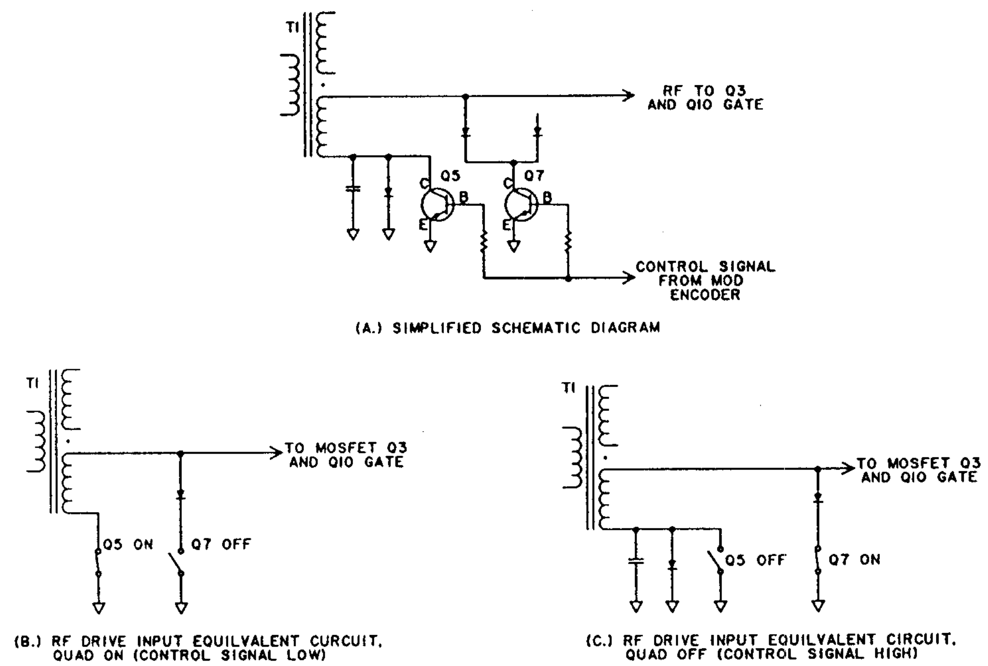

Figure C-4. RF Amplifier Module, Control Section Operation (817 2099 034)

A TTL “LOW” control signal from the Modulation Encoder will switch PNP transistor Q5 ON and switch NPN transistor Q7 OFF. A TTL “HIGH” control signal will turn Q5 OFF and Q7 ON.

Figure C-4b. shows the equivalent RF drive circuit when the RF amplifier is ON. Transistor Q5 is ON, which completes the RF ground path through the secondary of transformer T1 and provides RF drive to the gates of parallel MOSFETs Q3/Q10. The RF drive circuit for Q4/Q11 is the same, except that the RF ground path is through control transistor Q6.

Figure C-4c. shows the equivalent RF drive circuit when the RF amplifier is OFF. Transistor Q7 is ON, which clamps the positive half-cycle of the RF drive from transformer T1 slightly above ground. This prevents parallel MOSFETs Q3/Q10 from switching ON. The RF drive circuit for Q4/Q11 is the same, except that CR8, Q6, and associated components are used.

C.2.5 RF Transformer Primary Current: Amplifier Off

When an amplifier module is OFF, there is no current flow from the supply through the combiner transformer primary and the module does not supply any power to the combiner. Current will still flow through the combiner secondary, however, unless the total combiner RF output is zero. This combiner current will induce RF voltages in the toroidal transformer primary windings on all inactive modules.

If the combiner transformer primary sees an open circuit, induced voltages can damage amplifier MOSFETs, and high RF voltages in the unloaded primary can cause an arc which can crack the toroid. The “quad” amplifier configuration and reverse diodes in the MOSFETs provide an RF current path, as described in the next paragraphs.

This explanation is based on simplified diagram, Figure C-5. When the polarity of the induced voltage in the combiner transformer is as shown in the diagram, Q1/Q12 is OFF and Q2/Q9 is ON. A low-impedance RF current path is available through the reverse diodes in Q1/Q12, and bypass capacitors C1, C3, C4, and C2.

When the polarity of the voltage induced in the transformer winding reverses, Q1/Q12 turn ON and Q2/Q9 will turn OFF. The current flow will now be through the reverse diodes in Q2/Q9.

C.2.6 Oscillator Sync Signal

When the VSWR protection circuits turn all RF amplifiers in the Power Amplifier stage OFF, “ringing currents” will continue to flow in the output network, and in the RF combiner secondary, for several cycles. For maximum MOSFET reliability during a high VSWR, Q1/Q12 and Q2/Q9 in all PA Modules must switch in phase with output network ringing currents. This is accomplished with the Oscillator Sync circuitry, including an output network current sample and circuits on the Oscillator.

C.3 Circuit Description

Refer to Schematic 839-7855-080 in the Drawing Package.

C.3.1 Supply Voltage

The supply voltage for section A enters the module through P1-23, 24, 25 and 26; the supply voltage for section B enters the module through P1-29, 30, 31, and 32. The low side of each RF quad amplifier returns to ground. The supply voltage is +230

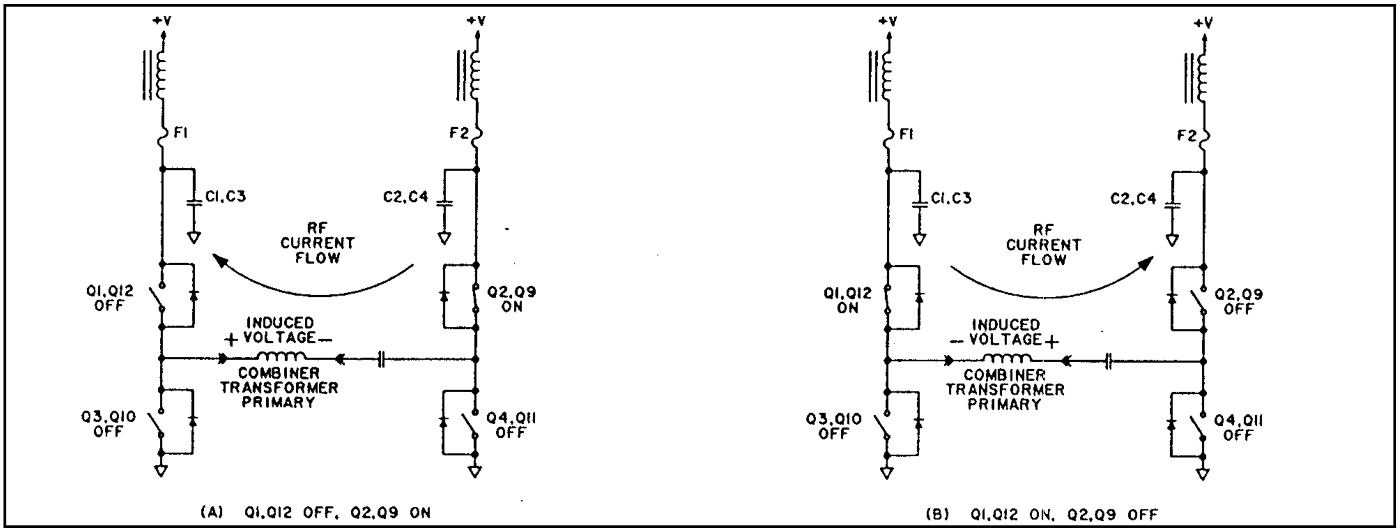

Figure C-5. RF Amplifier Module: Combiner Transformer Primary Winding Current Flow With Module Off (817 2099 035)

VDC for the "BIG STEP" PA Modules; +115 VDC and +60 VDC for "BINARY" PA Modules; +115 VDC Driver Modules; and +60 VDC for the Predriver Module.

The supplies then pass through RF chokes L1 and L2 and are fused by F1 and F2. If a fuse for a half-quad opens (typically, because of MOSFET failure), the other half-quad will continue to operate. For modules used in a full-quad configuration, the module will continue to deliver a reduced RF power level (at half the peak-to-peak RF voltage across the combiner output transformer primary).

The drains of Q1/Q12 and Q2/Q9 are bypassed to ground by C1 and C3, and C2 and C4.

C.3.2 LED Indicators

Red LED indicators DS1 and DS2 illuminate if there is a blown fuse on the module.

Green LED DS3 illuminates when the amplifier receives a turn-on signal from the Modulation Encoder. The current for the LED is derived from the rectified RF controlled by Q7 and Q8.

C.3.3 Cable Interlock

The cable interlock control signal from the Modulation Encoder loops through the RF amplifier on pins P1-35/36 and P1-37/38. The open fuse (Blown Fuse) indicators DS1 and DS2 are also tied to this circuitry through diodes CR11 and CR12. If CR11 or CR12 short, R16 and CR13 will clamp the supply voltage at +20 VDC.

Refer to SECTION L, Modulation Encoder, for a description of the Cable Interlock and Blown Fuse Indication circuitry.

C.3.4 RF Drive

RF drive is fed to transformers T1 and T2. One RF drive transformer is used for each half-quad. RF drive for section A enters the module at P1-49/50; RF drive for section B enters at P1-53/54. Individual coaxial cables from the RF Drive Splitter feed RF drive to the A and B section of each module so that if one section fails the drive to the other section will not be affected. A network in parallel with each RF drive transformer broadbands the input circuit, so that no component changes are required for operation at any frequency in the broadcast band. For T1, this network consists of L3, R3, R22, and L6; for T2, the network consists of L4, R4, R23, and L7.

Each RF drive transformer has two pairs of secondary windings, which provide two pairs of drive signals, 180° out of phase, for the upper and lower MOSFET pairs in each half-quad. On the schematic diagram, small circles at one end of each transformer winding indicate RF phasing.

Back-to-back zener diodes CR1, CR2, CR3, and CR4 protect the MOSFET gates against overvoltages, including possible transient voltages.

When modules are used in the Power Amplifier stage, RF drive is provided by the RF Drive Splitter. All RF drive cables are the same length, so that RF drive phase is the same to all modules. The RF amplifier schematic diagram indicates proper RF levels.

C.3.5 Control Section

Control signals enter at P1-45/46. Transistors Q5, Q6, Q7, and Q8 are the ON-OFF control transistors for the module. For modules used in the Driver stage, a "TTL HIGH" voltage at P1-45/46 (+4 Volts or more) turns the amplifier OFF. A negative voltage at P1-45/46 (-2 to -4 Volts) turns the amplifier ON.

For RF amplifiers used in the Power Amplifier stage, control signals from the Modulation Encoder switch between "TTL HIGH" and a small negative voltage to turn RF amplifier modules ON and OFF. The negative voltage is derived from the B-supply output of the DC Regulator. Because the switching characteristics of the modules change, depending on the number of modules on at any instant, this voltage will vary with modulation and change the turn-on and turn-off times of the modules.

For RF amplifiers used in the Driver stage, a fixed -5 VDC control voltage from the Driver Encoder/Temp Sense Board keeps the modules ON.

When the amplifier is turned ON, Q5 and Q6 and diodes CR5 and CR6 provide conduction paths for the RF drive signal.

When the amplifier is turned OFF, transistors Q7 and Q8 conduct and the RF drive signal is clamped at ground through CR7, CR8, CR9 and CR10. The positive voltage required to turn on the power MOSFETs is several Volts, much larger than the junction drop across the diodes.

Transistors Q13 and Q14 switch in capacitors C12 and C13 when the module is OFF. This will simulate the gate capacitance of MOSFETs Q3/Q10 and Q4/Q11 to keep the load on the drive stage constant.

C.3.6 RF Output

The output signal for each half-quad appears at the junction of the four MOSFETs. Section A output leaves the module through P1-1/2/3/4; section B output leaves the module through P1-7/8/9/10. Capacitor C8 provides dc isolation between the outputs.

C.4 Troubleshooting

C.4.1 Symptom: Blown Fuse Indicator Illuminated

C.4.1.1 Possible Cause: Shorted MOSFETs

An open fuse probably indicates that one or both MOSFETs in that half-quad is defective. You can continue to operate the transmitter until a normal shut-down period, the open fuse will cause no further damage. FlexPatch™ can be used to substitute for a failed module without shutting the transmitter OFF, to restore normal transmitter performance. Refer to SECTION VI, Troubleshooting, and SECTION L, Modulation Encoder, for information on using FlexPatch™ to substitute PA Modules.

The MOSFETs will have to be removed from the circuit in order to perform the following test.

C.4.1.1.1 Handling MOSFETs

Due to the fragile nature of the gate of a MOSFET, special care in their handling is required. The gate junction may be destroyed by static electricity if the static electricity is allowed to discharge through the MOSFET. For example, walking across a carpet to pick up a MOSFET that is not protected by antistatic packaging could result in the destruction of the MOSFET. A static charge could build up on a person walking across the carpet. This static charge will eventually have to be discharged. Discharging to the MOSFET could damage the MOSFET. Transistors which are in circuit are immune to this damage. The MOSFET transistors are shipped in antistatic packaging. The transistors should remain in this packaging until they are to be used or tested.

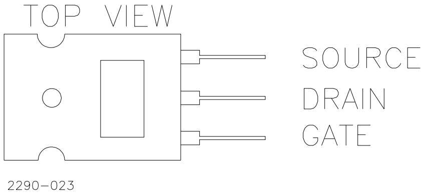

Figure C-6. MOSFET Configuration

C.4.1.1.2 Removing MOSFETs

NOTE

DO NOT TRY TO PRY THE HEATSINK AWAY FROM THE PC BOARD BEFORE REMOVING TRANSISTORS FROM THE HEATSINK. THE PC BOARD MAY BE DAMAGED AND THE HEATSINK MAY DISTORT.

- Remove all the screws from heatsinks and transistors. In most cases, the transistor will stick to the heatsink because of the seal created by the transistor pad. This seal will have to be broken before a heatsink can be removed. Remove the screw holding the MOSFET to the heatsink and gently pry the transistor away from its heatsink.
- Remove the heatsinks one at a time starting with the outer most sink. Break seals on transistor pads as each pair is exposed.
- Unsolder the MOSFETs from the pc board.

C.4.1.1.3 Testing MOSFETs

The MOSFETs may be checked using an ohmmeter with a battery voltage between 3 Volts and 18 Volts. A Simpson 260, which uses a 9 Volt battery on the Rx10k scale, works quite well. This test will show how a MOSFET can be switched “on” and “off” by charging and discharging the gate of the MOSFET.

Place the transistor face up on a non-conducting surface. Connect the positive lead of the ohmmeter to the drain (center lead) of the transistor and connect the negative lead to source (right lead). Touch a jumper from gate (left lead) to source to turn the MOSFET “on” and then from gate to drain to turn the MOSFET “off”. The ohmmeter should read towards infinity (at least 2 megohms) when the MOSFET is switched “off” and less than 90k Ohms when the MOSFET is switched“on”. Do not touch the leads when performing this test.

When repairing an RF amplifier, it is recommended that all four MOSFETs in the failed half of a module be replaced, even though only one or two of the four MOSFETs are found to be shorted. The remaining MOSFETs may have been stressed internally and may fail when supply voltage is reapplied. A blown fuse on one half of the amplifier does not effect the other half.

MOSFETs that appear to be undamaged after testing can be kept as spares for use if new replacements are not available. Also keep in mind that the amplifiers used in the Driver and PA are identical except that the Driver amplifiers operate at half voltage. This allows you to rotate a repaired module into the Driver position if so desired.

C.4.1.1.4 Replacing MOSFETs

- Inspect all the transistor pads for any damage that may have occurred when the transistors were removed from the heatsinks. Replace any damaged pad.
- Replace the ferrite beads on the center leads of Q3/Q10 and Q4/Q11. Insert the transistors into the pc board. Do not solder leads until heatsinks are in place.
- Reattach heatsinks in reverse order as they were removed. Tighten heatsink and pc board screws first and then tighten transistor screws (torque to 3 inch-lbs).

- Solder transistor leads and trim.
- Replace blown fuse(s).

C.4.1.2 Checking RF Module Operation

The most common method of troubleshooting an RF amplifier after a failure is to put the repaired amplifier in a known working step, i.e. step 1 through 5, and to put the working amplifier where the failure first occurred. This is known as module swapping and although it is less conservative, it will quickly tell you whether the amplifier fault was caused by the position it was in or by the amplifier itself.

After an RF amplifier has failed, some thought should be given as to what caused the failure before a replacement or repaired amplifier is put back in place and the transmitter is turned back on. For example:

Are the A and the B halves of the amplifier receiving the proper drive?

Is the amplifier receiving a proper ON/OFF control signal from the Modulation Encoder?

Did something short at the output of the amplifier?

After the MOSFETs were replaced, is there something else on the amplifier that may have been damaged?

Even though most causes for an RF amplifier failure are related to a power MOSFET breaking down, it is recommended that a more conservative approach be taken so as not to fail a second amplifier in the same position or fail the repaired amplifier a second time.

For information on troubleshooting repeated PA Module failures, refer to SECTION VI, Troubleshooting.

Table C-1. RF Amplifier Module Boards
Controls and Indicators

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
D8	DS1	Illuminates when fuse F1 is open and when there is a short circuit failure, or when the power MOSFETs try to conduct supply voltage when the amplifier is switched ON.
B8	DS2	Illuminates when fuse F2 is open and when there is a short circuit failure, or when the power MOSFETs try to conduct supply voltage when the amplifier is switched ON.
C7	DS3	Indicator LED, Illuminates when module receives “ON” command for Modulation Encoder.
D3	F1	Protects power supply and printed circuit board against damage from short-circuit currents.

D.1 Introduction

This section includes a description of the Driver Combiner/Motherboard.

The Buffer Amplifier and 15 RF amplifier modules plug into the Driver Combiner/Motherboard. RF drive from the Oscillator enters the board to drive the Buffer Amplifier. The Buffer Amplifier provides drive to the Predriver. The output of the Predriver is fed to through a series resonant circuit to the 14 RF amplifier modules that make up the Driver stage. The Driver outputs are combined and sent to the RF Drive Splitter to drive the 64 RF amplifier modules in the Power Amplifier. The Driver Combiner/Motherboard is located in the Driver Compartment. Removal, interconnecting wiring, and component access is made from the rear of the transmitter.

Refer to SECTION V, Maintenance, for pc board maintenance procedures. There are no adjustments on this board.

D.2 Circuit Description

Refer to the Driver Combiner/Motherboard Schematic, 839-7855-095, and Sheet three of the Overall Schematic, 839-7855-151, in the Drawing Package.

Refer to the following sections of this Technical Manual for descriptions of printed circuit boards which plug into the driver combiner/motherboard:

a. SECTION B, Buffer Amplifier A16.
b. SECTION C, RF Amplifiers

D.2.1 Buffer Amplifier Connections

The signal from the Oscillator enters the Driver Combiner/Motherboard at J28, and is routed directly to the Buffer Amplifier RF input J1-39/40/41/42.

The Buffer amplifier supply voltage from the +30 VDC supply goes through rheostat R2, enters the motherboard at J28-1, and is then applied to the Buffer Amplifier connector J1-23/24.

The Buffer Amplifier RF output enters the board at J1-5/6, and is routed to the Predriver connector J16. The RF output signal also goes to a peak detector CR1, R6, C5, and R5. Zener diode CR2 limits the detector's maximum DC output voltage. The peak detector provides a Buffer Amplifier "RF sense" signal to fault and overload circuits on LED Board A32.

D.2.2 Predriver

The Predriver RF output leaves the Driver Combiner/Motherboard at J27 and passes through series-tuned network L1, C2, and the primary windings of IPA Splitter T8. The value of C1 is frequency determined and T8 primary turns are selected at TB5 to provide coarse adjustment for Predriver tuning. Coil L1 is tuned for maximum RF drive to the 14 RF amplifiers in the Driver stage. The RF output from the splitter reenters the board at J17 through J20 to drive the 14 Driver Modules.

The Predriver supply voltage from the +60 VDC supply goes through rheostat R1 and enters the board at J28-2. The supply is fed through metering circuits R9, R10, R11 and R12 and then to J1 where it is fused on the Buffer Amplifier. The supply is then sent back to the Predriver connector J16.

Another of the RF feeds from the RF Drive Splitter is used to provide the Predriver "RF sense" signal. The RF sample enters the board at J17-1 and is routed to RF detector circuit, CR3, C6, R7, R8, and CR4. Zener diode CR4 limits the DC output voltage from this peak detector. The peak detector DC output voltage is sent to fault and overload signals on the LED Board.

D.2.3 Driver Stage

RF Amplifiers D1 through D7 and D9 through D14 operate from the +115 VDC supply which enters the board at E1 and E2.

RF amplifier D8 operates on a regulated supply from the Driver Supply Regulator. This 0-115 VDC supply enters the board at J29.

The Driver stage consists of fourteen RF amplifier modules, D1 through D14 which plug into J2-J15. The RF drive inputs from the IPA Splitter T8 enter the board at J17, J18, J19 and J20. The driver outputs are combined through T2 through T15 and efficiency resonator coils L2 through L15.

D.2.4 Control Signals

Logic LOW turn-on signals are brought in to the board at J21, J22, J23 and J24 from the Driver Encoder/Temp Sense Board. These signals will turn the Driver Modules ON when the PA Supply is energized. The Driver Modules are interlocked by series connections between each module. The interlock circuitry is on the Driver Encoder/Temp Sense Board. The removal of any module will result in a Cable Interlock fault to the LED Board.

D.2.5 RF Drive Combiner

The output combiner consists of 14 ferrite toroids with primary windings connected to the RF amplifier module outputs. A copper rod passes through the toroids for the secondary winding. The copper rod is attached to the RF Drive Splitter.

The combiner adds RF voltages from the RF amplifier modules as the secondary passes from one transformer to the next. The RF voltage is low or zero at the ground point of the secondary rod and increases until it is fed into the RF Drive Splitter. Because of the low impedance of the RF Drive Splitter (about 2 Ohms), the total RF voltage is less than 100 Vrms.

D.2.6 Driver Tuning

Capacitor assembly C3, connecting strap L5, and Buck/Boost transformer T10 provides a series resonant circuit for driver tuning. Capacitor assembly C3 and connecting strap L5 are located above the Driver Combiner/Motherboard and are accessed through a panel on top of the transmitter. Buck/Boost transformer T10 is a torroidal transformer located between the Driver Combiner/Motherboard and the RF Drive Splitter.

E.1 Introduction

This section includes a description of the Driver Supply Regulator, and troubleshooting information.

The Driver Supply Regulator assembly includes a printed circuit board and a heat sink. The printed circuit board is mounted to the heat sink with spacers. Power MOSFETs in the regulator circuit are also mounted on the heat sink.

E.2 Location

The Driver Supply Regulator is located in the Driver Compartment and is mounted on the right wall and covered by a clear safety cover.

E.3 Principles of Operation

The RF drive to the transmitter's Power Amplifier stage must be closely controlled for optimum transmitter performance. An RF drive "Automatic Level Control" loop maintains drive level automatically by monitoring a sample of the RF drive level to the Power Amplifier from RF Drive Splitter A15.

RF drive levels to the Power Amplifier stage can change, even if the Driver output remains the same. If MOSFETs on the Power Amplifier Modules fail, the load on the Driver will increase, causing drive level to decrease. The Driver output must then be increased to compensate for the additional load. The Driver Supply Regulator also compensates for RF drive changes caused by AC line voltage variation.

The Driver Supply Regulator controls and regulates two supply voltages to RF amplifier D8. Increasing the voltages to D8A and D8B will increase the Driver output. The regulator's two DC outputs can each vary from zero to about +110 VDC.

During normal operation D8A voltage will be between +40 to +80 VDC, and section D8B voltage will be zero. If Driver output begins to decrease, the Driver Supply Regulator will increase the voltage to D8A until it reaches about +100 to +110 VDC. If more RF drive is required, the Driver Supply Regulator will increase the voltage to D8B until it reaches about +100 to +110 VDC. If still more drive is required, RF amplifier D7 is turned on by the Driver Encoder/Temp Sense Board A19. The Driver Supply Regulator will then reduce the voltage to D8A and D8B.

Refer to SECTION V, Maintenance, for adjustment and maintenance procedures.

E.4 Circuit Description

Refer to Simplified Diagram E-1 and to Schematic 839-7855-004 in the Drawing Package.

E.4.1 +15 Volt Regulator

A 3-terminal integrated circuit voltage regulator, U1, provides the +15 Volt supply for U2.

E.4.2 Control +VDC Reference

A CONTROL +VDC voltage is developed for the regulator section from the Open Loop Adjust control (through a voltage follower), or from the output of a differential amplifier with inputs from the Closed Loop Adjust control and from the RF drive sample. Switch S1 selects one of these reference voltages.

E.4.2.1 "Open Loop" Reference Voltage

When S1 is in the "OPEN LOOP" position, OPEN LOOP ADJUST control R2 is the input to a voltage follower (gain = 1), using one section of operational amplifier U2. The voltage follower output provides a reference voltage, adjustable from about +1.5 Volts to +10 Volts, to the Q2 gate circuit. See Figure E-1.

E.4.2.2 "Closed Loop" Reference Voltage

When S1 is in the "CLOSED LOOP" position, the other half of U2 is used as a differential amplifier. "CLOSED LOOP ADJUST" control R12 provides an adjustable voltage to the inverting input of the differential amplifier. The non-inverting input is a DC voltage derived from a sample of the RF drive to the Power Amplifier stage and is offset by resistors R9 and R10.

E.4.2.3 RF Drive Sample

The RF drive sample for closed-loop operation is taken from the RF Drive Splitter A15, and fed to the primary winding on toroidal RF transformer T1. A network across the primary of T1 broadbands the transformer. Capacitors C4 and C5, across the secondary windings, are used to provide a load impedance for the RF Drive Splitter that is similar to the input impedance of an RF amplifier module.

The RF drive sample is rectified in a full-wave bridge rectifier (CR1 through CR4). The output of the bridge rectifier is a DC voltage sample of the Power Amplifier stage RF drive level. This DC sample is offset by resistors R10 and R9, filtered by C6 and fed into U2-3.

The other input to U2-2 is an adjustable DC voltage from Closed Loop ADJ R12. The output of U2-1 is the difference between the inputs times the gain of the amplifier. Differential amplifier gain is set by R11, R12, R13, R14, and R15.

The output of U2-1 is the CONTROL +VDC voltage and can be measured at TP4 and monitored on the RF MULTIMETER on the inside of the Driver Compartment door.

E.4.3 Power MOSFET Operation (A Short Review)

Power MOSFET operation will be reviewed briefly in this paragraph, for personnel who have not encountered them before. The n-channel power MOSFETs used in the Driver Supply Regulator section are effectively "cut off" (not conducting) when their input voltage is less than the +2 to +4 Volt gate-to-source threshold. As the input voltage rises above the threshold, the MOSFET will conduct more heavily. Increasing the gate voltage will increase the drain current and decrease the effective source-to-drain "resistance." An input voltage of less than +10 Volts will effectively "saturate" the MOSFETs in this circuit and result in minimum source-to-drain resistance.

E.4.4 Regulator Section Circuit Description

The regulator section includes an input amplifier stage Q2 and series regulator pass transistors for the two regulated outputs. Parallel pass transistors Q3 , Q4, and Q7 are used for the Section D8A output voltage, and Q5, Q6, and Q8 are used for the Section D8B output voltage.

Each series pass transistor section can also be thought of as a source follower circuit, with D8 as the load. The regulator output voltage will be 2 to 10 Volts less positive than the gate voltage. The gate voltage of Q3-Q4-Q7 will be determined by Q2 drain voltage and the voltage divider; the gate voltage of Q5-Q6-Q8 will be determined by Q2 drain voltage and the voltage offset circuit.

E.4.5 DC Amplifier Stage (Q2)

The reference voltage from U2-1 is fed through R16 to a current summing network at the gate of Q2. The inputs to the summing network include R19, Q2 stage negative feedback, R41, negative feedback from regulator section A output, and R42, negative feedback from regulator section B output. The output of the summing network is offset 1.4 Volts by diodes CR5 and CR6. The sum of the four currents creates a voltage drop across R20 which is the gate voltage for Q2. Capacitor C8 bypasses AC components around the voltage offset diodes to speed up regulator response time.

N-channel power MOSFET Q2 is used as a DC amplifier, with its drain connected to the +230 VDC supply through load resistors R25 and R26 on Fuse Board A24. The MOSFET begins conducting when its gate voltage goes above a +2 to +4 Volt threshold. Once the threshold is exceeded, the MOSFET's drain current will increase as the gate goes more positive and the drain voltage will decrease because of the voltage drop across load resistors R25 and R26 on Fuse Board A24. The output of the Q2 amplifier stage is coupled to Q3-Q4-Q7 gates through a resistive voltage divider, and to Q5-Q6-Q8 gates through zener diodes CR7, CR9, and CR10.

E.4.6 Series Pass Transistors Q3, Q4, and Q7 (For Section D8A Supply Voltage)

The regulated output voltage to driver section D8A is controlled by series pass transistors Q3, Q4, and Q7. When their gate voltage is zero, they are cut off and the section D8A output voltage is zero. Q3, Q4, and Q7 begin conducting (turning on) when their gate voltage is a few Volts positive (+2 to +4 Volts relative to their source). As the gate voltage becomes more positive, they conduct more heavily, and the section D8A output voltage increases.

E.4.6.1 Voltage Divider

The voltage drop across resistor R25 is the gate voltage for Q3, Q4, and Q7; R25 is part of a voltage divider between Q2 drain and Q3-Q4-Q7 source. The voltage DIFFERENCE between Q2's drain voltage and regulator output voltage "A" is divided by the voltage divider consisting of R22, R24, and R25. As Q2 drain becomes more positive, voltage across R25 increases, Q3-Q4-Q7 conduct more, and the section D8A output voltage increases.

Capacitor C9 and R23-C10 provide a low impedance path around R22 and R24 for AC components. Their effect is to speed up response to sudden variations in output; this action will also reduce AC ripple in the regulated output voltage.

Resistors R58, R59, and R64 in the source circuit are current equalizing resistors which compensate for variations in characteristics of the paralleled MOSFETs. Ten Volt zener diodes CR8, CR12, and CR16 protect the MOSFETs against excessive source-to-gate voltage.

Diode CR13 at the regulator output protects the circuit against negative transient voltages.

Resistor R41 provides negative feedback for the regulator section.

E.4.7 Series Pass Transistors Q5, Q6, and Q8 (For Section D8B Supply Voltage)

The regulated output voltage to driver section D8B is controlled by series pass transistors Q5, Q6, and Q8. Except for the zener voltage offset diodes, this section operates in the same way as pass transistors Q3-Q4-Q7.

E.4.7.1 Voltage Offset

The voltage across resistor R34 is the gate voltage for Q5, Q6, and Q8. Resistors R34, R33, and zener diodes CR7, CR9, and CR10 are all in series, between Q5-Q6-Q8 source and Q2 drain. The zener diodes will not conduct until the voltage at the drain of Q2 exceeds the 133 Volt sum of the zener voltages. Until the zener diodes conduct there will be no voltage drop across R34 and Q5, Q6, and Q8 remain cut off.

When the voltage at the drain of Q2 is high enough to overcome the zener voltage, Q5, Q6, and Q8 begin to turn on. At this point, Q3, Q4, and Q7 are conducting heavily so that output voltage "A" is nearly at the +115 VDC input. As the voltage at the drain of Q2 becomes still more positive, Q5, Q6, and Q8 turn on more, causing output voltage "B" to increase while output voltage "A" remains at maximum.

Transistor Q1 is used to ensure that Q5, Q6, and Q8 can turn on fully, so that the supply voltage to driver Section D8B can approach the +115 VDC input when required. The base-emitter voltage for Q1 is the voltage drop across R22, which is part of the voltage divider that controls Q3, Q4, and Q7. When Q3, Q4, and Q7 are nearly saturated, Q1 will begin turning on so that the voltage across Q1 and CR7 will be less than 39 Volts and the zener offset will be less than 133 Volts.

Capacitor C11, and R32-C12 provide low impedance paths around the zener diodes for AC components. Their effect is to speed up response to sudden variations in output; they also reduce AC ripple in the regulated output voltage.

Resistors R60, R61, and R65 are current equalizing resistors. Resistors R35, R36, and R63, in the gate circuits, are parasitic suppressors. Ten Volt zener diodes CR11, CR14, and CR17

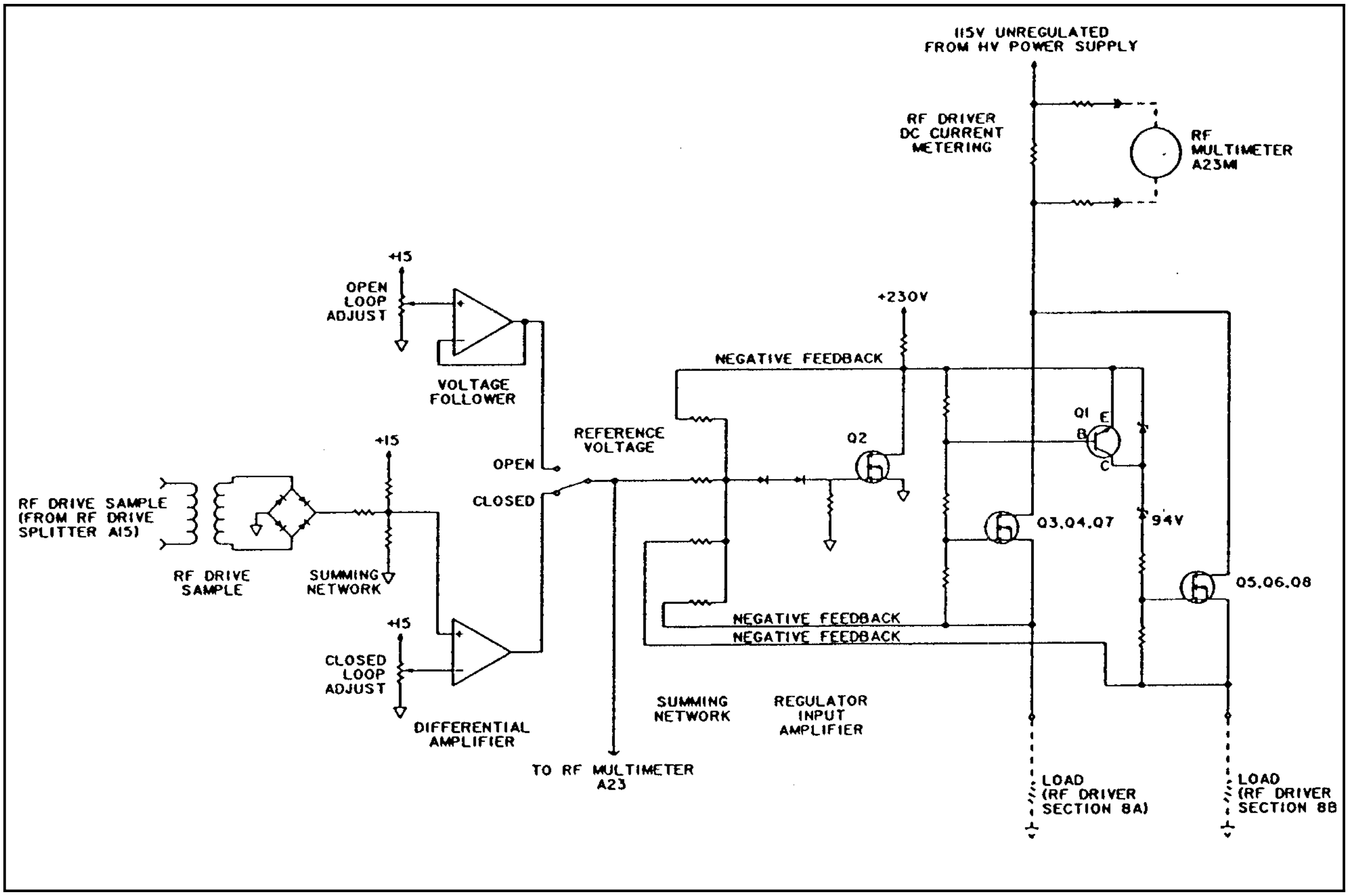

Figure E-1. Driver Supply Regulator
Simplified Schematic Diagram (817 2099 028)

protect the MOSFETs against excessive source-to-gate voltage. Diode CR15 protects the regulator circuit against negative transient voltages.

Resistor R42 provides negative feedback around the regulator section.

E.4.8 Metering Circuits

RF Driver voltages and currents are metered on the RF MULTIMETER.

E.4.8.1 Reference Voltage (CONTROL +VDC)

The RF level reference voltage outputs from U2A or U2B are metered in the “CONTROL +VDC” position. R4 is the meter multiplier resistor. The CONTROL +VDC voltage is also sent to the Driver Encoder/Temp Sense Board through R5.

E.4.8.2 115 VDC PA Supply Voltage (DRIVER +VDC)

The +115 VDC supply voltage is metered in the DRIVER +VDC position. The +115 VDC is sampled at the supply side of R3 and enters the Driver Supply Regulator at J2. Resistors R46, R47, R48, and R49 form the meter multiplier circuit used in this position.

E.4.8.3 Driver Current Metering (“DRIVER IDC”)

The “DRIVER IDC” position of the RF Multimeter reads total Driver current. All Driver current passes through the three 0.1 Ohm resistors R3A, R3B, and R3C, and the voltage drop across the resistor is measured. Resistors R44 and R45 are voltmeter multiplier resistors.

E.4.8.4 Driver Amplifier D8 Voltages (DRIVER 8A +VDC) and (DRIVER 8B +VDC)

The Driver Supply Regulator output voltages feeding D8A and D8B are metered in these two positions. R54, R55, R56, and R57 are the “A” circuit meter multiplier resistors while R50, R51, R52, and R53 form the “B” circuit.

E.5 Troubleshooting The Driver Supply Regulator

Troubleshooting the Driver Supply Regulator can be done by first checking for proper operation of the regulator, then, if the fault is determined to be in the regulator assembly, removing the assembly and making out-of-circuit measurements to locate the fault.

Because the operation of the Driver Supply Regulator is dependent on the overall drive from the Driver Stage, the voltage readings of D8A and D8B can change under various conditions. If the AC line voltage changes, the DC voltage to the Driver Modules will change and the Driver Supply Regulator will vary the voltage to D8A and D8B to compensate.

The operation of the Driver Supply Regulator is also dependent on the operation of the AUTO module from the Driver Encoder/Temp Sense Board. If the AUTO Driver D7 is ON, the Driver Supply Regulator will decrease the voltage to D8A and D8B.

If the DC supply goes DOWN, the Driver Supply Regulator will INCREASE the voltage to D8A and D8B.

If the DC supply goes UP, the Driver Supply Regulator will DECREASE the voltage to D8A and D8B.

Proper operation of the Driver Supply Regulator can be determined by changing the overall drive level and noting the operation of the regulator circuit.

To change the overall drive level, move S1 on the Driver Encoder/Temp Sense Board to the ON position. This will enable the spare driver D6. If the Regulated D8A and D8B readings on the RF MULTIMETER decrease, the board is working properly.

E.5.1 Symptom: Driver Sect D8A +VDC and Sect D8B +VDC Both High

E.5.1.1 Possible Cause: No +15 VDC

Check the Regulator +15 VDC position on the RF MULTIMETER. This voltage should be present any time primary power is applied to the transmitter, even if the transmitter is "OFF." If this voltage is zero (or very low), possible causes include no +22 VDC input or defective U1E. Check for +22 VDC on the front panel multimeter; check connector to J2 on the Driver Supply Regulator. To check U1 operation, you can remove the Driver Supply Regulator assembly and check on the bench with an input of +22 VDC at J2-1.

E.5.1.2 Possible Cause: Defective U2

If U2 output remains LOW, both Driver Supply Regulator output voltages will be high. Check U2 operation by removing the Driver Supply Regulator assembly, and checking on the bench by applying an input of about +22 Volts at J2-1. When OPEN LOOP ADJUST control R2 is adjusted over its range, U2 output should vary from about +1.5 to +10 Volts.

E.5.1.3 Possible Cause: Defective S1

If the Gate Voltage at Q2 remains low (no input voltage from S1), both Driver Supply Regulator outputs will remain high. Refer to the "bench check" under "Defective U2," above.

E.5.2 Symptom: One Output Voltage Is +100 To +110 Volts, Other Can Be Adjusted.

E.5.2.1 Possible Cause: Shorted MOSFET in a series regulator section (Q3, Q4, Q5, Q6, Q7, or Q8)

Remove the regulator assembly and check MOSFETs. If a MOSFET is shorted, its gate-to-source zener diode should also be checked as a precaution.

E.5.3 Symptom: Both Driver Supply Regulator Output Voltages Are Zero.

E.5.3.1 Possible Cause: No +115 VDC

Remove all primary power and check F10 on Fuse Board A24 in the high voltage power supply compartment. If F10 is open, check for possible short circuits to ground in the +115 VDC supply components, cabling, and on the Driver Supply Regulator. If F10 is good, check for loose connector or other open circuit between the +115 VDC supply output and the Driver Supply Regulator.

E.5.3.2 Possible Cause: Driver Supply Regulator component

The fault is probably in the Driver Supply Regulator, and could be any of the following:

a. Defective U2. If the input to Q2 remains HIGH, both Driver Supply Regulator output voltages will remain LOW. Check U2 operation by removing the Driver Supply Regulator assembly, and checking on the bench by applying an input of about +22 Volts at J2-1. When OPEN LOOP ADJUST control R2 is adjusted over its range, U2 output should vary from about +1.5 to +10 Volts.

b. Shorted Q2. Check Q2, using the out-of-circuit MOSFET ohmmeter check in Section 5, Maintenance (The ohmmeter check used for bipolar transistors will NOT check MOSFET's).

E.5.4 Symptom: One Driver Supply Output Voltage is Zero, the Other Can Be Adjusted.

E.5.4.1 Possible Cause: Shorted Gate-to-Source Zener Diode (CR8, CR11, CR12, CR14, CR16, or CR17)

Use an ohmmeter to check the zener diodes in the faulty section (Q3-Q4-Q7) circuit or Q5-Q6 -Q8 circuit). You should read a high resistance in one direction and a low resistance in the other direction. One shorted zener diode will cause both MOSFETs to remain cut off, so that output voltage for that section is zero.

E.5.5 Symptom: Section D8B Voltage Increases Before Section D8A Voltage Reaches +100 Volts.

E.5.5.1 Possible Causes: Voltage Offset is Too Low

A low offset voltage in the regulator section could be caused by a leaky or shorted transistor Q1, or a zener diode that is shorted or is conducting at a low voltage. Remove all primary power from the transmitter, remove the driver regulator assembly from the transmitter, and check these components.

E.5.6 Symptom: Open Loop Operation is Correct, Closed Loop Operation is Faulty.

E.5.6.1 Possible Cause: No RF Sample Voltage

If there is no RF sample voltage, Driver Supply Regulator output voltages will be high, because the regulator will attempt to increase Driver output. Adjusting CLOSED LOOP ADJUST control (R12) to minimum may reduce Driver output. Check the coaxial cable and connectors between RF Drive Splitter A15 and Driver Supply Regulator A22 for continuity.

E.5.6.2 Possible Cause: Shorted Diode in Bridge Rectifier CR1-CR4

Check bridge rectifier diodes CR1 through CR4 for shorted diodes (the diodes in this bridge can be checked in-circuit, using an ohmmeter).

E.5.6.3 Possible Cause: Defective U2

Operation of U2 can be checked with the Driver Supply Regulator assembly on the bench, using a +22 VDC DC supply at J2-1.

The voltage at U2-1 should vary when CLOSED LOOP ADJUST Control R12 is varied over its range.

NOTE

If the setting of R12 is changed, refer to the section on setting RF drive in the Tuning/Frequency Change Procedure in SECTION V, Maintenance, for proper adjustment of RF drive.

Table E-1. Driver Supply Regulator Board A22
Controls and Indicators

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
D5	R2	When S1 is in the “Open Loop” position, R2 adjusts RF drive level to the power amplifier, by varying supply voltages to driver sections 8A and 8B.
D6	R12	When S1 is in the “Closed Loop” position, R12 adjusts RF drive level to the power amplifier by varying supply voltages to driver sections 8A and 8B.
D6	S1	Selects either open loop or closed loop operation.

F.1 Introduction

This section describes the RF Multimeter board.

The RF Multimeter provides metering of the Predriver and Driver sections of the transmitter. A probe, with four meter positions, is also provided for AC and DC voltage measurements on printed circuit boards in the transmitter's non-interlocked compartment. The RF Multimeter is located on the back of the Driver Compartment door. The probe is located in the Center Control Compartment.

Refer to SECTION V, Maintenance, for pc board maintenance procedures. There are no adjustments on this board.

F.2 Circuit Description

Refer to the RF Multimeter Schematic, 839-6208-230, in the Drawing Package.

The meter has a 100 microampere movement, and two scales, 0-3 and 0-10. The meter switch positions are labeled with the name of the metered function and the scale used. For some positions, a X10 or X100 multiplier is applied to the meter scale reading.

Meter M1 is protected against excessive voltages and currents by 1-Amp rectifier diodes CR4 and CR5. Capacitor C3 provides RF bypassing around the meter movement.

F.2.1 Metering Driver Section Parameters

For 0-3 Volt, 0-30 Volt, and 0-300 Volt DC ranges, the multimeter is a 10,000 Ohm per Volt meter. For current ranges, the meter acts as a voltmeter, measuring the voltage drop across a resistor in the DC current path. One side of the meter is grounded through a section of switch S1 for Driver stage voltage measurements. The meter is isolated from ground for current measurements.

The RF Multimeter positions are defined and detailed in the Sections where the meter resistors are located. These positions are as follows:

PREDRIVER
PREDRIVER
CONTROL
DRIVER
DRIVER
DRIVER 8A
DRIVER 8B

F.2.2 Multimeter Probe

The multimeter uses a flexible coiled patch cord with a clip-on probe for convenient measurement of voltages in the non-interlocked compartment. Measurement ranges available are 0 to 30 Peak AC Volts, 0 to +3 VDC, 0 to +30 VDC, and 0 to -30 VDC.

Resistor R5, 29.4K 1%, is the multiplier resistor for the 0-3 Volt range. The total 30K resistance required for this range includes the meter resistance.

Resistor R3, a 301K 1% resistor, is the multiplier resistor for the 0-30 Volt range. Positive and negative voltage ranges are obtained by grounding either the negative or positive meter terminal through S1.

For AC Voltage measurements, CR1, R4, C1 and R1 make up a peak detector. Resistor R2 is the multiplier resistor for the AC voltage range.

Section G
RF Combiners:
Binary Combiner/Motherboard (A1) and Main Combiner/Motherboards (A2 through A4)

G.1 Introduction

This section includes a description of the Main and Binary Combiner/Motherboards.

G.1.1 Principles of Operation

Each RF amplifier output is connected to a ferrite toroid transformer. A basic principle of toroid cores is that each time the conductor passes through the center or inside of the toroid, it is counted as a turn. All of the secondaries of the RF transformers are connected in series by one continuous conductor. Because of the basic principle of a "winding" or "turn" passing through the center of the toroid, a solid copper pipe or rod can be used as the secondary conductor.

The combiner secondary (copper rod) is made in sections, which are bolted together to facilitate removing any combiner/motherboard if necessary. Each motherboard holds 16 toroid transformers with the RF amplifiers mounted in two rows of eight.

All of the Big Step RF amplifiers RF33-RF90 have transformers with a turns ratio of 16:1; that is, sixteen turns for the primary winding and one turn for the secondary. Amplifiers RF91-RF96 (B7-B12) use a combination of different supply voltages and transformer turns ratios to achieve binary weighting.

Each RF amplifier module induces an RF voltage in the combiner's secondary "winding" (rod). The RF voltages from all RF amplifiers which are turned "ON" add in the secondary (the copper rod). The total Power Amplifier stage output appears at the end of the combiner, at about an 8 Ohm impedance point. At the transmitter's nominal 25 kW power, RF current in the combiner secondary (pipe) is 40 Amperes, and the large copper rod used for the secondary is required to keep IR losses low.

Because the modules are effectively connected in series by the transformers, the same current flows in all modules. This is true whether a module is in the "on" or the "off" state.

At any instant in time, some of the modules will be "OFF" (except at a very high positive modulation peak, when all modules will be ON). RF amplifier modules used as Binary Steps will deliver less RF voltage than those used as Big Steps. In the transmitter Power Amplifier stage, individual RF amplifier output voltages add to produce the total RF voltage. At any instant, the RF voltage observed on an oscilloscope (or producing an instantaneous reading on a modulation monitor) is the sum of the incremental voltages from the contributing modules. The current at that instant is this total voltage divided by the combiner load impedance (approximately 8 Ohms).

At 25 kW carrier power, the RF current in the combiner is nominally 40 Amperes. At a 100% positive modulation peak, this current will double to 80 Amperes (the RF voltage at the output will also double). Typically 23 modules are "ON" at carrier power (25 kW, and 47 modules will be "ON" at a 100% positive modulation peak. This will provide twice the VOLTAGE across the combiner and therefore twice the RF output voltage.

Refer to Section IV, Overall System Theory, for more information.

Refer to Section V, Maintenance, for general pc board maintenance procedures. There are jumper settings on the Binary Combiner/Motherboard. There are no adjustments on the boards.

G.2 Circuit Description

Refer to the Main Combiner/Motherboard schematic, 839-7855-094, Binary Combiner/Motherboard schematic, 839-7855-093, and Sheet 4 of the Overall schematic, 839-7855-151, in the Drawing Package.

G.2.1 Main Combiner/Motherboards (A2 through A4)

Each Main Combiner/Motherboard contains combiner transformer toroids T1 through T16 and printed circuit board sockets for 16 RF amplifier modules. A tapped air-core "efficiency coil," is paralleled with each transformer winding. Tap position depends on operating frequency and is listed on Sheet 1 of the frequency determined components chart, 839-7855-140, in the Drawing Package.

The motherboard also contains connectors for DC supply voltage, RF drive inputs, and encoded audio inputs from the modulation encoder board.

G.2.1.1 DC Supply

On the Main Combiner boards, all modules operate from the +230 VDC supply input at E1 and E2.

G.2.1.2 RF Drive Inputs

RF drive for the sixteen modules on each motherboard enters at J17, J18, J19 and J20. Each module receives two RF drive cable inputs from the RF Drive Splitter A15. All RF drive cables are the same length, so all RF drive signals are in phase.

G.2.1.3 Encoded Audio (Module On/Off Control Signals)

The encoded audio inputs, control signals, from the Modulation Encoder board enter at J21, J22, J23 and J24. These encoded digital signals turn on the number of modules needed for the RF output at each instant in time.

G.2.2 Binary Combiner/Motherboard (A1)

Refer to the Combiner Motherboard/Binary Schematic, 839-7855-093, in the Drawing Package.

The RF Input and Control Signal Input signals enter the Binary Combiner/Motherboard on the same input jacks as the Main Combiner/Motherboards.

On the Main Combiner/Motherboards, all active amplifiers deliver the same RF voltage. On the binary combiner/motherboard all active amplifiers deliver combinations of equal and binary weighted RF voltages.

G.2.2.1 Binary Steps

The RF amplifier modules used in binary step positions are identical to all other RF amplifier modules, and are interchangeable. The differences in binary steps are all on the Binary Combiner/Motherboard. The Binary steps are: the 1/2 Step B7 (RF 91); the 1/4 Step B8 (RF 92); the 1/8 Step B9 (RF 93); the 1/16 Step B10 (RF 94); the 1/32 Step B11 (RF 95) and the 1/64 Step B12 (RF96). (Recall that these are RF voltage, NOT power steps).

The fractional Binary Steps are obtained by operating these amplifier modules with a combination of reduced supply voltages and different combiner transformer turns ratios. As the steps become smaller, there are more turns in the combiner transformer primary windings.

In addition, four of the Binary steps (1/2, 1/4, 1/8, and 1/16) have tapped transformer primary windings for fine adjustments in step amplitude. The tap positions depend on operating frequency and are selected with P30, P31, P32, and P33. Tap positions are shown in the Frequency Determined Components chart in SECTION IX, Diagrams.

G.2.2.2 DC Supply Voltages

All Big Step amplifiers, RF81-RF90, operate from the +230 VDC supply which is fed to the Binary Combiner/Motherboard at terminals E7 and E3.

The 1/2 Step B7 and the 1/4 Step B8 amplifiers operate at +115 VDC. This is fed to the Binary Combiner Motherboard at terminal E4.

The 1/8 Step B9, the 1/16 Step B10, the 1/32 Step B11 and the 1/64 Step B12 amplifiers operate at +60 VDC which is fed to the Binary Combiner/Motherboard at E5/E6.

Section H
Output Sample Board (A26) and Output Monitor (A27)

H.1 Introduction

This section includes circuit descriptions and troubleshooting information for the Output Sample Board and Output Monitor.

The Output Sample Board contains circuits to sample RF voltage and RF current. The outputs of these sample circuits are fed to the Output Monitor. The Output Sample Board is located in the Output Network Compartment.

The Output Monitor includes circuits for VSWR protection, power metering, and modulation monitoring. The Output Monitor is located on the upper left side of the Center Control Compartment.

H.2 Circuit Description

Refer to schematic 839-7930-018 and schematic 843-5400-101 in the Drawing Package.

Refer to SECTION V, Maintenance, for adjustment procedures and pc board maintenance procedures.

H.2.1 Output Sample Board

The Output Sample Board contains RF voltage samples and RF current samples from the 50 Ohm point in the output network. These are sent to the Output Monitor for VSWR protection and Forward/Reflected power monitoring.

H.2.1.1 Current Samples

The RF output conductor between 2C4 and the output connector J2 passes through toroidal transformers T1 and T2. These transformers pick up samples of RF current.

- A voltage proportional to the current through T1 is developed across resistors R1 through R4 for the Antenna VSWR circuit and sent to the Output Monitor at J1-1.
- Voltages proportional to the current through T2 are developed across resistors R10 through R17 for forward/reflected current samples to the directional coupler. The forward sample is sent to the Output Monitor at J1-3 and the reflected sample is sent to the Output Monitor at J1-5. These voltages are 180° out of phase.

H.2.1.2 Voltage Samples

A copper strap connects the RF output conductor to E1 and then to capacitor C7 for RF voltage samples.

- Capacitive voltage divider C11/C14/C15 develops a voltage sample for the forward power directional coupler. This sample is sent to the Output Monitor at J1-13.
- Capacitive voltage divider C10/C13/C16 develops a voltage sample for the reflected power directional coupler. This sample is sent to the Output Monitor at J1-15.
- Capacitive voltage divider C9/C12/C17 develops a voltage sample for the Antenna VSWR circuit at J1-11.
- A voltage sample for the Network VSWR circuit from 2C2 is fed to the board at E2 and leaves the board on J1-1.

H.2.1.3 Calibration Jumpers

Plugs P1 and P2 and jumper JPR4 are used to calibrate the VSWR circuits on the Output Monitor.

H.2.2 Output Monitor

The Output Monitor contains circuits to detect a VSWR condition when arcs, faults, or impedance changes occur in the transmitter bandpass filter/output network or in the antenna system or load connected to the transmitter output. If a VSWR fault is detected, the PA modules are immediately turned off and the “Oscillator Sync” circuit is activated. This will protect the PA module transistors during a VSWR shut-down. The VSWR logic on the LED Board will return the transmitter to normal operation within approximately 20 milliseconds unless a number of VSWR trips occur in quick succession.

Directional Coupler circuits to detect Forward/Reflected power and Modulation Monitor sample adjustment circuits are also on this board.

H.2.2.1 Phase Angle Detector, Theory Of Operation

This description of Phase Angle Detector circuit operation applies to both the Antenna VSWR and Bandpass Filter VSWR phase angle detectors. Refer to the Simplified Schematic Diagram (Phase Angle Detectors), Figure H-1, for the following discussion.

When a transmission line is terminated with a resistive load, the VSWR will be 1.0 and voltage and current in the line will be in phase and will have amplitudes determined by Ohm’s law (E=IR). If the load RESISTANCE changes, the current and voltage AMPLITUDE relationship will change. If the load REACTANCE changes, the current and voltage PHASE relationship will change. The phase angle detectors used in the transmitter are balanced or “nulled” for the phase and amplitude relationships that exist when the output network is properly tuned into a 50 + j0 Ohms. Any VSWR condition will cause the RF current and voltage phase/amplitude to change. This will produce a voltage at the output of one or both phase angle detectors.

a. CURRENT SAMPLE: The current sample for the phase angle detector is a current transformer. The primary, a copper tube or rod carrying the RF current, passes through the secondary, a ferrite core inductor. Resistors are connected across the secondary to load the winding and to convert the current sample to a voltage sample for the phase angle detector.

b. VOLTAGE SAMPLE: A capacitive voltage divider provides an RF voltage sample for the phase angle detector.

The RF voltage sample and the RF current sample are applied to opposite ends of the primary winding of the phase angle detector transformer (T1 or T3). When the samples are in phase and have the same amplitudes, there will be no RF current flow through the transformer. If the phase and/or amplitude of either sample changes, current will flow through the transformer primary

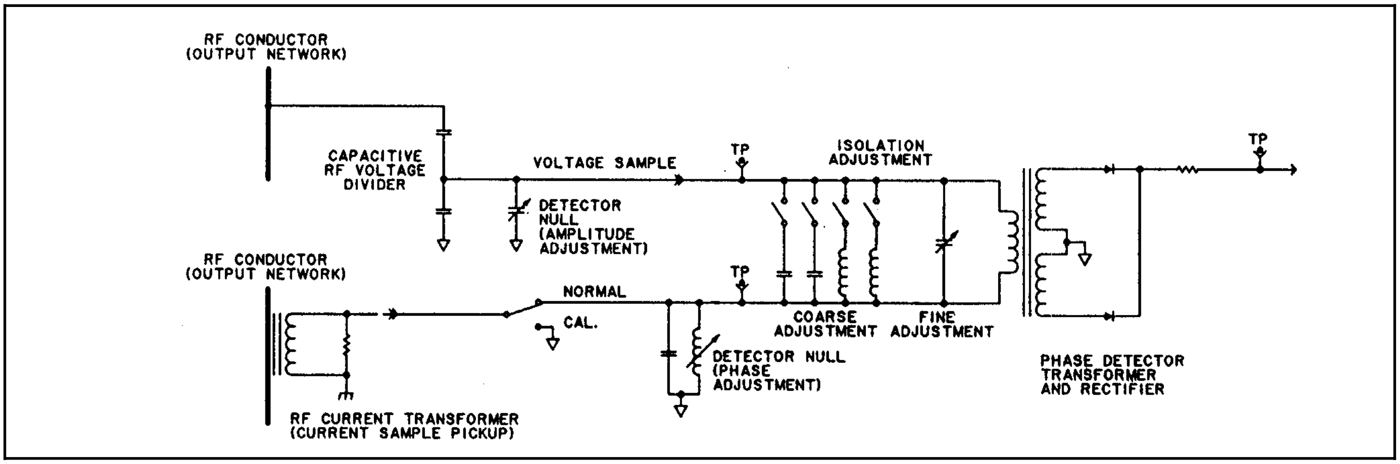

Figure H-1. Phase Angle Detector, Simplified Diagram
(817 2099 038)

winding and a voltage will be induced in the secondary winding. A full-wave rectifier will then produce a DC output voltage at the phase angle detector output.

To eliminate any interaction between voltage and current samples, the primary winding is tuned to parallel resonance at the transmitter's operating frequency to provide a high impedance between the samples. Switch-selected capacitors and inductors are used for coarse tuning, and a variable capacitor is used for fine tuning. The normal/cal switch is provided to resonate the transformer primary circuit. When the switch is in the "Cal" position, the current sample is disconnected and the RF voltage sample will be applied to one end of the transformer primary.

The RF voltage sample (AMPLITUDE) adjustment is a variable capacitor across the lower half of the capacitive voltage divider. The RF current (PHASE) adjustment is a capacitor in the parallel L-C circuit. With the transmitter properly tuned, the detector is "balanced" by adjusting the RF voltages at opposite ends of the transformer primary for equal amplitude and phase. When the detector is balanced, the DC output of the detector should be zero.

H.2.2.2 Antenna VSWR Phase Angle Detector

The Antenna VSWR Phase Angle Detector current sample from the Output Sample Board enters at J1-1 and is fed to parallel circuit L12 and C43 through C46. Switch S6 selects the capacitance and L12 is used to adjust the phase.

The Antenna VSWR Phase Angle Detector voltage sample from the Output Sample Board enters at J1-11 and is fed to amplitude adjustment C15.

Parallel components C41, C42, L9 and L10, selected by S9, and capacitor C29 are used to resonate the primary of T1 to the carrier frequency.

The output signal is rectified by CR7 and CR9 and applied to the inverting input of U3.

H.2.2.3 Bandpass Filter VSWR Phase Angle Detector

The Bandpass Filter VSWR Phase Angle Detector is also referred to as the "Internal Phase Angle Detector".

The Bandpass VSWR Phase Angle Detector current sample from T9 enters the board at J3-6 is fed to parallel resonant circuit L5 through L8 and C12, C39 and C47. Switch S7 is used to select coarse values of inductance and capacitance.

The voltage sample input at J1-9 is fed to amplitude adjustment C16 and parallel capacitors C20 and C28 selected by S2.

Parallel components L2, L3, C3 and C5, selected by S1, and capacitor C21 are used to resonate the primary of T3 to the carrier frequency.

The output of T3 is rectified by CR12 and CR16 and applied to the inverting input of U2.

H.2.2.4 "Phase Angle Detector Null" Meter Indications

The phase angle detector outputs at TP8 and TP9 are DC voltages which are sent to the LED Board on J2-23 and J2-25. The signals pass through the LED Board to the Controller where voltage follower amplifiers are used to drive the front panel MULTIMETER. The voltages are metered as "DETECTOR NULL (ANTENNA)" and "DETECTOR NULL (FILTER)." These voltages are also available at the external interface for remote metering.

The "DETECTOR NULL" indications are relative readings. When phase detectors are properly balanced they should both read zero. Once the transmitter is tuned, any change in the Bandpass Filter will cause the DETECTOR NULL (FILTER) reading to increase. The DETECTOR NULL (ANTENNA) reading will increase if the load on the transmitter output changes.

H.2.2.5 VSWR Trip Circuits

Because the Antenna VSWR and Bandpass Filter VSWR circuits are identical except for time constants, only the Antenna VSWR trip circuit will be discussed.

H.2.2.5.1 Comparator

The trip circuit uses an LM-360 differential comparator U3. The non-inverting input U3-5 is an adjustable positive "reference" voltage from the ANTENNA VSWR TRIP ADJUST control, R24. The inverting input U3-4 is the DC signal from the phase angle detector. Normally, the inverting input U3-4 will be at zero Volts, and the comparator output U3-11 will go HIGH. If a VSWR condition occurs, the voltage from the phase angle output at U3-4 will exceed the "reference" voltage at U3-5 and the comparator output will go LOW. Diodes CR11 and CR13 protect U1 from transient voltages.

H.2.2.5.2 *R-C Network*

A VSWR condition may last for only a few microseconds. Because the transmitter output is turned off very rapidly by a logic signal which goes directly to the Modulation Encoder, this may not be enough time for fault and overload logic to act. Capacitor-resistor network C14/R38 holds the comparator output low for about 20 microseconds or more after the phase angle detector output returns to normal.

H.2.2.5.3 *Manual VSWR Trip*

Manual VSWR Trip switch S4 simulates a VSWR fault by pulling the phase angle detector output to +5 VDC.

H.2.2.5.4 *VSWR Loop Self Test*

The transmitter includes a self-test feature. Each time the transmitter low voltage supply is turned on, the VSWR trip circuits and logic are tested. The result of the "self-test" is indicated by the VSWR Sensor "STATUS" LED on the ColorStat™ panel. The LED will pulse red and then turn green if the test is successful, but will remain red if the test fails.

VSWR self-test logic circuits are described in SECTION Q, LED Board. The logic generates a Self-Test Logic LOW pulse, and evaluates the results of the test, whenever any of three conditions occurs:

a. Transmitter low voltage is applied (either after shut-down for maintenance or after a power failure).
b. The VSWR Sensor "MANUAL TEST" button on the ColorStat™ panel is depressed.
c. A remote VSWR "Manual Test" command is given, through the External Interface.

On the Output Monitor, the logic LOW self-test pulse turns on transistors Q5 and Q6, pulling the non-inverting inputs of both VSWR trip comparators to +5 VDC (Logic High) and simulating a VSWR fault.

H.2.2.6 "VSWR Trip" Logic

The output of U3-11 goes to monostable multivibrator U6-1 and also to AND gate U5-9.

H.2.2.7 AND Gate U5

If U5-9 or U5-10 goes LOW, U5-8 also goes LOW. This output goes directly to the Modulation Encoder to immediately turn all PA modules OFF.

H.2.2.8 Monostable Multivibrators

Each time a VSWR condition is detected by one of the phase angle detector circuits, dual retriggerable monostable multivibrator U6 is triggered by the falling (negative going) edge of VSWR trip comparators U2-11 or U3-11. The U6 output LOW pulses go to the VSWR fault and overload logic on the LED Board.

Section U6-4 is the output to the "Antenna VSWR trip" and section U6-12 is the output for the "Bandpass Filter VSWR trip." The output LOW pulse width for each trip pulse is determined by a resistor-capacitor network. For the "Antenna VSWR trip" C48 and R51 at U6-15 set a pulse width of 14 milliseconds. For the "Bandpass VSWR trip" C49 and R50 at U6-7 provide a 19 millisecond pulse width.

Switch S5 prevents U6 from generating a pulse during phase angle detector circuit adjustments.

H.2.2.9 Directional Coupler Circuit Description

A voltage proportional to RF current from the Output Sample Board enters the board at J1-3 and J1-5 and is fed to the anodes of CR28 and CR33. The voltages are taken from opposite sides of the RF current transformer, so they are 180° out of phase.

Voltage samples are taken from two capacitive dividers on the Output Sample Board and enter the board at J1-15 and J1-17

The "Forward Balance" adjustment C6 is in parallel with the voltage divider capacitor on the Output Sample Board.

Under normal operation, P1 and P3 are connected between 1-3. The voltage and current samples on the Anode and Cathode of CR33 are 180° out of phase. The DC current flow through R18 establishes a voltage proportional to the current flow and the square root of forward power. RF choke L1 and capacitor C4 form a filter to remove the RF component and series resistor R20 isolates the coupler from load variations. Resistor R18 and capacitor C26 also form a low-pass filter to remove audio-frequency variations due to modulation from the coupler's output. For the forward power coupler, reversing jumper plugs P1 and P3 changes the coupler to read reflected power for calibration.

The reflected coupler operates the same way as the forward coupler, except that the current sample is 180° out of phase. During VSWR conditions, the phase/voltage relationships at the ends of CR28 change such that current will begin to flow through R19. The voltage established through R19 will be proportional to the square root of the reflected power. Variable capacitor C40 is a balance adjustment, low-pass filter L4 and C13 remove the RF component and R22 and C22 form a low-pass filter to remove audio-frequency components. Resistor R22 also isolates the coupler from load variations. For the "reflected power" coupler, reversing jumper plugs P1 and P3 changes the coupler to read forward power to calibrate the reflected power meter.

H.2.2.9.1 *Other Power Metering Components*

The outputs of the directional coupler go through the LED Board to voltage followers on the Controller. The voltage follower outputs drive the power meter on Switch Board/Meter Panel and the forward and reflected power outputs at the External Interface. Forward and reflected power calibration controls are located on the Switch Board/Meter Panel.

H.2.2.10 Detected Audio

Transformer T2 and Diodes CR6 and CR10 form an audio detection circuit. The output is available at J4 and can be used to monitor the audio signal.

H.2.2.11 Modulation Monitor Sample

The Modulation Monitor Sample circuit includes relays and adjustments to provide the same RF output level to the modulation monitor at any power level.

The from adjustable tapped inductor L7, in the Output Network Compartment, enters the board at J7-1. The signal to the modulation monitor at LOW power is adjusted by the tap on L7. When the transmitter is in the MEDIUM or HIGH power position, the RF voltage from L7 will increase. Switched potentiometers R7 and R8 reduce the voltage to the desired level.

When relay K2 is energized, the mod monitor sample output is taken from R7, MED PWR MON ADJ. When both K1 and K2 are energized the sample output is taken from R8, HIGH PWR MON ADJ. Logic circuits on the LED Board provide logic HIGH signals when the transmitter is in medium or high power. A logic HIGH signal at J2-9 will turn on transistor Q4 and energize low-voltage relay K2 for the MEDIUM power sample. A logic HIGH signal at J2-7 will turn on Q3 and Q4 through CR18. This will energize both K1 and K2 for the HIGH power sample.

H.2.2.12 +5 VDC And -5 VDC Regulators

DC supply inputs to the Output Monitor are +8 VDC and -8 VDC, from the low voltage power supply. Each input is fused, with 0.5 A fuses F1 and F2, and regulated to +5 VDC and -5 VDC.

Series pass transistor Q1 is controlled by regulator U1-12. If U1-9 detects an undervoltage or overvoltage condition, a +5 FAULT-L (LOW) signal is sent to the LED Board at J2-21.

The -5 Volt supply is similar, and uses regulator IC U4, and series pass transistor Q2.

For a description of the regulator IC’s and circuit operation, refer to SECTION M, DC Regulator.

Table H-1. Output Monitor Board A27,
Controls and Indicators
See Figure H-2

COMPONENT	FUNCTION/DESCRIPTION
C6	Balances (nulls) Forward Power directional coupler section.
C40	Balances (nulls) Reflected Power directional coupler section.
C29	Ant. VSWR detector, Fine Isolation Adjust. Adjusted for maximum isolation between current sample and voltage sample.
C15	Ant. VSWR detector, Voltage sample amplitude. Adjusted, along with current sample adjustments, for the same phase and amplitude at TP6 and TP5 (for a detector null).
C21	BPF VSWR detector, Fine Isolation Adjust. Adjusted for maximum isolation between current sample and voltage sample.
C16	BPF VSWR detector, Voltage Sample Amplitude, fine adjust. Adjusted, along with current sample adjustments, for the same phase and amplitude at TP1 and TP10 (for a detector null).
F1	Protects +8 Volt supply, if +5 Volt regulator fails (short-circuits).
F2	Protects -8 Volt supply.
L12	Ant. VSWR detector, Current sample, Fine phase. Adjusted, along with voltage sample amplitude at TP6 and TP5 (for a detector null).
L5, L6, L7, and L8	BPF VSWR detector, Current sample, Fine phase and amplitude, adjustments. When selected with S7, each is adjusted for the same phase and amplitude at TP1 and TP10 (for a detector null).
P1 and P3	Directional Coupler, Jumper Plugs. Normal position is P1-1 to 3 and P3-1 to 3. Change both jumper plugs to position 1 to 2 when adjusting Forward Bal (C6) or when calibrating Reflected Power meter.
P2	Directional Coupler Reflected Balance, Coarse adjustment. Jumper plug is set according to Frequency Determined Components Chart.
R23	Adjusts Bandpass Trip sensitivity.
R24	Adjusts Antenna VSWR TRIP sensitivity.
R7	Adjusts Mod Monitor Sample output level when in MEDIUM power.
R8	Adjusts Mod Monitor Sample output level when in HIGH power.
S4	Depress to check Antenna VSWR Trip comparator and logic.
S8	Normal/Cal Switch. The CAL position is used only during phase angle detector adjustment, when adjusting isolation.
S5	Press and Hold To Null Each Phase Angle Det
S6	Ant. VSWR detector, Current sample, Coarse phase and amplitude. DIP switch, initially set according to the Frequency Determined Components Chart.
S3	Depress to check Bandpass Filter VSWR Trip comparator and logic.
S7	BPF VSWR detector, Current sample, Coarse phase and amplitude adjust. DIP switch, initially set according to the Frequency Determined Components Chart.
S2	BPF VSWR detector, Voltage Sample Amplitude, coarse adjust. Set per Frequency Determined components chart.
S9	Ant. VSWR detector, Coarse Isolation Adjust. DIP Switch, initially set according to the Frequency Determined Components Chart.
S1	BPF VSWR detector, Coarse Isolation Adjust. DIP Switch, initially set according to the Frequency Determined Components Chart.

Table H-2. Output Monitor Board A27, Test Points
See Figure H-2

COMPONENT	FUNCTION/DESCRIPTION
TP6	Antenna phase angle detector, voltage sample, used during phase angle detector adjustment.
TP5	Antenna phase angle detector, current sample, used during phase angle detector adjustment.
TP1	Bandpass Filter phase angle detector, voltage sample, used during phase angle detector adjustment.
TP10	Bandpass Filter phase angle detector, current sample, used during phase angle detector adjustment.
TP7	+5 Volt regulator output test point.
TP2	-5 Volt regulator output test point.
TP4	Antenna Threshold test point (Reference voltage for Antenna VSWR comparator).
TP3	Filter Threshold test point (Reference voltage for Bandpass Filter VSWR comparator).

J.1 Introduction

This section includes a description of the Analog Input Board and troubleshooting information.

The Analog Input Board includes audio and power control circuits. The output is an audio signal with a DC component, which goes to the Digital to Analog Converter. The DC component determines the transmitters carrier power output, and the audio component amplitude modulates the transmitter.

The Analog Input Board is located on the left inside wall of the Center Control Compartment.

Refer to SECTION V, Maintenance, for adjustment and pc board maintenance procedures.

J.2 Circuit Description

Refer to Schematic 839-7855-100 in the Drawing Package.

The Analog Input Board includes the following circuits:

a. Bessel Filter, to optimize audio overshoot performance.
b. Transformerless, balanced audio input stage.
c. Maximum Power Adjustment.
d. Power supply hum and noise cancelling.
e. Digitally controlled potentiometer, for power control.
f. “Dither” circuit for optimizing transmitter noise performance.
g. Audio sample for the DC Regulator, B- signal.
h. A “PA Turn on/Turn off” circuit.
i. On-board voltage regulators.

J.2.1 Audio Input

The audio input signal from the External Interface enters at either J1, J2 or J3. Back-to-back zener diodes on the External Interface provide protection against transients and excessive voltage at the input.

J.2.2 Bessel Filter

The Bessel Filter uses passive components L1 through L4, C1 through C4, and R7 through R12. The Bessel Filter rolls off frequencies above the audio band without introducing overshoot. Audio frequency response of the transmitter is less than 0.9 Db down at 10 kHz, and square wave overshoot is minimized when the filter is properly matched to the source impedance of the processing equipment. Processing equipment with IC output stages typically have a low source impedance. Consult the technical manual for your processing equipment.

The Analog Input Board includes three audio input connectors (J1, J2 and J3), each with different series resistors for various source impedances. Use J1 if the source impedance is 600 Ohms or more, J2 if it is between 150 and 600 Ohms, and J3 if it is 50 Ohms or less.

If you do not know the source impedance use either J1 or J2. If the source impedance is greater than the input impedance, some overshoot will result. If the source impedance is less than the input impedance, high frequency response will change slightly.

J.2.3 Instrumentation Amplifier (U6, U9)

An Instrumentation Amplifier configuration is used to convert the balanced input to an unbalanced output and to provide rejection to any noise on the input signal.

The audio signal from the Bessel Filter is AC coupled through C5, C6, C7 and C8 to the input stage. Back-to-back zener diodes CR1 and CR2, and series resistors R11 and R12 provide input protection.

The input to the first section of the instrumentation amplifier is U6-5 and U6-3. Both non-inverting amplifiers, U6A and U6B, have the same gain and Audio Gain Adjust control R15 allows inputs from -10 dBm to +10 dBm to be used. The outputs U6-3 and U6-1 are sent to U9-2 and U9-3.

Voltage divider R68 compensates for the gain difference between the inverting and non-inverting inputs of U9.

Note that the 10k resistors used in this circuit are each one section of DIP (Dual Inline Package) resistor arrays R68 and R69. All resistors are labeled “R68" or ”R69," and the DIP terminals for each resistor section are given.

J.2.4 Buffer Amplifier (U7)

The output of U9-1 goes through a voltage divider to the input of Buffer Amplifier U7-3. The input to the buffer amplifier can be observed at TP1. When the transmitter is modulated at 100% with a sine wave, the audio signal amplitude at TP1 will be about 1.5 Vp-p with no DC component.

The signal is amplified by U7 (gain of 2) and sent to the maximum power circuit U7-6.

J.2.5 Maximum Power Adjust (U7, R27)

The Max PWR Adjustment R27 adds a DC component to the audio signal to set the maximum carrier power of the transmitter.

A negative DC voltage from R27 is fed to the non-inverting input U7-5 where it is summed with the audio signal. The output of U7-7, TP-4, will be a -(Audio + DC) signal. The audio component from TP1 is amplified by U7.

With the “maximum power adjust” set, the DC voltage at TP4 will be about -1.0 VDC at 30 kW with no modulation. With 100% modulation, the -(Audio + DC) signal at TP4 will be a 2 Vp-p audio signal with a -1.0 VDC component. The voltage at TP4 will NOT change when the RAISE or LOWER controls on the front panel are operated or when the transmitter is switched between LOW, MEDIUM, or HIGH powers. If Maximum Power Adjust is set for less than 30 kW, the DC component at TP4 will be less than -1.0 VDC.

J.2.6 Analog Divider (U10)

The Analog Divider IC U10 compensates for variations in the +230 VDC supply and reduces hum and noise. If the feedback voltage from the +230 VDC supply increases, the output from the analog divider will decrease. If the feedback voltage from the +230 VDC supply decreases, the output from the analog divider will increase.

The -(Audio + DC) output of U7-7 is fed to U10-6, an Analog Multiplier IC connected as an analog divider. A sample from the +230 VDC supply from U12-7 is fed into the input U10-10. Resistor R17 sets the "scaling factor" so that the output at U10-8/4 is a signal defined as [(Audio + DC)/power supply sample voltage x 4.93].

J.2.6.1 Power Supply Sample Circuit

The "power supply sample" voltage at TP5 and U10-10 is determined by the "supply sample" voltage divider on Fuse Board A24 and the gain of non-inverting buffer amplifier U12. The high voltage supply sample from Fuse Board A24 enters the Analog Input Board at J5-8 through choke L5 and P1. Inductor L5 is a common-mode choke, which cancels any noise induced in the wiring between Fuse Board A24 and the Analog Input Board. Some filtering for low frequency THD optimization is performed by C51 and R52. P1 is used during factory test.

A voltage from the supply current sample circuits on the LED Board is brought in through J4-29, CR22 and CR21 and is applied to U12-5 if there is a current overload fault. This will cause the output of U12 to increase and reduce output power.

When the high voltage supply is off, the output of U12-7 is zero. This could also occur if a power supply sample circuit fault occurs. With no voltage at U10-10, the output U10-8/4 would increase toward the -15 Volt supply and the transmitter power output would increase to a high level.

To prevent this, diode CR9 will conduct to maintain the voltage at U10 pin 10 and TP5 at about +3.9 Volts. When the power supply sample is normal, CR9 cathode is more positive than the anode and the diode is cut off.

J.2.7 Digitally Controlled Potentiometer (U8)

Integrated Circuit U8 is a 3-1/2 digit Digitally Controlled Potentiometer (an attenuator). A 12-bit BCD (Binary Coded Decimal) input from the Controller at U8-4 through U8-15 controls the output of U8. The digital power control logic inputs will be logic LOW, near zero Volts, or logic HIGH, near +15 Volts. The output of U8-1 is buffered by U11. The output of U11-6 at TP-7 will be from 0.000 to 0.999 times the input U8-17. The DC component at TP-7 determines the carrier power, and the audio component modulates the transmitter output.

At 30 kW with 100% modulation, the (Audio + DC) output will be a 2 Vp-p audio signal with a +1.0 VDC component. At lower power levels, both the audio and DC components will be less. The DC voltage at TP-7 will change when the RAISE and LOWER buttons are depressed, or when the transmitter is switched between HIGH, MEDIUM and LOW power levels. The audio signal will also change proportionally with the DC component.

J.2.7.1 BCD Logic Input To U8

The BCD power control signal is generated on the Controller and enters the Analog Input Board at J4. Pull-down resistors, in DIP resistor arrays R47 and R48, ensure that each line is at ground unless one of the tri-state logic outputs from the Controller pulls that line HIGH.

The BCD Power Control data is stored in TTL latches U17 and U18. Six bits of the 12 bit signal are stored in each latch. The "RESET" and "CLOCK" inputs of the latches are tied together.

The clock input is the Data Strobe-H (logic HIGH) input from the Controller through Schmitt Trigger U13. This will delay the Data Strobe-H signal slightly to ensure that the BCD information on the inputs of the latches is correct.

Data stored in latches U17 and U18 will change when a transition from LOW to HIGH logic level occurs at the CLOCK input (pin 11) of each latch. The latch will store the data present at its inputs at that instant, and that data will then remain in the latch until the latch is either RESET or another positive-going transition occurs at the CLOCK input.

If a Data Clear-L (logic LOW) signal from Controller occurs, the RESET input of each latch will be pulled LOW and the BCD outputs will go LOW (corresponding to zero power output from the Power Amplifier stage). The Data Clear-L input is delayed by two sections of U13 and goes to the "RESET" inputs of U17 and U18.

The BCD output data from U17 and U18 is converted to CMOS logic levels (+15 VDC for logic HIGH) for U8 by hex level shifters U14 and U16. Outputs D1 through D4 are the binary bits for the first (most significant) decimal digit, D5 through D8 are the bits for the second decimal digit, and D9 through D12 are the bits for the third (least significant) decimal digit.

If outputs D1 through D12 were "0000/0000/0000" from a BCD number of 0.000, the digital potentiometer U8 would be at maximum attenuation and the DC voltage at TP-7 would be 0.0 VDC. This would result in no carrier power.

For a BCD input of 0.999, D1 through D12 would be "1001 1001 1001", digital potentiometer U8 would be at minimum attenuation and the voltage at TP-7 would be +1.0 VDC. This would result in a carrier power of 30 kW.

J.2.8 Analog Buffer (U4)

The (Audio + DC) output of U11-6 at TP-7 feeds buffer U4-3 which is a non-inverting amplifier with a gain of +2. Series resistor R82 and JFET switch Q7 in the PA Turn Off circuit form a voltage divider to ground at U4-3. When Q7 is turned ON, the (Audio + DC) input to U4-3 will be pulled to zero, so the Power Amplifier stage output will be zero (all PA Modules are turned off).

J.2.8.1 PA Turn On/Turn Off Circuit (U13-2, Q1, Q7, U13-4, Q2, Q8)

The Q2 and Q8 circuitry is identical to that of Q1 and Q7 with the exception of additional components used to create the "Half Power Step-Up" during the turn on sequence.

WARNING: Disconnect primary power prior to servicing.

A "PA Turn Off-H" signal is generated by the Controller during fault protection and when the transmitter is turned OFF. This logic HIGH input to U13-1 from J4-39 will be inverted to a logic LOW at U13-2. This will turn Q1 ON and apply a positive voltage to Q7 through Q1 and R20.

Transistor Q7 is an N-channel depletion mode JFET switching transistor. When the gate of Q7 approaches zero Volts it conducts (turns ON) and the drain-source resistance becomes less than 80 Ohms. Transistor Q7 and R82 form a voltage divider, so when Q7 is ON, it effectively shorts the (Audio + DC) signal at U4-3 to ground.

When the transmitter is turned ON, the "PA Turn Off-H" signal goes to logic LOW and turns off Q1 through U13. The gate of Q7 is pulled to -15 VDC by R25 which will turn it OFF. When Q7 is OFF it is an open circuit and the (Audio + DC) signal is applied to U4-3. During normal operation, Q1 is not conducting, C46 is charged to -15 VDC through R45, and Q7 is OFF.

Transistor Q8 and R23 form a second JFET voltage divider with R82. This circuit is in parallel with Q7. When Q8 is turned on, the series resistor R23 will cause the (Audio + DC) signal at U4-3 to be attenuated, but not shorted to ground.

Transistor Q8 will conduct longer than Q7 due to the delay circuit C86 and R49 on the U13-3 input. When the "PA Turn Off-H" signal changes from HIGH to LOW, C86 discharges slowly through R49, and keeps Q2 conducting. When the "PA Turn Off-H" signal is generated, C86 charges quickly through CR20 to reset the circuit.

This allows the RF power to come up in a two-step sequence: first to half power, then, after a 1.5 to 2 second delay, full power. The delay minimizes stress on the power supply and will give antenna system components time to "settle down" or cool after an arc has occurred, i.e. the antenna ball gaps and/or guy wire insulators.

J.2.9 Differential Amplifier/Inverter U4

The (Audio + DC) signal is applied to U4-6 and a small level 72 kHz "dither" signal is added at U4-5. The output of U4-7 is sent to the LED Board. For a 60 kW power output with 100% modulation, the (Audio + DC) signal at U4-7 will be a -2 VDC level with a 3 Vp-p audio level. A very small 72 kHz "dither" component will be riding on the audio.

J.2.9.1 Dither Oscillator U13, U19, U5)

The Analog to Digital (A/D) conversion process has an inherent +/-1 digit uncertainty. As the analog input changes, there may be some switching back and forth between two steps because of this uncertainty. This can result in some low-level residual noise. The "Dither" oscillator minimizes this residual noise by introducing a small 72 kHz triangle wave on the signal. This frequency is well above the audio frequency range, but low enough so that any 72 kHz sidebands are attenuated by the bandpass filter/output network. The Dither Oscillator is made up of an integrator (U3) and a square wave generator (differential amplifier U19).

J.2.9.1.1 *Square Wave Generator U19*

Differential amplifier U19 operates "open loop," so its gain is very high. Assuming no "Big Step Sync" input, inverting input U19-2 is at zero Volts. If the voltage at the non-inverting input U19-3 is slightly positive the output U19-6 will go to the +15 V supply rail. If the voltage at U19-3 is slightly negative, the output will go to the -15 V supply rail. The output of U19 is clamped by zener diodes CR11 and CR12 to +6 Volts or -6 Volts (the 5.1 Volt zener voltage plus the 0.7 Volt forward junction drop of the other diode).

J.2.9.1.2 *Integrator U3*

This voltage is applied to potentiometer R41 to the inverting input of U3-2. When the input is +6 Volts the output of U3-6 will ramp DOWN and when the input is -6 Volts, the output of U3 will begin ramping UP. The rate at which the output of U3 changes is determined by the R41-C62 time constant, so that adjusting R41 will adjust the oscillator's frequency.

The output of the Dither Oscillator at U3-6 and TP10, is a triangle wave with an amplitude of 1 Vp-p and a frequency of 72 kHz. Resistors R39-R40 form a voltage divider, with one end at either +6 or -6 Volts (fixed by the zener diode voltages) and the other end at the oscillator's output voltage (a triangle wave varying between +1 and -1 Volt). The output at U13-6 will cause U19-6 to switch High and LOW which will, in turn, feed back to the input of U3-2. A voltage divider formed by R42 and Dither Level Adjust potentiometer R43 reduces the dither signal to a very low level at TP9 and U4-5.

J.2.9.1.3 *A/D Big Step Sync*

The "Big Step Sync" signal from the Analot to Digital Converter consists of a short pulse each time a "Big Step" occurs. The sync pulses at TP11 are buffered in non-inverting amplifier U5. The output of U5-1 feeds to U19-2 as synchronizing pulses. If the dither signal is ramping UP when a "Big Step" is turned OFF the "Big Step Sync" pulse will change the direction of the dither signal so it ramps DOWN. If the dither signal is ramping DOWN when a "Big Step" is turned ON, the sync pulse will cause the dither signal to change and ramp UP.

J.2.10 -(Audio + DC) Sample To DC Regulator

The DC Regulator provides a Modulated B- "bias voltage" to the PA Modules to compensate for changes in their turn-on or turn-off times as the number of modules ON changes. The "OFFSET" control R84 is used to adjust the amount of DC offset to U5-6 which will change the -(Audio + DC) signal sent to the DC Regulator.

J.2.11 Analog Input Board Power Supplies

Supply voltages to the Analog Input Board are +22 VDC and -22 VDC from the low voltage power supply. Voltage regulator U2 provides a -15 VDC output. Voltage regulator U1 provides +15 VDC which is also regulated to +5 VDC by zener diode CR15. The regulated supplies are fused by F2 and F3. The regulators also provide "Supply Fault" outputs which feed through the Controller to fault circuits on the LED Board.

Refer to SECTION M, DC Regulator, for a further description of these voltage regulator circuits.

Refer to SECTION Q, LED Board, for a further description of the fault circuits.

J.3 BCD (Binary Coded Decimal) Coding

The following information is included for reference, if missing bits in the BCD Power Control signal are suspected as a problem. For the two most significant bits, you should be able to use the "raise" and "lower" controls to change power one "step" at a time and measure logic level signals with a logic probe, voltmeter, or oscilloscope.

The Binary Coded Decimal input to the Digitally Controlled Attenuator in the transmitter consists of three decimal digits, from 0.000 to 0.999. If this number is represented as "0.XYZ," "X" is the most significant digit, "Y" is the next most significant digit, and "Z" is the least significant digit.

Each digit is represented in Binary form, as shown in Table J-1.

The complete "BCD" number is represented as "XXXX/XXXX/XXXX," where each "X" (Binary "BIT") can be either "0" or "1." The binary BITS are also represented on the schematic diagrams as D1 through D12, so that the BCD number appears in the following order:

D1 D2 D3 D4/ D5 D6 D7 D8/ D9 D10 D11 D12

For reference, several transmitter power levels are represented below in both decimal and BCD notation. (Maximum power is set by the "Max Pwr Adj" control R27).

J.4 Troubleshooting

Observing waveforms and voltages at Test Points with an oscilloscope, with a sinewave at the audio input, will isolate most faults to one stage of the Analog Input Board. (The sine wave amplitude should be the level normally required for 100% modulation; signal levels for this input are indicated on the schematic diagram and given in Table J-3, "Analog Input Board Test Points").

Some specific symptoms and possible causes are described in the following paragraphs.

J.4.1 Symptom: Normal Signal At TP4, No Signal At TP7 (Digitally Controlled Potentiometer Output).

J.4.1.1 Possible Causes

J.4.1.1.1 U8, U10, or U11 faulty

Check U10-8/4 output. If no signal is present, U10 is probably faulty. Check U8 output at CR3 cathode; if (Audio + DC) signal is present, U11 is probably faulty. If Audio + DC is present at U8 input but not at U8 output, refer to the following paragraphs.

J.4.1.1.2 Digital Control Signal at U8 is Zero

There are several possible causes, including:

a. BCD (Binary Coded Decimal) Control Signal from Controller A38 is Zero. With the transmitter ON, use an oscilloscope or voltmeter to check Power Control Lines at inputs to U17 and U18. If the inputs are all LOW, there is no power control information from the controller. Refer to SECTION P, Controller, for further troubleshooting information.

b. DATA CLEAR Input (at J4-27) is LOW. Measure the voltage at U13-8. If the voltage is less than +1 VDC, the controller is instructing the data latches (U17-U18) to CLEAR, that is, reset to zero. Refer to SECTION P, Controller, for further troubleshooting information.

c. No Data Strobe Pulses (At J4-25). Measure the voltage at TP15. A logic HIGH pulse from the Controller should appear at this point when the LOW, MEDIUM or HIGH button is depressed.

d. Defective U17 or U18. If the BCD data, Data Clear-L, and Data Strobe-H signals from the controller are correct but there is no output from one or both latches, the latches may be defective.

e. Defective Logic Drivers (U14, U16). For each logic driver section, the input and output logic should always be the same. The TTL inputs will switch between zero and +5 VDC. The CMOS outputs will switch between zero and +15 VDC.

J.4.2 Symptom: Power Increases or Decreases in Steps, Not Continuously

J.4.2.1 Possible Cause:

J.4.2.1.1 BCD Information incorrect

This could indicate that some bits or digits in the BCD power control signal are not changing or that one or more PA Modules have failed. Check the logic level signals for the BCD bits at different power levels, at J4, at U18 outputs, and at U14 outputs.

J.4.3 Symptom: +15 VDC or -15 VDC faults

J.4.3.1 Possible Cause:

J.4.3.1.1 Defective Component

If the unregulated voltages to the board are present, the first thing to check when troubleshooting a voltage regulator problem is the input fuse F2 or F3. If the fuse is open, try replacing the fuse. If there is a problem with the regulator IC, pass transistor, or zener, the fuse will open again.

If the fuse opens again, measure the resistance of the supply to ground with the low voltage OFF. If there is a very low resistance to ground, remove any IC associated with the faulty supply until the resistance increases.

J.4.3.1.2 Defective fault logic

Measure voltage at TP12, TP13 or TP14 depending on which supply is indicating a fault. If the voltage is normal, but the fault is still indicated, measure the fault output on U1-10 or U2-10. If the fault line output is LOW, but the voltage at the Test Point is good, then the regulator IC is defective.

If the fault line is output HIGH but there is still a fault indicated on the ColorStat™ panel, refer to SECTION Q, LED Board for troubleshooting information on the fault circuits.

Table J-1. Decimal to Binary

Decimal Digit	Binary Number	Decimal Number	Binary Number
0	0000	5	0101
1	0001	6	0110
2	0010	7	0111
3	0011	8	1000
4	0100	9	1001

Table J-2. Power Level Coding

Power Level	Decimal	BCD (Binary Coded Decimal)
Maximum Power	0.999	1001 1001 1001
One-half power	0.707	0111 0000 0111
One-fourth power	0.500	0101 0000 0000
One-tenth power	0.316	0011 0001 0110
Zero power	0.000	0000 0000 0000

Table J-3. Analog Input Board A35, Controls and Indicators

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
A7	F2	Protects +22 V supply from +15 Volt regulator faults.
B7	F3	Protects -22 V supply from -15 Volt regulator faults.
D5	R15	Audio Gain Adjust. Adjusts audio input sensitivity (audio input level required for 100% modulation).
E5	R27	Sets maximum output power that can be obtained with the “RAISE” pushbutton.
A2	R41	Dither Frequency Adjust. Adjusts Dither Oscillator frequency (nominally 72 kHz)
B3	R43	Dither Level Adjust. Sets Dither Level; adjusted for minimum noise without excessive 72 kHz sidebands.
B1	R84	Offset. One of four “Modulated B- Supply” adjustments. Refer to the “Tuning/Frequency change” procedure in Section 5, Maintenance.
A1	R85	Gain. Same as “Offset, R84" above.

Table J-4. Analog Input Board A35, Test Points

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
C3	TP1	Audio sample, output of “input amplifier.” (about 1.5 Vp-p audio at 100% modulation, no DC component).
C3	TP2	Ground
D4	TP3	“Max Pwr Adj” voltage sample (negative DC voltage).
D3	TP4	Inverted (Audio + dc) sample (about 1.5 Vp-p audio at 100% modulation, with -0.75 Volt DC component).
D3	TP5	“Power Supply Sample” (approximately +5 VDC).
D3	TP6	Ground.
D2	TP7	
		“Carrier Power.” Digitally Controlled Potentiometer output (about 2 Vp-p audio with +1.0 VDC component at 25 kW, 100% mod.
B2	TP8	Ground.
B2	TP9	“Dither” signal (72 kHz triangle wave, typical amplitude less than 5 mV p-p).
B2	TP10	“Dither” oscillator output (72 kHz, 1 Vp-p triangle wave).
C1	TP11	“Big Step Sync” signal.
B4	TP12	Regulated -15 VDC sample.
B7	TP13	Regulated +5 VDC sample.
C5	TP14	Regulated +15 VDC sample.

K.1 Introduction

This section describes the Analog to Digital Converter board and includes a “silkscreen” of component locations.

The schematic diagram can be found in the Drawing Package and the parts list can be found in Section VII. “Analog to Digital is also referred to as ”A/D" or “A to D”. The A/D board is located in the center control compartment.

K.2 Principles of Operation

An analog audio signal from the Analog Input board goes to the A/D board where it is converted to a 12-bit digital audio signal by an A/D chip. The rate of this conversion is 1.2 to 2.5 microseconds depending on the transmitter frequency. The A/D conversion process is synchronized with the RF signal so that PA modules are switched on and off when the RF driver current crosses through zero and the PA transistors are not conducting, called the “zero crossing”. The digital audio signal from the A/D is stored in latches.

The latch outputs go to the Modulation Encoder board where they are used to turn on PA modules. The latch outputs also go to the reconstruction audio circuit and to the big step sync circuits on the A/D board. The reconstruction audio signal goes to the envelope error circuit on the Controller board (A38). The big step sync signal goes to the dither oscillator on the Analog Input board.

The following description refers to the schematic diagram for the Analog to Digital Converter board (drawing 839-7855-177).

Refer to SECTION V, Maintenance, for adjustment and pc board maintenance procedures.

Refer to SECTION IV, Overall System Theory, for a block diagram and overall descriptions of the audio and digital audio sections of the transmitter.

K.3 Circuit Description

K.3.1 Converting a PA Sample to the A/D ENCODE Pulse (T1, U29, Q9)

There are two RF sample inputs to the A/D converter board. One is the Splitter Sample Frequency Input from the RF Splitter (A15) on pins J3-1 and J3-2.

PA modules must be switched on and off when the RF drive crosses through zero.

The RF input goes to the primary winding of wide-band toroidal RF transformer T1. Resistor R18 and an L-C network with components selected by section of DIP switch S1 provide adjustable, frequency-determined phase shift (refer to the Tuning/Frequency change procedure in Section 5, Maintenance for information on setting S1).

Schmitt Trigger U12C converts the RF input to TTL level pulses. Diodes CR14 and CR15 limit the voltage at the Schmitt trigger’s input to between +0.7 and +4.3 Volts.

K.3.2 Frequency Divider (U29, Q9)

The frequency output at TP6 is at the RF input frequency (from J3 pin 1) if the jumper plug is installed between JP10 pins 5 and 6,. The output at TP6 is at one-half of the RF input frequency if the jumper is installed between pins 1 and 2. The output at TP6 is at one-third of the RF input frequency if the jumper is installed between pins 3 and 4.

The position of the jumper plug JP10 depends on the transmitter’s operating frequency. Refer to the note on the A./D converter schematic diagram or to the Frequency Determined Components chart.

K.3.3 ENCODE Signal Pulse Width (Q9)

The timing diagram labeled A/D Converter Board Signals shows the interaction of signals on this board. The signal on TP6 goes through C106. The base of Q9 is held at about 0.7 V. The falling edge of the pulse from TP6 causes Q9 to turn off. This allows the collector of Q9 to increase in voltage. R78 and R79 charge up the base of Q9, turn it on again and cause the collector to drop 0.3 V. The end result is a pulse at TP3. The length of this pulse depends on the value of resistors R78 and R79. This pulse width should be between 20 and 50 nanoseconds. This is the ENCODE signal that goes into the A/D and starts the conversion process.

K.3.4 Analog to Digital Converter Circuit

K.3.4.1 Analog Input Circuit (U28)

The analog input signal (J4-10) to the A/D converter is the Audio + DC from the Analog Input board (actually the negative Audio + DC). The DC component determines the unmodulated transmitter power output (“carrier” level) by turning on a constant number of PA modules. The audio component amplitude modulates the output by turning PA modules on or off to vary the instantaneous RF output voltage.

The analog signal level at the board’s input is high so that any noise pickup on interconnecting cables does not degrade the signal-to-noise ratio. Inverting amplifier U28 has a gain of 0.5 to provide the proper single level to the A/D chip input and also provides isolation between the board’s input and the A/D chip.

A very small amount of signal from the big step sync circuit is added to the input signal through R70 at the inverting input of U28 (pin 2). When a big step occurs in the output the last-bit uncertainty in the A/D conversion process could cause a transition back to the previous step. This will produce a “glitch” or spike in the modulated output as the unwanted switching between big steps takes place. The small voltage from the big step sync circuit forces the input higher, just enough to ensure the A/D converter will not switch back to the previous step.

High-speed Schottky diodes (CR16, CR18) protect the A/D’s (U1) input against overvoltages. Schottky diodes also have low turn-on voltages, 0.5 Volts or less. CR16 prevents the voltage level input from going negative. CR19 prevents the voltage level from going higher than about +5 Volts since CR10 is a 4.7 Volt zener diode.

K.3.4.2 Analog to Digital Converter (U1, DL1)

A 12-bit analog to digital converter AD1671 is used. Conversion time of the AD1671 is less than 800 nanoseconds. The analog input voltage range is 0 to +5 Volts. An input of 0 Volts gives a digital output of “0000 0000 0000". An input of +5 Volts gives an output of ”1111 1111 1111".

The analog signal that is going to be converted to digital goes into the A/D chip at pin 23. The ENCODE pulse goes into the A/D chip at pin 17 and tells the A/D to do a conversion.

The 12 A/D output data lines are at pins 2 through 13. Pin 2 is the least significant binary bit (LSB) and pin 13 is the most significant binary bit (MSB). Pin 16 is the DAV pin (data available pin). DAV is a negative pulse that indicates when a conversion is complete and data is valid on the 12 output lines.

The DAV pulse goes into a 450 nanosecond delay chip, DL1. This delay is used to make this A/D board (843-5100-094 Rev A) compatible with the previous A/D board (843-4038-049 Rev P). The old version of the A/D board used a slower A/D chip that was taken out of production.

K.3.4.3 Digital Data Latches (U3, U4, DL3)

The negative pulse from DL1 also goes to a 60 nanosecond delay, DL3. The output from DL3 is the LATCH STROBE pulse. The rising edge of this pulse latches the digital audio information from the A/D converter into U3 and U4.

The digital audio data from latches U3 and U4 also goes to two digital to analog (D/A) converters. D/A U22 is part of the big step sync circuit and D/A U8 is part of the reconstructed audio circuit.

The negative pulse from DL1 goes to the input of U7 pin 1 and is the signal DATA STROBE-L on J6-26. The signals on the J6 connector go to the Modulation Encoder board. The rising edge of the DATA STROBE-L is used to transfer the bits from latches U3 and U4 into latches on the Modulation Encoder board.

K.3.5 Error Detecting Circuits

There are circuits on the A/D board that determines if the clock signal is being received and if the A/D converter is working properly. The error detection circuits use three re-triggerable monostable mulitvibrators, called one-shots. If an error is detected the logic signal CONVERSION ERROR-L will go low and clear the storage latches on the A/D board and the storage latches on the Modulation Encoder board.

K.3.6 One-Shot Operation (U13, U14)

One-shots produce an output pulse each time a rising or falling edge is detected on the input. Each one-shot has three inputs; A, B and CLEAR. Each has two outputs; Q and QN (not-Q). There is an RC network connected to each one-shot which determines the length of the pulse.

The following table logic low will be 0 and logic high will be 1. Up is the rising edge of a pulse and down is the falling edge. X denotes that either a 0 or 1 may be present.

A	B	CLEAR	Q
0	up	1	pulse (pos.)
down	1	1	pulse
0	1	up	pulse
1	X	X	0
X	0	X	0
X	X	0	0

One-Shot Operation Table

Re-triggerable means that if an input trigger condition occurs again during an output pulse, the R-C network will be reset and the pulse will be extend for the R-C time constant.

K.3.6.1 Power Up Reset (C41, R16, U12-F)

When the +5 Volt supply first comes on, the signal POWER UP RESET-L (TP2) will be low for about 5 milliseconds. This logic low clears the error detection one-shots (U13, U14). The signal CLEAR-L (TP17) will be low which will clear the A/D latches (U3, U4). The signal DATA CLEAR-L (J6-28) will also be low and will clear the latches on the Modulation Encoder board. Setting all latches to zero for 5 milliseconds will allow time for power supplies to reach full voltage before any PA modules are turned on and will also remove any data that might be entered in any latches by transients during power-up.

The +5 Volt supply initially comes on causing C41 to charge through R16 and the voltage at the inverter Schmitt trigger U12-F to increase from zero. When the voltage across C41 goes above the threshold of the inverter, the output will go high.

If the +5 Volt supply voltage fails, C41 will discharge through diode CR13. The signal POWER UP RESET-L will again be low.

K.3.6.2 Clock Error Detection Circuit (U14-A)

The clock frequency TP6 can be from 410 kHz to 820 kHz so the period is 1.2 to 2.5 microseconds. This is the input to pin 2 of one-shot U14-A. The output of the one-shot is labeled CLK ERROR-L. The one-shot output pulse is 3.6 microseconds long. As long as the clock pulses are present the one-shot continues to re-trigger and the output will remain 1. If the pulses stop or the frequency is too low the one-shot output will go low.

K.3.6.3 A/D Converter Monitor Circuit (U13-A)

The signal DAV at TP5 comes from the A/D converter after each conversion. The period of this signal is 1.2 to 2.5 to microseconds. This is the input to pin 2 of one-shot U13-A. The output of the one-shot is labeled A/D ERROR-L. The one-shot output pulse is 3.6 microseconds long. As long as the DAV signal is present, the one-shot will continue to re-trigger and the output will remain 1. If the pulses stop or the frequency is too low, the one-shot output will go low.

K.3.6.4 Conversion Error Indicator (U14-B, U11, DS1)

The signals CLK ERROR-L and A/D ERROR-L go into AND gate U15-A. The output of this gate is the signal CONVERSION ERROR-L at TP8. If the signal CONVERSION ERROR-L goes low, it triggers one-shot U14-B. The output of this one-shot will be a low pulse at pin 12 for 10 microseconds. This low propagates through U15-B and U15-C and causes the signal CLEAR-L to go low. This ensures that any error will cause the bits that are driving the PA modules to be cleared for at least 10 microseconds.

Operational amplifier U11B functions as a comparator with the inverting input level set at about +1.4 Volts by the R28-R29 voltage divider. If there is an error, then U15 pin 6 will have a lower voltage then pin 5. U11 pin 7 will be -15 Volts. This will cause bicolor LED DS1 to indicate RED. If there is no error, then U15 pin 6 will have a higher voltage than pin 5. U11 pin7 will be +15 Volts. This will cause bicolor LED DS1 to indicate green. The signal CONVERSION ERROR-H goes to the LED board A32 and is high if an error has occurred.

K.3.7 Big-Step Sync Circuit

The big step sync circuit produces a pulse each time a big step occurs in the transmitters output. In the DX 10 and the DX 25 a big step occurs whenever a change occurs in any of the six most significant bits from the A/D chip. In the DX 50 a big step occurs whenever a change occurs in any of the seven most significant bits from the A/D chip.

The big step sync pulse synchronizes the “dither” oscillator on the analog input board. Also the big step sync adds a small amount of voltage to the analog input signal that goes into the A/D chip. This small amount of voltage is to minimize undesired switching back and forth between the big steps.

K.3.7.1 Big Step Sync Circuit D/A Converter (U22)

A digital to analog converter is used to convert the bits of the digital audio signal back into an analog signal. Switch S2 determines the number of bits that go into the D/A. Section A of S2 is between pins 1 and 4. Section B of S2 is between pins 2 and 3. Section A and B are open for DX25 operation so the 6 MSB’s go to the D/A. Section A of S2 is closed in the DX50 operation so the 7 MSB’s go to the D/A.

The D/A converter output, at U22 pin 4, is a current level which goes into R35 and produces a 0 to -1 Volt signal.

K.3.7.2 Amplifier Stage (U24, U25, U26)

The output of the A/D converter is amplified by U24 and U25. The gain of the amplifier stage is slightly over 5. U24 is an operational amplifier and U25 is a current amplifier that’s used to increase the current output capability of the amplifier to drive the next stage without degrading the stepped waveform.

The low-pass filter R53-C93 removes any high frequency components. U26 is a buffer stage. The output of U26 is added, through R70, to the analog input signal. The output of U26 also drives a differentiator.

K.3.7.3 Differentiator and Buffer (U27)

R55 and C92 form a differentiator which produce a pulse each time a transition occurs. The pulses can be observed at the output of U27 pin 6 or at R63. The output signal from U27 is the big step sync pulses which go to the dither oscillator circuit on the Analog Input Board (A35).

K.3.8 Reconstructed Audio Circuit

An audio signal is reconstructed on the A/D board by sending the bits into D/A converters U8. Another audio signal comes from the envelope detector at the transmitter’s output. These two audio signals are compared at the envelope error circuit on LED Board A32. (Refer to Section Q, LED Board, for a discussion of the envelope error circuit).

K.3.8.1 Reconstructed Audio Circuit D/A converter (U8)

The 12-bit digital audio signal is converted back to an analog signal by D/A converter chip U8, operational amplifier U9 and current amplifier U10. The unfiltered D/A converter circuit’s output is at U10 pin 8 and is available for viewing at test point TP9. Voltage divider R31-R30 isolates the D/A converters output from any loading by test equipment. The unfiltered output at TP9 varies between 0 and 5 Volts when observed using a high-impedance probe .

K.3.8.2 Reconstruction Filter (L1, L2, L3, C47, C48, C49)

The D/A converters output is stepped. The reconstruction filter is a low-pass filter which passes the audio components and removes the higher frequency components in the steps. This smooths the output (a D/A reconstruction filter is also sometimes referred to as a “smoothing” filter). The response of this filter is approximately the same as the output network’s response, thus allowing the audio from the two filters to be compared in the envelope error circuit LED board A32. Operation amplifier U11 isolates the filter output from any load variations.

K.3.8.3 Grounds A, AA, B and Chassis

There are four grounds being used on this board. Ground A is used in the digital signal sections. Ground B is used in the analog signal sections. Ground AA is used in the reconstructed audio section. Chassis ground is used where the two RF samples sections. Ground A and ground B are connected through JP1 as instructed on the data sheet for the AD1671. Ground A and ground AA are connected through JP2. Chassis ground is connected to the transmitter chassis through mounting hole 2 by using JP3.

Care must be used when connecting test equipment to avoid ground loops or other ground connections through test equipment which can introduce noise and cause errors in measurement.

K.3.8.4 Voltage Regulators (U2, U16, U18, U19, U20, U21, Q1)

Four regulated voltages are provided by on-board regulators. U2 is a 7815 which converts 22 V to 15 V. U18 is a 7915 which converts -22 V to -15 V. U21 is a 7905 which converts -15 V to - 5 V which is used by A/D chip U1.

U16 is a LT1123 and Q1 is a MJE1123 transistor. These two parts combine to form a +5 V low dropout regulator. The input voltage to this regulator can get as low as +5.5 V and it will still maintain an output of +5 V. It can also supply 4 A of current.

U19 is a 78L05 which converts +22 V or + 8 V to +5 V. Two voltages drive this regulator in case one of them fails. This +5 V supply is used by U20, an LM339 quad comparator chip that monitors the regulated voltages. If the +15 V fails the signal +15 FAULT-L goes from +22 V to 0 V. If the -15V fails the signal -15 FAULT-L goes from -7 V to -20 V. If the +5 V fails the signal+5 FAULT-L goes from +5 V to 0 V.

K.4 Maintenance

K.4.1 Printed Circuit board Maintenance

Refer to section 5, Maintenance, in this technical manual for general printed circuit board maintenance procedures.

K.4.2 Adjustments

K.4.2.1 Sync Sample Phasing (S1)

Adjustment of sync sample phasing is described in the Tuning/Frequency Change procedure in section 5, Maintenance, in this technical manual.

K.4.2.2 Clock Pulse Width Adjustment (R78)

Adjustment of his control is described in the Tuning/Frequency Change procedure in Section 5, Maintenance, in this technical manual

K.4.2.3 Digital to Analog Converter Bit Selection (S2)

Switch S2 determines the number of bits that go into the D/A. Section A of S2 is between pins 1 and 4. Section B of S2 is between pins 2 and 3. Section A and B are open for DX25 operation so the 6 MSB's go to the D/A. Section A of S2 is closed in the DX50 operation so the 7 MSB's go to the D/A.

K.5 Troubleshooting

Refer to Schematic 839-7855-177, in the Drawing Package. Test Points and waveforms are provided at various signal points on the board.

NOTE

Analog signal amplitudes (including reconstructed analog signal amplitudes) given are for 50 kilowatt transmitter output with 100% modulation. At lower power levels and/or lower modulation levels, these analog signal amplitudes will be smaller.

K.5.1 Symptom: ColorStat™ panel CONVERSION ERROR Indicator is RED, transmitter operates normally.

If the transmitter operates normally, but there is a CONVERSION ERROR on the LED Board, the problem is in the indicator circuits. Check DS1 on the Analog to Digital Converter. If the ColorStat™ panel "Conversion Error" indicator is RED but A34DS1 is GREEN, measure the output of U12-4.

1. If you measure a logic LOW, the problem is in the indicator circuits on the LED Board. Refer to SECTION Q, LED Board, Troubleshooting.
2. If you measure a logic HIGH, replace U12.

NOTE

The "Conversion Error" indicator DS1 on the Analog to Digital Converter will indicate RED whenever there is no RF drive, for example, when the transmitter is "OFF." The ColorStat™ panel CONVERSION ERROR LED will still indicate GREEN because LED Board logic inhibits the conversion error fault indicator when the transmitter is turned OFF.

K.5.2 Symptom: ColorStat™ panel CONVERSION ERROR indicator is RED, transmitter can be turned ON. No RF out.

K.5.2.1 Check Logic Level at TP8.

a. If TP8 measures logic HIGH, measure U15-5. If it is logic LOW, U14 is faulty.
b. If TP8 measures logic LOW, the problem is the EOC-L, the CLK ERROR-L, or the POWER RESET-L signal. To isolate the cause to a circuit on the Analog to Digital Converter, check logic levels at U15-1 and U15-2, then refer to the appropriate paragraph. If pin 1 is LOW, an "EOC-L Fault" is present; if pin 2 is LOW, a "CLK ERROR-L Fault" is present; if both pins are LOW, a "POWER RESET-L Fault" is present.

K.5.2.2 CLK ERROR-L: No signal at TP6

If no TTL pulses are present at TP6, make certain that sample frequency input is present at J3-1. A loose connector is the most likely cause of no sample frequency input because no RF drive would also cause an Underdrive Fault on the ColorStat™ panel.

If the sample frequency input is present at J3-1, check the Schmitt Trigger input U12-5 and output U12-6. If there is no signal, check for shorted CR13 or CR14, or defective Schmitt trigger U12. If signal is present at U12-6 output but not at TP6, U29 or other sections of U12 are defective.

K.5.2.3 CLK ERROR-L: Signal present at TP6

Check the Frequency Determined Components chart for the proper position of P10, and calculate the frequency of the logic signal at TP6 for your operating frequency. The frequency of the logic signal at TP6 should be between 410 kHz and 820 kHz, depending on transmitter frequency. Check the factory test data sheet for the transmitter, or the Frequency Determined Components Chart, for the proper position of P10 (and therefore whether the divider divides by 1 or 2). If the frequency at TP6 is wrong, P10 is in the wrong position or U29 is faulty.

K.5.2.3.1 Troubleshooting the Frequency Divider

The Synchronous Binary Counter, U29, divides the input by four at pin 14. In this circuit, this output is fed back to the clock input to get the divide by 2 function.

To check operation of U29, turn the Power Amplifier stage “OFF” by placing the PA OFF switch S5 on the Controller in the OFF (UP) position.

Remove the jumper plug at P10, and use a dual-trace oscilloscope to observe input and outputs from U29. The output at U29-14 should be TTL level logic pulses at one-fourth the input frequency.

K.5.2.4 EOC-L FAULT

Use a dual trace oscilloscope to compare timing of signals at TP3 and TP5. If the EOC status output of U2 at TP5 is still HIGH when the next START CONVERT pulse at TP3 occurs the EOC-L signal at U13-4 will stay LOW. This would indicate a fault in A/D converter IC U2.

Component	Function/Description
DS1	illuminates when an A to D converter failure occurs. This indication is also available on the Status Indicator Panel and at the External Interface
F1	Protects the +22 V supply from +15 V regulator faults.
F2	Protects the +8 V supply from +5 V regulator faults
F3	Protects the -22 V supply from -15 V regulator faults
JP10	Selects division ratio for A/D sample (divide by 1, 2 or 3). Refer to schematic diagram or Frequency Determined Components chart.
JP11	Enables RF sample phase correction circuit when in position 1-2 and 3-4
R78	Adjust pulse width of ENCODE signal to the A/D converter
R7	Compensates for voltage offset errors in the A/D converter
S1	Frequency determined adjustment; adjusts RF sample phase to switch PA Modules on or off at the RF zero crossings
S2	Sections A and B are open in the DX 10
	Section A is closed in the DX 25.
	S2A and S2B are closed in the DX 50.

Table K-1. Analog to Digital Board A34 Controls and Indicators

K.5.2.5 POWER UP RESET-L FAULT

Measure the voltage at U12-13. There should be a +5 VDC signal present when the Low Voltage is ON. If there is no +5 VDC signal and the +5 VDC supply at TP15 measures correctly, capacitor C41 may be faulty. If there is a +5 VDC signal at U12-13, but TP1 is logic LOW, replace U12.

K.6 Technical Assistance

See Technical Assistance clause on back of title page.

K.7 Replaceable Parts Service

See Replaceable Parts Service clause on back of title page.

Component	Function/Description
TP1	Audio + DC, analog signal that is converted to digital in the A/D chip
TP2	POWER UP RESET-L, logic signal that’s active low
TP3	ENCODE, logic signal that tells the A/D chip to do a conversion
TP4	+15 V FAULT-L, 0 Volts when the +15 V is not working
TP5	DAV, logic signal that’s low when the A/D conversion is done
TP6	CLOCK, logic signal that is used to create the ENCODE pulse
TP7	LATCH STROBE, logic signal that stores data in latches U3 and U4
TP8	logic signal that’s low when A/D ERROR-L or CLK ERROR-L is low
TP9	Unfiltered reconstructed audio signa
TP10	AA Ground (reconstructed audio signal ground)
TP11	+ 5 V FAULT-L, 0 Volts when the + 5 V is not working
TP12	-15 V regulator output
TP13	+15 V regulator output
TP14	-15 V FAULT-L, -20 Volts when the -15 V is not working
TP15	+5 V regulator output
TP16	B Ground (analog ground)
TP17	CLEAR-L, logic signal that’s active low
TP18	B Ground (analog ground)
TP19	A Ground (digital ground)
TP20	A Ground (digital ground)
TP21	A Ground (digital ground)
TP22	-5V regulator output

Table K-2. Analog to Digital Board A34 Test Points

WARNING: Disconnect primary power prior to servicing.

L.1 Introduction

This section includes a description of the Modulation Encoder and troubleshooting information.

Refer to SECTION V, Maintenance, for maintenance and replacement procedures. There are no adjustments on the Modulation Encoder.

The 12-bit digital audio signal from the Analog to Digital Converter is fed to the board and “encoded” to provide the correct Turn-On/Turn-Off signals for the 64 PA Modules.

The DX-25U uses Modulation Encoder A37.

a. Modulation Encoder A37 controls “Big Steps” RF33 through RF90 and “Binary Steps” B7 through B12 (RF96 through RF91).

The Modulation Encoder includes cable interlock and blown fuse circuitry to monitor the PA Modules. The Driver Encoder/Temp Sense Board cable interlock circuit is also interfaced on A37 to monitor the Driver Module interlocks.

L.2 Principles Of Operation

L.2.1 Modulation Encoding: Explanation and Example

The digital audio signal consists of a stream of 12-bit digital “words”. The 12 bits are referred to as B1 through B12, where B1 is the MSB (Most Significant Bit) and B12 is the LSB (Least Significant Bit). The 12 bits are divided into two groups of binary information to be decoded: B1 through B6 control “Big Step” RF amplifiers RF33 through RF90; B7 through B12 control “Binary Step” RF amplifiers RF96 through RF91.

The following example decodes the binary word “010111/001011”.

L.2.1.1 “Big Steps”(RF33-RF90).
If the status of B1 through B6 is:

B1
0

The total number of “Big Step” RF amplifiers turned ON can be calculated by changing the binary number to its decimal equivalent. This example would indicate that 23 amplifiers are turned ON. Typically, 23 “Big Step” RF amplifiers are required for a carrier power of 25 kW.

L.2.1.2 “Binary Steps” B7-B12 (RF96-RF91).
The “Binary Steps” are controlled directly by the individual bit. If the bit is a logic “HIGH”, then the associated RF amplifier is turned ON. If the bit is a logic “LOW”, then the associated RF amp is turned OFF.

a. B7 = 1/2 Step
b. B8 = 1/4 Step
c. B9 = 1/8 Step
d. B10 = 1/16 Step
e. B11 = 1/32 Step
f. B12 = 1/64 Step

If the status of B7 through B12 is:

B7
0

In the 12-bit example, the status of the “Binary Step” amplifiers would be:

a. B7 = OFF
b. B8 = OFF
c. B9 = ON
d. B10 = OFF
e. B11 = ON
f. B12 = ON

L.2.1.3 Modulation Encoding: Read Only Memories
The Modulation Encoder uses eight 256x8 ROM (Read Only Memory) IC’s. Each ROM contains 256 eight-bit addressable memory locations that are permanently programmed at the factory with an eight-bit digital word at each memory location.

The eight MSB’s (Most Significant Bits: B1 through B8) of the encoded audio address any of the 256 memory locations in each ROM. Each memory location contains the information to control the number of “Big Step” RF amplifiers necessary to correctly represent the eight MSB’s of the encoded audio. When a memory location is addressed, the 8-bit digital word stored at that location appears at the outputs of the IC (pins 6-9 and 11-14). Each bit of the digital word provides a turn-on/turn-off signal for a “Big Step” PA Module.

L.3 Circuit Description

Refer to the Mod Encoder Schematic, 839-7855-174, in the Drawing Package.

B2B3B4B5B6
1 0 111

L.3.1 Supply Voltages

Three supply voltages from the DC Regulator are fed to both Mod Encoders:

a. B+ Supply (+5.75 VDC)
b. Modulated B- Supply
c. +22 VDC

To prevent overdissipation of the regulator pass transistors on the DC Regulator when the cooling fans are not operating, the B- and B+ supplies are disabled when the transmitter is OFF.

L.3.1.1 B+ Supply
The B+ Supply is filtered by C1 through C3 and provides +5.7 VDC to Inverter/Drivers U1 through U30, U39 and U40. Zener diode CR2 regulates the B+ to +5 VDC and is fused by F1. All remaining integrated circuits on the board operate from the +5 VDC Supply.

L.3.1.2 Modulated B- Supply

The Modulated B- Supply is brought into the board at J19-1 and is applied to the outputs of the driver IC's through pull-down resistors. RF amplifier turn-on/turn-off times depend on the load on the modules, that is, on the total number of modules turned ON at any moment. To compensate for changes in turn-on/turn-off times, the timing of the control circuits is varied with modulation. This "active bias" voltage is provided by the Modulated B- supply from the DC Regulator. Refer to SECTION M, DC Regulator, for a description of the B+ Supply and Modulated B- Supply.

L.3.1.3 +22 VDC supply

Unregulated +22 VDC is brought into the board at J19-9 for the Blown Fuse and Cable Interlock circuits. This supply is present on the Modulation Encoders whenever the Low Voltage is ON.

L.3.2 Digital Audio Data Circuits

The 12-bit digital word from the Analog to Digital Converter enters at J17-2 through J17-24 (odd numbered pins are ground). Resistive dividers R10 and R11 provide "pull-up" and "pull-down" functions and are only installed on Modulation Encoder A37. When a LOW-to-HIGH transition appears at the "Clock" input of data latches U49 and U50, the digital data on the inputs will be latched through to the outputs. The DATA STROBE-L (LOW) signal at J17-26 from the Analog to Digital Converter is inverted by U57. The latch outputs will then remain in that logic state until the next DATA STROBE-L signal latches the next digital audio word or a PA TURN OFF-L (LOW) signal appears at the latch "Clear" inputs. When the "Clear" input is LOW, all latch outputs go to a logic LOW which turns all PA Modules OFF.

L.3.2.1 "Binary Step" Digital Audio Circuits

Six bits (B7 through B12) are inputs to data latch U51. The outputs of U51 go through U60 and U61 and then to a jumper configuration comprised of P8-A,B,C, and D. The A37 Modulation Encoder uses position P8-D, which connects B7 through B12 to the Inverter/Driver inputs U1, U2, and U40.

L.3.2.2 "Big Step" Digital Audio Circuits

Eight bits (B1 through B8) address U41 through U48. Each ROM encodes the 8 bits by outputting the digital pattern stored in the addressed location to latches U31 through U38. The outputs of U32 through U38 go to Inverter/Drivers U3 through U30, which provide turn-on/turn-off signals for "Big Step" RF amplifiers on the Modulation Encoder. On Modulation Encoder A37, U31 only connects to Inverter/Drivers U39A and U40A to drive two "Big Step" RF amplifiers.

L.3.3 Inverter/Driver Circuits

The Inverter/Driver Circuits convert a TTL signal to proper voltages for RF amplifier ON/OFF control. Dual MOS clock drivers are used to provide turn-on/turn-off inputs to the RF amplifiers.

L.3.3.1 Simplified Diagram

Refer to the Simplified Inverter/Driver Output circuit diagram (Figure L-1). The output circuit of the DS0026 driver is taken from two internal transistors. The collector of the "pull-up" (current source) transistor is connected to the B+ supply (+5.75 VDC) and the emitter of the "pull-down" (current sink) transistor is connected to the V- terminal (Gnd). Only one transistor is turned on at a time, so that the output is pulled to B+ or Gnd. The driver output feeds a voltage divider, made up of a "pull-up" resistor in series with the output and a second "pull-down" resistor connected to the Modulated B- Supply. The resistor junction is the input to the PA Module turn-on/turn-off control circuit.

A logic HIGH signal to the input of the Inverter/Driver will cause the "pull-down" transistor to conduct. The PA Module control voltage is pulled down to the modulated B- supply, and the RF amplifier turns ON.

A logic LOW signal to the input of the Inverter/Driver will cause the "pull-up" transistor to conduct. The PA Module control voltage is pulled up the +5 VDC B+ supply, and the RF amplifier turns OFF.

L.3.3.2 Circuit Description

The Inverter/Driver circuit for each RF amplifier is identical. Therefore, only the circuit for RF33 will be described.

The output at U32-2 provides the turn-on/turn-off signal for "Big Step" amplifier RF33, through P1-1 (1,2). When the signal is logic HIGH at this point, RF33 will be turned ON. The latch output goes to Inverter/Driver U3-2 through isolating resistor R117 (1,2). Capacitor C117 bypasses high-frequency components around R117 to improve pulse rise and fall times at the input of U3. Pull-down resistor R132 (1,2) will hold U3-2 LOW if the jumper at P1-1 (1,2) is removed.

L.3.4 Cable Interlock Circuit

The cable interlock circuit will apply a "PAOFF-L" signal to clear the data latch outputs, illuminate a red "CABLE INTERLOCK" LED on the ColorStat™ panel, and illuminate the interlock LED on the Modulation Encoder when:

a. Any of the interconnecting cables between the Modulation Encoders and the Combiner/Motherboards are disconnected.
b. Any PA Modules are not installed.
c. Any Driver Modules are not installed.
d. The power cable from the DC Regulator to either Modulation Encoder is disconnected.

A Cable Interlock Fault will cause the Controller to turn the transmitter OFF and will not allow the transmitter to be turned ON until the fault is corrected.

L.3.4.1 Circuit Description

Refer to Mod Encoder Interconnect Diagram, Figure L-2, and Cable Interlock Circuit Diagram. Figure L-4, and the Mod Encoder schematic for the following text:

The Modulation Encoder has eight identical interlock circuits and each circuit monitors eight PA Modules. Each interlock circuit output is monitored by 10-segment LED display DS1 and fed to U67. The Driver Modules are interlocked by a circuit on the Driver Encoder/Temp Sense Board and fed to J18-8 on Modulation Encoder A37. The fault summary output from Mod Encoder A37 is fed to the LED Board at J18-10. If any circuit generates a fault, the ColorStat™ panel "Modulation Encoder CABLE INTERLOCK" LED will illuminate red. Refer to the interlock chart on sheet four of the Mod Encoder Schematic to identify the RF amplifier numbers monitored by each interlock LED.

NOTE

The LED supply voltages are muted by the DC Regulator when the transmitter is OFF. In order to activate the DS1 display when the transmitter is OFF, P1 on the DC Regulator must be placed in the TEST position. It is normal for the BLOWN FUSE LED and the PA OFF LED to be red under this condition. Return P1 to the NORMAL position after troubleshooting.

For example: If RF amplifier B8 (RF95) is not inserted into the motherboard, the continuous circuit between J1-9 (INTL-1A) and J1-19 (INTL-1B) will be open. This will make U62-4 more positive than U62-5 and U62-2 would go to logic LOW. Inverter U54-2 will go to logic HIGH and "INTRLK 1" LED on Mod Encoder A37 will turn red. At the same time, U67-1 will go to logic LOW and U67-8 will go to logic HIGH. This will force U53-6 LOW and U56-4 HIGH. This "CABLE INTRLK-L" signal is inverted by U56 and sent to the LED Board. The signal can be monitored at TP6.

L.3.5 PA Off Circuit

The PA Off Circuit generates a "PAOFF-L" logic LOW signal which clears all data latch outputs and illuminates the "PA OFF" section of DS1 on the Modulation Encoder. Under this condition, the PA Power Supply may be energized but there will be no RF output from the transmitter. This signal is generated when any of the following occur:

a. "CABLE INTRLK-L" fault.
b. "PWR-UP RESET-L".
c. "PA TURN OFF-H" from fault and overload circuits on the LED Board.
d. "PA TURN OFF-L" from the Output Monitor.
e. "PA TURN OFF-L" from the Analog to Digital Converter.

L.3.5.1 Circuit Description

Refer to sheets one and four of the Mod Encoder Schematic and Figure L-3.

PA Turn-Off Logic on the Modulation Encoders consists of "OR" gates, so that any of the input signals listed above will produce the logic LOW "PAOFF-L" signal to the "Clear" inputs of all data latches on the Modulation Encoders.

L.3.5.1.1 *CABLE INTRLK-L FAULT Input.*

When a "CABLE INTERLK-L" signal is present at U59-10, inverter U56-4 will go to logic HIGH and force U53-8 output to logic LOW. This forces U59-2 LOW to produce a "PAOFF-L" signal at TP4.

The "CABLE INTRLK-H" signal at TP6 triggers fault detection circuitry on the LED Board which generates an OFF command to the Controller and returns a "PA TURN OFF-H" command back to the Modulation Encoder at J18-5.

When the "PA TURN OFF-H" command from the LED Board is present at TP7, two sections of U56 act as a delayed buffer to force U53-8 LOW. This drives U59-4 LOW to produce the "PAOFF-L" signal on the A37 Modulation Encoder at J18-8. Inverter U56-4 goes to a logic HIGH which drives U53-8 to logic LOW. This forces U59-2 to logic LOW, and produces the "PAOff-L" signal. The "Cable Intrlk Fault" triggers fault detection circuitry on the LED Board. The LED Board will trigger the OFF command on the Controller, and return a "PA TURN OFF-H" command to the Modulation Encoders.

When "PA TURN OFF-H" is present at U56-11, two sections of U56 act as a buffer to force U53-8 LOW. This drives U59-4 LOW to produce the "PAOFF-L" signal on the Modulation Encoders.

L.3.5.1.2 *PWR UP RESET-H Input.*

The "PWR UP RESET-H" signal holds the PA Modules OFF for approximately 20 milliseconds during Low Voltage Supply power-up, to allow all supply voltages to reach normal operating values. When the +5 VDC supply from the DC Regulator in energized, inverting Schmitt Trigger U56-5 input is LOW and U56-6 is HIGH which forces U53-8 LOW. This keeps U59-2 LOW and holds the PA Modules OFF.

When the +5 VDC supply is present, capacitor C4 charges through R35. When the C4 voltage rises above the threshold of Schmitt Trigger U56-5, U56-6 goes LOW. If no other PA OFF signals are present, the "PAOFF-L" signal is removed and the PA Modules turn ON.

L.3.5.1.3 *PA TURN OFF-L Input from Analog to Digital Converter*

If a Conversion Error Fault occurs on the A/D Converter, a "PA TURN OFF-L" logic LOW signal is applied to J17-28. The signal is inverted at U59-6 and becomes the "PAOFF-L" signal.

L.3.5.1.4 *PA TURN OFF-L Input from Output Monitor*

If a VSWR fault is detected on the Output Monitor, a short pulse is generated and applied as a "PA TURN OFF-L" input at J18-1. The signal is inverted by U59-4 and becomes the "PAOFF-L" signal.

L.3.6 Blown Fuse Circuits

The blown fuse circuits will cause the "RF AMP" LED on the ColorStat™ panel to illuminate red when any of the 64 PA Modules has a blown fuse. This will alert the operator of a fault condition on one or more of the PA Modules. A visual inspection must be made to determine which amplifier is at fault. The transmitter will NOT turn OFF because of a red "RF AMP" LED.

L.3.6.1 Circuit Description

Refer to Mod Encoders Interconnect Diagram, Figure L-2, and Blown Fuse Circuit Diagram, Figure L-4.

The Modulation Encoder has eight identical blown fuse circuits and monitors 64 PA Modules by using the same connections as the Cable Interlock circuitry.

A blown fuse on an RF amplifier is typically caused by a shorted output device. A shorted MOSFET will apply a ground at the junction of CR11 and DS1 or CR12 and DS2. An open fuse will allow current to flow through the 56K resistor from the +230 VDC PA Power Supply to illuminate the red LED. Current also flows from the +22 VDC supply on the Modulation Encoder through the 33K resistor and the 30K resistor and diode CR11 or CR12 on the RF amplifier.

The voltage level at U62-7 will drop below the voltage at U62-6 and force U62-1 to logic LOW. This will force U66-8 to a logic HIGH and illuminate the red Blown Fuse segment of DS1 on the Modulation Encoder and the red “RF AMP” led on the Color-Stat™ panel.

Under normal conditions, the +230 VDC PA Power Supply provides current flow through the fuse and not through the 56K resistors and LED’s on the RF amplifier. Diodes CR11 and CR12 are reverse biased and no current will flow from the +22 VDC supply through the 30K resistor on the RF amplifier. Instead, current flows through the resistors on the Modulation Encoder. Under this condition, the voltage at U62-7 is greater than the voltage at U62-6 which causes U62-1 to be logic HIGH.

When the transmitter is OFF and the Low Voltage Supply is ON, the PA Power Supply is not energized and there is no +230 VDC supply to F1 and F2 on the PA Modules. This applies a virtual ground to F1 & F2 and provides a current path for the +22 VDC supply. Therefore, the circuit would indicate a “Blown Fuse” fault. However, the Blown Fuse segment on DS1 will not illuminate since the +5 VDC supply to the Modulation Encoder is muted by the DC Regulator until the transmitter is turned ON.

NOTE

The LED supply voltages are muted by the DC Regulator when the transmitter is OFF. In order to activate the DS1 display when the transmitter is OFF, P1 on the DC Regulator must be placed in the TEST position. It is normal for the BLOWN FUSE LED and the PA OFF LED to be red under this condition. Return P1 to the NORMAL position after troubleshooting.

L.3.7 Clip Circuit

L.3.7.1 Function

The Clip Circuit keeps the “Binary Steps” from switching OFF if the audio input level exceeds the maximum positive peak modulation capabilities of the transmitter.

L.3.7.2 Circuit Description

As the analog input signal to the A/D Converter increases, the “Binary Steps” begin turning on in a binary sequence to increase the RF output in small increments. When all “Binary Steps” are ON and the audio level is still increasing, the next “Big Step” turns ON and all “Binary Steps” turn OFF. This sequence continues as long as the audio input level continues to increase. If all “Big Steps” are ON and all “Binary Steps” are ON, a further increase in the audio input would cause the A/D converter to provide a turn-on signal for a “Big Step” that does not exist. This would turn OFF all “Binary Steps” and the RF output would drop by almost one “Big Step” (actually by 63/64 of a “Big Step”). The “Binary Steps” would then turn ON again. This would result in a “Sawtooth” peak instead of a “Flat Topped” peak.

Eliminating the “Sawtooth” and providing a “Flat Topped” positive peak is accomplished by simply holding all “Binary Steps” ON if excessive audio input causes the A/D converter to attempt to turn ON a “Big Step” that does not exist.

A “CLIP” patch cable is used to jumper P15 to the first unused “Big Step” latch output. If the A/D converter attempts to turn this unavailable step ON, the line will go HIGH and drive inverter U57-9. The inverted signal at U57-8 is buffered by U59, to become the “CLIP-L” signal at TP5. This signal is inverted at U56-8 and fed to one input of U60 and U61 in the “Binary Step” data lines. This logic HIGH input holds all “Binary Steps” ON, as long as the CLIP signal is present.

NOTE

Clip patch (P15) should be moved to the first unused output if the module is used for FlexPatch™ operation.

L.4 FlexPatch™

P1 through P8 are 16-pin sockets with U-shaped jumper plugs. If a PA Module fails, a high step module (starting at RF90 and working down) can be substituted for the failed module without turning the transmitter off by using the FlexPatch™ function. Refer to FlexPatch™ operation in SECTION VI, Troubleshooting, for additional information.

L.4.1 Example

Assume that the step six (RF38) PA Module has failed. Because 23 PA Modules are turned ON for 25 kW carrier, the output power will decrease. Step six will be ON except when negative modulation peaks exceed -70%, and the failed step will also increase distortion slightly. PA Module RF90 is only used for extremely high positive modulation peaks at 30 kW carrier, and can be substituted for step six with (in the worst case) only a slight reduction in positive peak capability. This module substitution can be done on the Modulation Encoder without turning the transmitter OFF, or physically exchanging modules, as follows:

- Remove the U-shaped jumpers for RF38 and RF90 at P5-6 (11,12) and P8C-2 (3,4). With the jumpers removed the modules remain OFF.
- Connect a jumper from the control signal (latch output) for RF38 at P5-6 (11) to the turn-on/turn-off inverter input for RF90 at P8C-2 (4). In this configuration whenever RF38 is required to be ON, RF90 will turn ON and substitute for the faulty RF38.
- The DX-25U can now be operated at normal performance, until the next regular maintenance period. Up to three PA Modules may be substituted in this manner.

NOTE

FlexPatch™ can be used for “Big Step” RF amplifier substitutions ONLY! If a “Binary Step” fails it is necessary to turn the transmitter OFF and replace the RF amplifier. The failure of a “Binary Step” amplifier will result only in a slight power reduction and minimal increase in distortion.

L.4.2 Single RF Amp Momentary Test

Sheet 3 of the Mod Encoder Schematic diagram shows this circuit. The circuit consists of switch (S2), which connects pins P9-1 and 2 to +5 Volts through R28, to provide a logic HIGH signal.

This circuit is useful for troubleshooting. When any U-shaped jumper is removed for a “Big Step”, and a patch cable is then connected between the Inverter/Driver input and P9-1 or 2, the "Momentary Test" button can be depressed to turn that module ON.

L.5 Troubleshooting

NOTE

Place P1 on the DC Regulator in the TEST position to enable the B+ and B- supplies for the Modulation Encoder when the PA Power Supply is not energized. Return P1 to NORMAL position after troubleshooting.

L.5.1 Symptom: Suspected Faulty Modulation Encoding

L.5.1.1 Troubleshooting Suggestions

Faulty latches and other digital IC's can be identified using a voltmeter to check inputs and outputs. Typically, PA Modules RF33 through RF55 are turned ON for 25 kW carrier. This can be verified by the green LED indicators on the modules. For 100% positive peak modulation with a continuous sine wave, PA Modules RF33 through RF79 should be turned ON.

L.5.2 Symptom: Red "PA Off" Indicator Illuminated

L.5.2.1 Troubleshooting Suggestions

Check the ColorStat™ panel for other indications. Most causes for a "PA OFF" indication will also cause a RED Fault indication on the ColorStat™ panel. If there are no other indications, you can check the logic inputs to PA Turn-Off gates to isolate the source of the incorrect logic signal, then trace back to its cause (which may be on another board). (Refer to the simplified diagram of PA Turn-Off logic, Figure L-3, and to the Schematic Diagram for PA Turn-Off logic).

Most causes of "PA Off" indications on the Modulation Encoder will be traced back to "PA Off" signals from other printed circuit boards. Failure of logic gates, inverters, or drivers can also cause a "PA Off" indication, and a logic probe or a voltmeter can be used to check inputs and outputs of gates, inverters, or drivers for HIGH and LOW logic level signals.

Additional causes for a "PA OFF" indication include the External PA OFF input from an interlocked component or from the PA OFF switch S5 on the Controller.

L.5.3 Symptom: Cable Interlock Indication

NOTE

A Cable Interlock condition will prevent an ON command from being generated. Because the regulated voltages to the Modulation Encoders are muted on the DC Regulator until an ON command is generated, the DS1 Cable Interlock LED indicators will not be active. To activate the regulated voltages to the Modulation Encoders, place P1 on the DC Regulator in the TEST position. Return P1 to the NORMAL position after troubleshooting.

L.5.3.1 Possible Cause: PA Module Removed or Not Properly Inserted in Socket

Check PA Modules to make certain that all are installed and fully inserted in their sockets.

L.5.3.2 Possible Cause: Defective component on PA Module

Once the Cable Interlock fault is isolated to a group of eight modules by using the chart on Sheet 4 of the Modulation Encoder Schematic, 839-7855-174, swap each module out one at a time to identify the defective module.

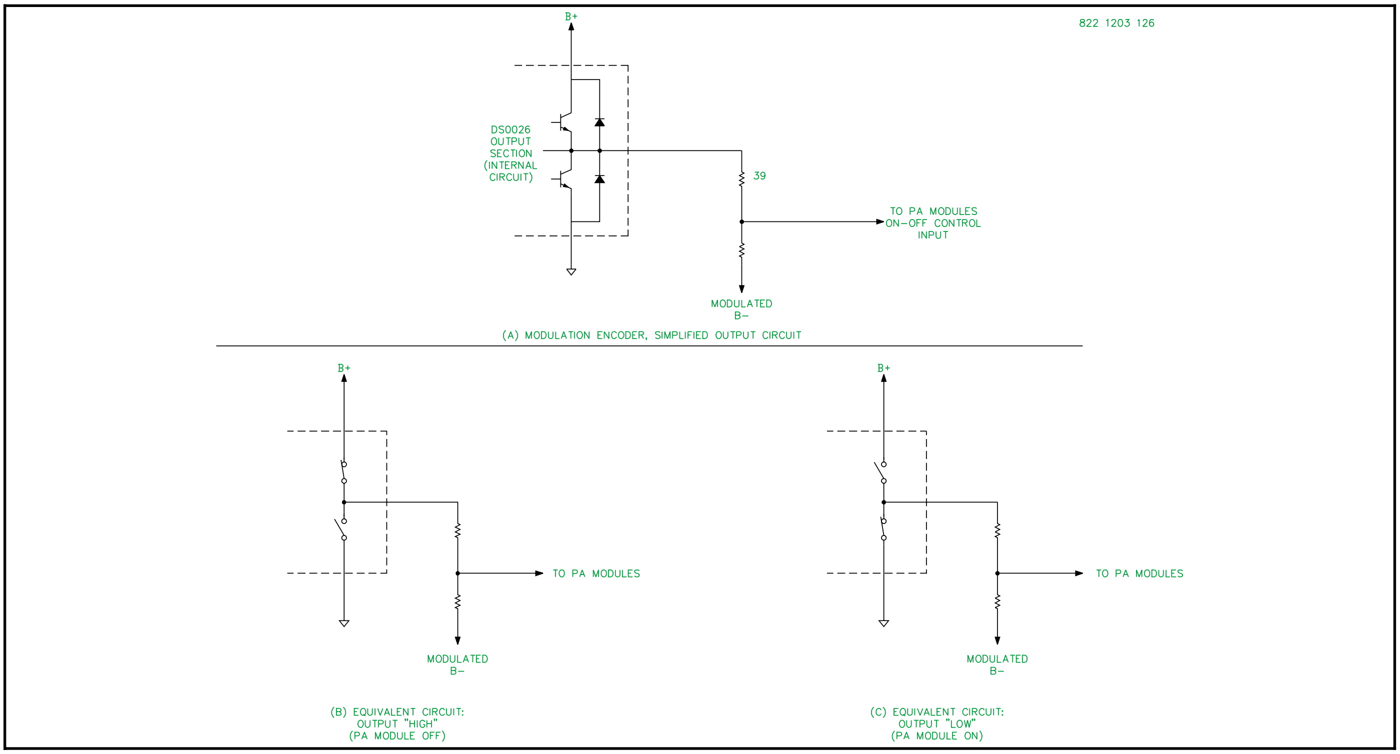

Figure L-1. Modulation Encoder, Simplified Output Circuit

WARNING: Disconnect primary power prior to servicing.

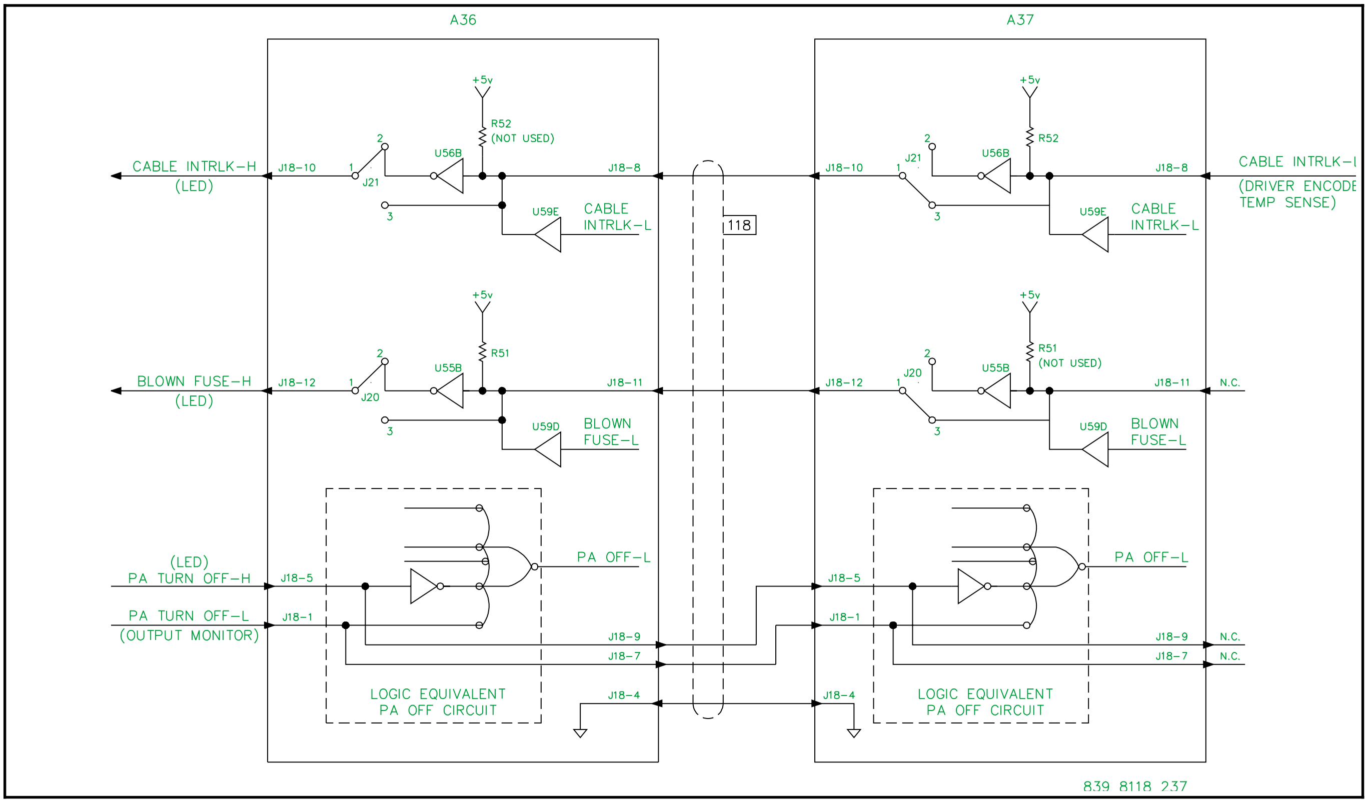

Figure L-2. Mod Encoders Interconnect Diagram

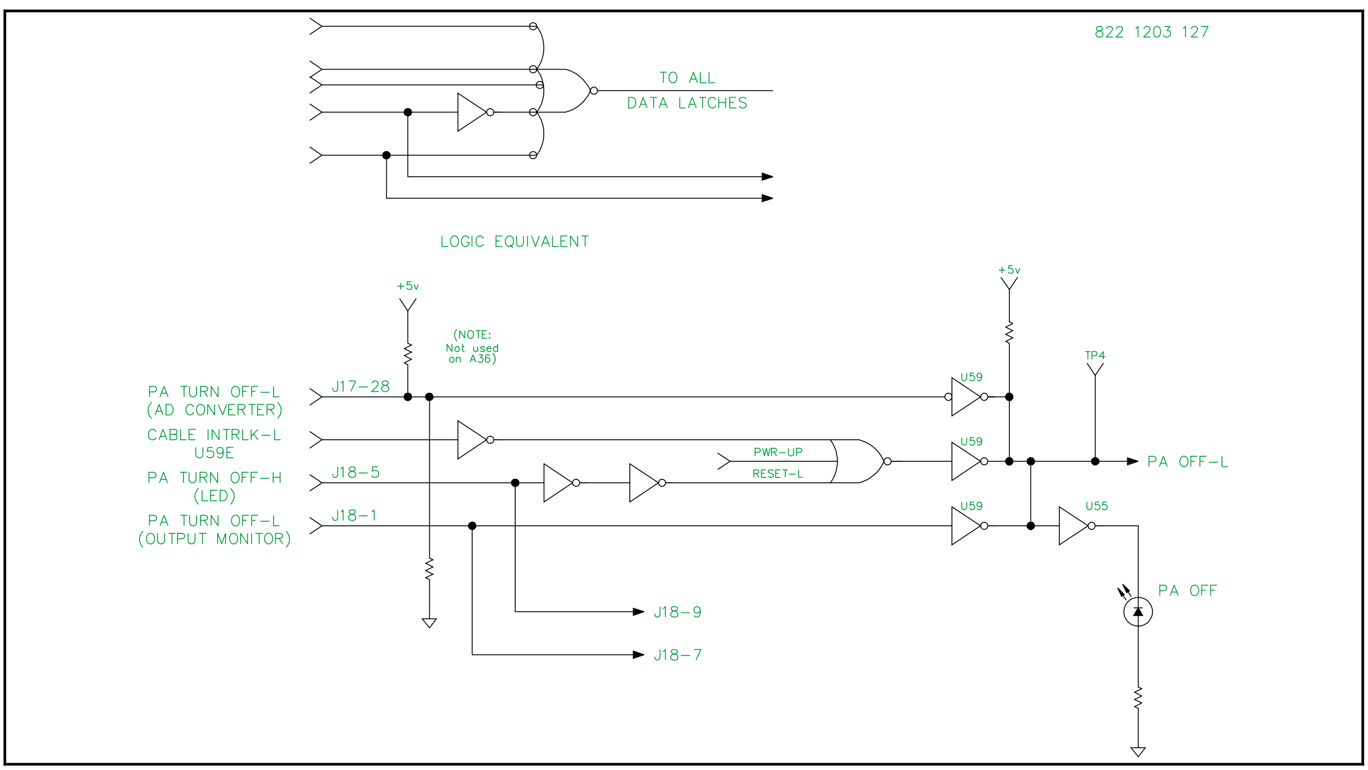

Figure L-3.

WARNING: Disconnect primary power prior to servicing.

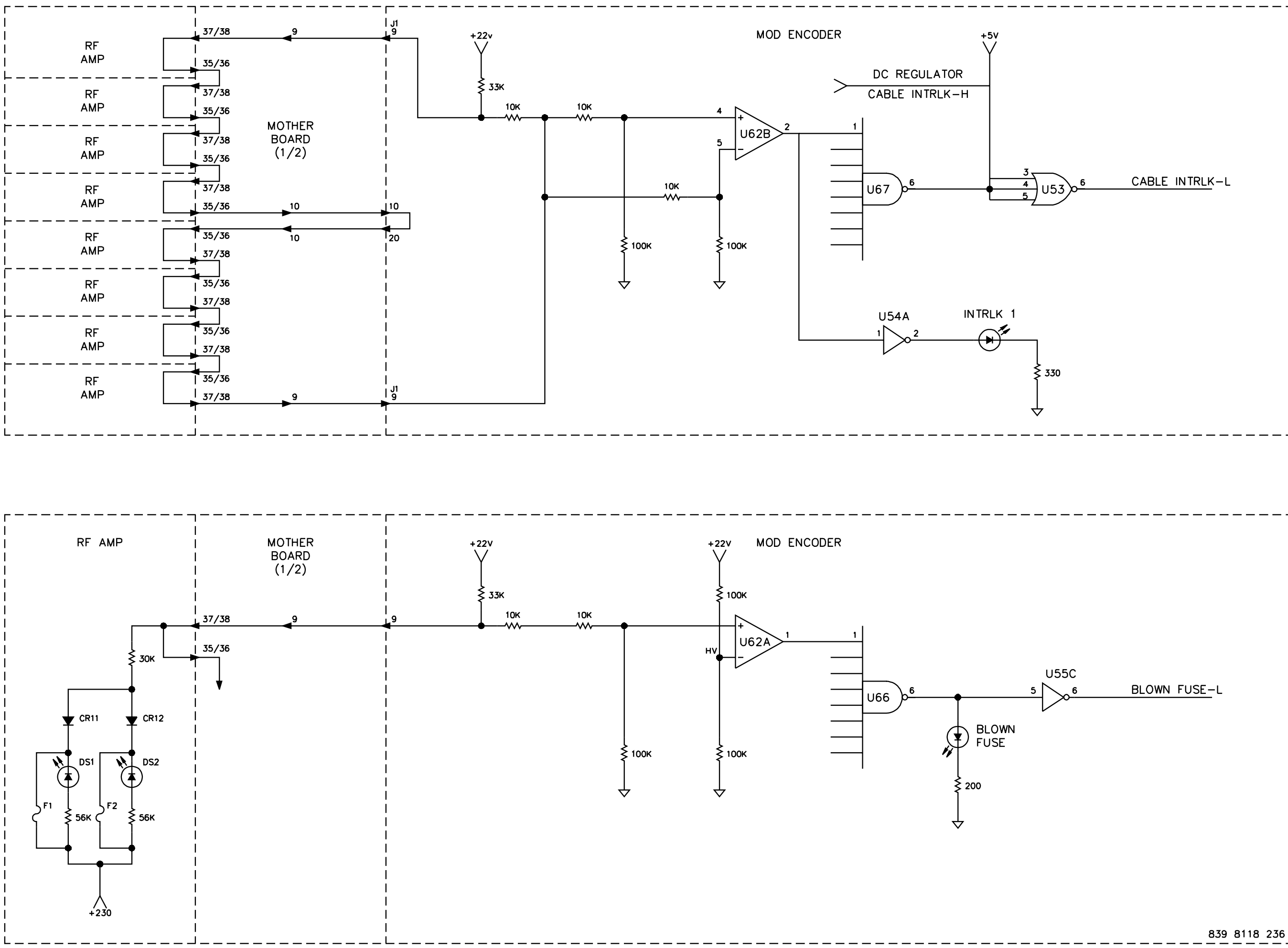

Figure L-4. Cable Interlock & RF Amp Fault Indicator

WARNING: Disconnect primary power prior to servicing.

L.5.3.3 Possible Cause: Cable From Modulation Encoder to a Combiner/Motherboard is not connected, or connector plug loose in socket

Check cable connectors to determine that all are plugged in and properly seated in the printed circuit board sockets.

L.5.3.4 Possible Cause: Printed circuit board fault or connector damage

These are unlikely, but careful visual inspection could show a printed circuit board fault (short, damaged pc board trace, poor solder joint) or a damaged connector.

Because there are eight identical Interlock Circuits on each Modulation Encoder, it is possible to compare voltage readings between circuits to isolate a defective component.

Table L-1. Modulation Encoder, Controls & Indicators

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
C1	DS1	When illuminated, indicates a Cable Interlock Error, (1 thru 8), PA OFF, Blown Fuse.
C1	Fuse F1	+5 volt supply fuse.
B1-B8	P1 thru P8	Used for FlexPatch™ and troubleshooting.
C6	P9	Used for troubleshooting to patch Single RF Amp Momentary Test signal (from switch S2) to RF amplifier on/off control inputs.
C8	P10 thru P12	Used with P15 during normal operation.
B8	P15	“CLIP” patch; connect a patch cable from P15 to the first unused modulator line to activate the “Clip” circuit. Normal operation jumpered to either P10, P11, or P12 depending upon which transmitter board is in.
C6	S2	Used with P9, to momentarily turn on an RF amplifier during troubleshooting or maintenance.

Table L-2. Modulation Encoder, Test Points

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
A1	TP1	Test Point for Modulated B- voltage.
C1	TP2	Test Point for +5 Volt regulator output.
C2	TP3	Test point for DATA STROBE logic signal (logic HIGH pulses)
D1	TP4	Test point for PA TURN-OFF Signal (LOW when Data Clear signal is present).
D3	TP5	Test point for CLIP-L signal.
D2	TP6	Test point for “Cable Interlock-H” logic signal (logic HIGH if a cable interlock fault exists).
C2	TP7	Test point for “PA Turn Off -H” signal from LED board (logic HIGH if fault and overload circuit is generating a PA turn-off signal).
C2	TP8	Test point for “PA Turn Off -L” signal from Output Monitor (logic LOW when VSWR is above the VSWR detection threshold.
C6	TP9	Test point for +22 Volts
B7	TP10	Ground
B5	TP11	Ground
B3	TP12	Ground
B1	TP13	Ground
D5	TP14	Ground
B1	TP15	Test point for B+ voltage

WARNING: Disconnect primary power prior to servicing.

SECTION M
DC REGULATOR (A30)

M.1 Introduction

This section describes the DC Regulator, and includes troubleshooting information. The UC3834 integrated circuit voltage regulators used on the DC Regulator are also used on other boards in the transmitter; this section describes all positive and negative voltage regulator circuits using this integrated circuit.

The DC Regulator supplies B+ (+5.75 VDC regulated) and Modulated B- voltage for Modulation Encoder/Binary A37. Unregulated +22 VDC for cable interlock sensing on the Modulation Encoder also passes through the DC Regulator. Fault sensing and metering circuits for these supplies are located on the DC Regulator. The DC Regulator is located in the Left Control Compartment.

M.2 Principles Of Operation

Refer to Schematic 839-7855-163 in the Drawing Package.

M.2.1 Circuit Grounds on the DC Regulator

Grounds for the B+ (+5.75 VDC) and Modulated B- supplies are kept separate on the board. On the DC Regulator Schematic Diagram, the grounds are referenced as “A” and “B”, along with a power supply ground. The grounds are brought separately to the cabinet ground at the low voltage power supply to minimize ground loops and AC and RF noise.

M.2.2 UC3834 Integrated Circuit Linear Regulator

On the DC Regulator, four UC3834 regulators are used, one in each of the B+ (+5.75 VDC) supplies and the other two in the “Modulated B-” supplies.

M.2.2.1 Other Supplies Using the UC3834

This IC is also used in on-board regulated supplies on other printed circuit boards in the transmitter. Additional regulated supplies using this IC are:

a. Analog to Digital Converter (A34)
   1. -15 Volt supply
   2. +15 Volt supply
   3. +5 Volt supply

b. Analog Input Board (A35)
   1. -15 Volt supply
   2. +15 Volt supply

c. Output Monitor (A27)
   1. -5 Volt supply
   2. +5 Volt supply

d. Controller (A38)/LED Board (A32)
   1. +5 Volt supply
   2. +15 Volt supply
   3. -15 Volt supply

M.2.2.2 Linear Regulator IC Description

The UC3834 integrated circuit voltage regulator can be used for either positive or negative regulated supplies. Figure M-1 is a block diagram. An external pass transistor is used to increase current capability. The integrated circuit has internal reference voltages, internal fault monitoring, and a “Fault Alert” open-collector output for external logic and indicator circuits. An external compensation network at pin 14 is required to ensure regulator stability. The current sensing feature is not used in any supply in the transmitter, and the Current Sense input terminals (IC pins 6 and 7) are simply shorted together.

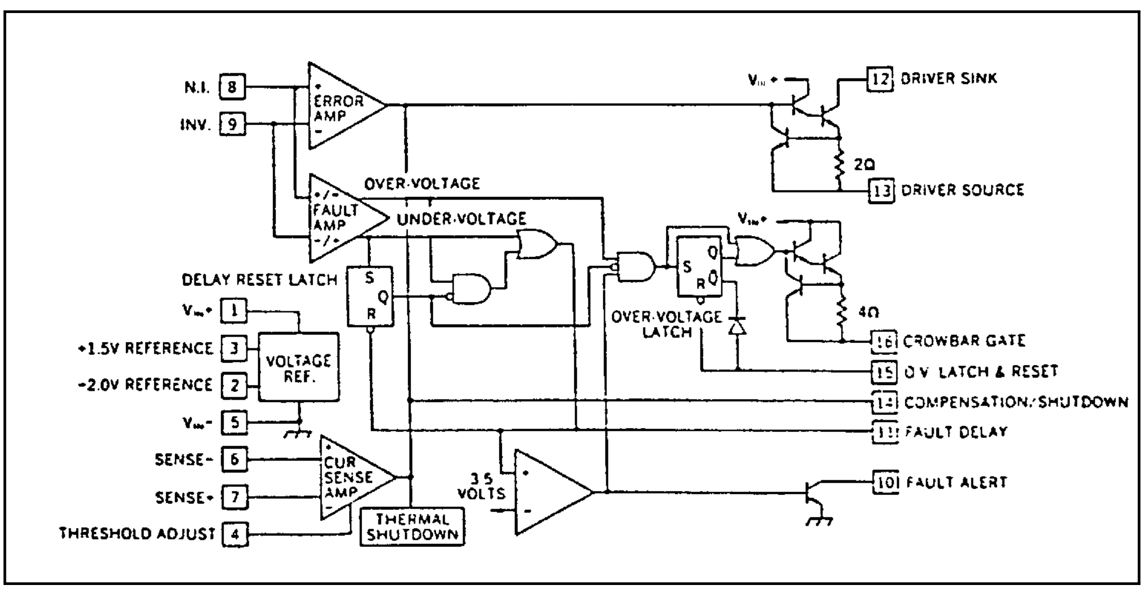

Figure M-1. Block Diagram, UC3834 Linear Regulator

M.2.2.3 Regulator Circuit Operation

The basic regulator is conventional, and consists of the internal voltage reference which is compared with a sample of the supply output voltage by the error amplifier. Figure M-2 (a) shows a basic positive regulator, and Figure M-2 (b) shows a basic negative regulator. The error amplifier output is the input to a driver amplifier in the IC, with internal over-current protection for the driver amplifier. The

IC's internal driver amplifier provides base current for the external series pass transistor, at the "Driver Sink" for positive supplies, or at the "Driver Source" for negative supplies. If the supply output voltage increases, the regulator IC decreases base current to the external series pass transistor, reducing the output voltage; if the supply output voltage decreases, the regulator IC increases base current to the external series pass transistor, increasing the output voltage.

M.2.2.4 Regulator IC: Fault Logic

Refer to Figure M-1, Block Diagram, UC3834 Linear Regulator. The fault monitoring circuit senses both under-voltage and over-voltage conditions. Internal fault logic activates the Fault Alert and pulls pin 10 to the regulator IC's internal ground at pin 5, which is the "V(in)-" terminal. When there is no fault, the "Fault Alert" output is an open collector. If an out of tolerance condition exists, pin 10 is an active "LOW".

A "fault delay" capacitor from pin 11 to ground provides a delay to prevent a "Fault Alert" when transient over-voltage or under-voltage conditions occur.

The internal fault logic circuit is supplemented by external fault circuitry on the DC Regulator. No Fault Alert outputs from the IC are used on the DC Regulator.

A thermal shutdown circuit pulls the Error Amplifier output LOW, turning off the IC's internal drive transistor and external pass transistor, when junction temperatures become excessive.

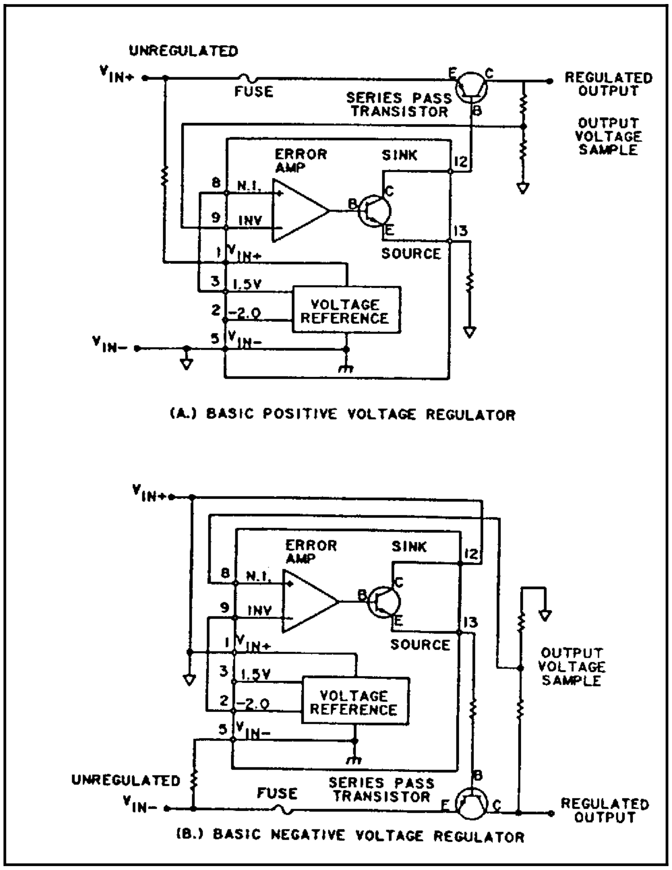

Figure M-2. Basic Positive and Negative Voltage Regulator Circuits

This protects the IC from over-dissipation. The under-voltage will then cause a "Fault Alert" to be generated.

M.2.3 B+ (+5.75 VDC) Regulated Supplies (DC Regulator)

There are two identical "A" and "B" supplies on the DX-25U DC Regulator — one for each Modulation Encoder. Only the "A" supply will be described here.

The B+ "A" supply uses regulator IC U3, and series pass transistor Q1. The unregulated input at TP3 is +8 VDC, fused by F2, from the Low Voltage power supply. Capacitors C17 and C20 bypass transients and high frequency noise on the unregulated input. The output voltage can be measured at TP4.

M.2.3.1 Basic Regulator Circuit (U3, Q1)

The output voltage is determined by the reference voltage at pin 8 (Vref) and the voltage sample divider R16 and R19. The regulator controls the output voltage so that the reference voltage at pin 8 is equal to the voltage sample at pin 9. The output voltage, then, is Vout = Vref/[R19/(R16 + R19)]. The reference voltage for the positive voltage regulators is the internal +1.5 Volts from pin 3.

The base of series pass transistor Q1 is driven by the "sink" output of the IC, at pin 12. The "Source" at pin 13 goes to ground through emitter resistor R14.

M.2.3.2 Error Amp Reference Circuit

The B+ supply includes a turn-on circuit, consisting of R20 and CR6. Diodes CR4 and CR5 provide a reference voltage of approximately +1.2 Volts. Before the internal reference voltage has come on during turn-on, Schottky diode CR6 is forward biased, providing a voltage of slightly less than 1 Volt at pin 8, the error amplifier non-inverting input. When the internal reference voltage increases, diode CR1 will be reverse biased and the error amplifier reference voltage will be the +1.5 Volts from the regulator IC's internal reference.

M.2.3.3 Other Regulator Circuit Components

Additional components include:

a. Supply voltage for the IC's internal circuits: Resistor R17 to pin 1 supplies voltage for the regulator's internal circuits, and current sense inputs at pins 6 and 7 are tied to pin 1. This supply voltage is not fused.
b. Feedback Loop Compensation: Capacitor C10 and resistor R12, from pins 14 and 15 to ground, forms feedback loop compensation.
c. Output protection: Protection at the output includes zener diode CR7 and bypass capacitors C14 and C16.
d. Reverse voltage protection: Diode CR3 across series pass transistor Q1 provides protection if a reverse voltage is accidentally applied at the unregulated input.

M.2.3.4 Other Positive Regulated Supplies in the Transmitter

Operation of all regulated supplies using the UC3834 linear regulator IC is similar to operation of the B+ supply on the DC Regulator. Voltage sample divider resistances, compensation components, and IC driver emitter resistances will be different in different supplies. Also, the +15 VDC supplies do not have the "Start Up" circuit used in the +5 VDC supplies.

M.2.4 Modulated B- Supplies

The Modulated B- supplies provide a negative voltage to the Modulation Encoder, which varies with the transmitter audio input and power level. The effect of the modulated B-voltage is to control PA Module turn-on/turn-off times. Turn-on/turn-off times depend on loading on each module, which in turn depends on the total number of modules which are operating.

At low power levels (including negative modulation peaks), only a few "Big Steps" are ON, and each PA Module is lightly loaded. As additional "Big Steps" turn ON, the loading changes considerably and the required turn-on/turn-off times also change. At higher power levels (more modules turned ON), the loading on each module does not change nearly as rapidly when additional modules turn ON or OFF.

To compensate, the B- voltage must be more negative on positive peaks, but must change more slowly as the transmitter's instantaneous output becomes greater (and more modules are turned ON). Therefore, the B- voltage must vary in a non-linear manner as the -(Audio + DC) sample changes. A non-linearity circuit between the -(Audio + DC) input and the regulator IC reference voltage input purposely distorts the audio input.

M.2.4.1 Approximate Modulated B- Supply Output Voltages

At an operating power of 25 kilowatts and with 100% modulation, the instantaneous Modulated B- voltage should vary between roughly -1 and -3 Volts. With no power out, the DC level should be approximately -1.25 VDC. At negative 100% modulation peaks, the instantaneous voltage should be approximately -1.35 Volts, and at positive 100% peaks, the instantaneous voltage should be approximately -2.85 Volts. This voltage range will be less at lower operating powers.

There are three adjustments for the Modulated B- supplies: one on the Analog Input Board (A35) and two on the DC Regulator. These adjustments are described in SECTION V, Maintenance.

M.2.5 Modulated B- Supplies: Circuit Description

There are two identical Modulated B- supply circuits on the DX-25U DC Regulator, only the "A" supply associated with Modulation Encoder (A37) will be described here. The modulated B- supply uses regulator U6, and series pass transistor Q2.

M.2.5.1 -(Audio + DC) Input

The "reference voltage" for the Modulated B- supply is a negative (inverted) sample of the analog audio signal and DC power control signal from the output of the Analog Input Board (A35).

The pre-distortion circuit consists of diode CR16, Diode CR17, and resistors R65, R56, and R53. Zener diode CR20 and resistor R46 provide a regulated -1.22 Volt reference for this circuit. Schottky diode CR15 provides protection, preventing accidental positive reference voltages.

M.2.5.2 Modulated B- Supply Regulator Circuit

The output voltage from the regulator circuit depends on the reference voltage and the setting of adjustable resistor R51 in the output voltage sample divider. The error amplifier in U6 compares the pre-distorted reference voltage, at pin 9, and a sample of the supply output voltage at pin 8. The regulator IC controls the base current into series pass transistor Q2 to adjust the output voltage, so that the differential voltage between pin 9 and pin 8 is essentially zero.

The unregulated input is -8 VDC, fused by F3, from the Low Voltage power supply. Capacitors C23 and C22 provide high and low frequency bypassing. The unregulated input voltage can be measured at TP5. The negative output voltage, measured at TP6, depends on transmitter power and instantaneous modulation level. Supply voltages for the internal circuitry in the regulator IC are +8 volts, through R40 to pin 1 (V+) and -8 Volts, through R47 to pin 5 (V-).

The compensation network is R43 and C30, from pins U6-14/15 to V-. The "Fault Delay" is determined by capacitor C33, from pin 11 to the unregulated input. Diode CR10, across series pass transistor Q2, protects the regulator circuit if reverse voltage is accidentally applied at the unregulated input. Zener diode CR14 provides transient protection and clamping should the regulator fail. Capacitors C27 and C34 are bypass capacitors for transients.

M.2.6 Other Negative Regulated Supplies in the Transmitter

Operation of all negative regulated supplies using the UC3834 linear regulator IC is similar to operation of the modulated B- supply on the DC Regulator except the reference voltage is not modulated. Other negative supplies return pin 1, "V+ IN" to ground. The -5 VDC supplies include a start-up circuit like the one used for the +5 VDC supply; -15 VDC supplies do not have the start-up circuit. Voltage sample divider resistances, compensation components, and IC driver emitter resistances will be different in different supplies.

M.2.7 Regulator Output Inhibit Circuit (U2)

CMOS analog multiplexer U2 and associated circuitry will shut down the B+ and B-regulators until the +230 VDC supply is energized. This prevents over dissipation of the regulator pass transistors until air flow is available. Integrated circuit U2 is used to multiplex 2 different control requirements from one command.

The B+ (+5.75 VDC) regulators are shut down by tying pins 14 and 15 of U3 and U13 to ground (GND). The shut down signals for these two IC's are gated together through CR8 and CR35 into pin 13 of U2. Pin 14 of U2 provides the switched connection to GND.

The B- regulators are shut down by tying pins 14 and 15 of U6 and U15 to -8 VDC. The U3 and U4 shut down signals are gated together through CR9 and CR40 into U2-1. U2-15 provides the switched connection to -8 VDC.

When the PA Power Supply is energized, a "TXONEN" signal enters the DC Regulator at J3-19 and is routed to pins 9, 10, and 11 of U2 to control the 2 analog switches. The "TXONEN" signal will be logic LOW when the transmitter is ON. Jumper plug P1 is used for initial setup and troubleshooting of the DC Regulator.

M.2.8 +5 VDC Supply

The DC Regulator fault sense circuitry is operated from a regulated +5 VDC supply consisting of regulator U11. Unregulated +22 VDC passes through the DC Regulator to the Modulation Encoder (A37) for the cable interlock protection circuits. Zener diodes CR26 and CR36 reduce the +22 VDC supply to approximately +15 VDC at TP23. Diodes CR31 and CR37 ensure that the fault detection circuitry will be active if either F1 or F4 opens. Transient protection and clamping is provided by CR25.

M.2.9 -5 VDC Supply

A -5 VDC supply is used for the B- Reference Modulator circuit and to power U10. Two separate -8 VDC unregulated inputs are diode gated through CR12 and CR11 to regulator U12. This allows for continued operation of the B- Fault Detector if either F3 or F6 were to open. CR27 provides transient protection and clamping should U12 fail.

M.2.10 Fault Detection Circuits

A problem on the DC Regulator will output either a B+ fault or B- fault to the Controller (A38) and will illuminate the B- or B+ fault LED on the ColorStat™ panel. Either fault will inhibit a transmitter ON command and prevent the PA Power Supply from energizing.

The fault indicator LED's on the DC Regulator are inhibited until a "TXONEN" command is generated during turn-on. A "TXONEN" command will cause U8-6 to go HIGH enabling the B+ and B- fault gates and will also enable LED driver tri-state inverter U7. To enable the fault gates and LED's for troubleshooting purposes, P1 should be moved to the "TEST" position.

CAUTION

DO NOT LEAVE P1 IN THE TEST POSITION FOR EXTENDED PERIODS OF TIME DUE TO LACK OF COOLING FOR THE REGULATOR PASS TRANSISTORS.

M.2.11 B+ Fault Circuit

The B+ fault gate consists of U9 and U8. Any logic HIGH signal on the input of U9 will cause the output at pin 1 to go HIGH. The output of U8-11 will then go LOW. Any of seven individual fault circuits gated together by U9 will trigger the B+ fault circuit. These are:

a. Ambient Temp. Sensor
b. B+ Fault Detector "A"
c. +5V Detector "A"
d. +22V Detector "A"
e. B+ Fault Detector "B"
f. +5V Detector "B"
g. +22V Detector "B"

As the "A" and "B" circuits are identical, only the "A" circuits will be described.

M.2.11.1 Ambient Temp. Sensor

The ambient temperature detector is an Airpax model 66F070 which trips at 70 Degrees C, +/-5 degrees. An ambient temperature fault will light DS5 and trigger B+ Fault gate U9.

M.2.11.2 B+ Fault Detector

IC U4 will produce a B+ Fault output if the B+ voltage drops below 15% or rises above 10% of normal. Pin 7 (TP13) of U4 establishes the over-voltage threshold at approximately +3.7 VDC and Pin 4 (TP16) of U4 establishes the under-voltage threshold at approximately +3.0 VDC.

M.2.11.3 +5V Detector

The +5 VDC detector monitors the supply used for the Modulation Encoder (A37) logic circuits. This +5 VDC supply is derived by placing a diode in series with the 5.75 VDC B+ supply on the Modulation Encoder. A sample is then fed back to the DC Regulator for the fault detection circuit. If the voltage at pin 10 of U5 falls below the reference at pin 11, pin 13 will go to logic HIGH state and trigger the B+ fault gate.

M.2.11.4 +22V Detector

Unregulated +22 VDC is used on the Modulation Encoder (A37) for cable interlock circuitry. The Modulation Encoder receives it's supply through F1 and F4 on the DC Regulator. The +22V fault detector monitors this line and will output a logic HIGH on U5-14 if the voltage at pin 8 of U5 falls below the reference at U5-9.

M.2.12 B- Fault Circuit

The B- Fault Circuit consists of the B- Fault gate, B- Fault Detector and B- Reference Modulator. The circuit will produce a B- Fault if the modulated B- voltage drops below 10% of normal or exceeds -6 VDC.

A sample of the B- output is brought into pins 4 and 7 of U5. A reference voltage of approximately 1.7 VDC on U5-6 corresponds to an over-voltage of -6 VDC. Pin 1 of U5 will go to logic LOW under a B- over-voltage condition.

Because the B- voltage is a modulated supply, the under-voltage reference at U5 pin 5 is also modulated with the same B- pre-distortion signal seen at TP14. This -(Audio + DC) pre-distorted signal is placed on a positive bias by U10. If the B- falls below 10% of normal, U5 pin 2 will go to a logic LOW condition.

M.2.13 Interlock Status Circuit

The DC Regulator includes only resistors and interconnections for the circuit. Interlocks are shown on the Overall Schematic, and Interlock Status logic is located on the LED Board.

Drive signals for contactors K1 and K2, and their auxiliary contact status return signals pass through the DC Regulator as part of the overall interlock system. No components are involved.

Three other interlock status circuits pass through the DC Regulator: "Door Interlocks", "External Interlocks", and "Interlock String DC". Door Interlock status and External Interlock status are indicated on the ColorStat™ panel, and are also available for remote readout.

M.2.14 LCD Multimeter

The LCD Multimeter allows for metering of the various supplies on the DC Regulator. When using an external meter to measure supplies at the Test Points, the LCD meter switch should be in the OFF (number 1) position.

The switch positions for the meter are as follows:

- OFF (1)
- B +8V IN (2)
- B B+ OUT (3)
- B -8V IN (4)
- B B- OUT (5)
- +5V IN (6)
- +5V OUT (7)
- -5V OUT (8)
- SPARE (9)
- B- REF (10)
- B- DRIVE (11)
- A +5V IN (12)
- A B- (13)
- A -8V IN (14)
- A B+ OUT (15)
- A +8V IN (16)

M.3 Troubleshooting

NOTE

Prior to starting a troubleshooting procedure check all switches, power cord connections, connecting cables, and power fuses.

A fault on the DC Regulator will register as either a B+ or B- fault on the ColorStat™ panel. To determine which circuit on the DC Regulator is registering as a B+ or a B- fault, P1 should be moved to the TEST position. This will enable the individual fault indicators on the DC Regulator.

CAUTION

DO NOT LEAVE P1 IN THE TEST POSITION FOR EXTENDED PERIODS OF TIME DUE TO LACK OF COOLING FOR THE REGULATOR PASS TRANSISTORS.

M.3.1 Symptom: B+ Fault

An ambient temperature greater than 70 degrees C or any fault in a DC Regulator positive supply will result in a B+ fault indication on the ColorStat™ panel. To isolate a B+ Fault:

a. Move Jumper P1 to the TEST position.

b. Note which LED is illuminated

c. Read LCD Multimeter reference voltage

Once the fault is isolated to an individual circuit, troubleshoot possible causes.

M.3.1.1 +22V Fault

This would indicate an open fuse F1 or F4 on the DC Regulator, depending on the particular fault indicated. The +22 VDC is distributed to the Modulation Encoder (A37) for the Cable Interlock circuitry. Any IC or component associated with the +22 VDC Interlock circuitry should be inspected for a short circuit or evidence of discoloration due to overheating.

M.3.1.2 MOD ENC +5V Fault

The +5 VDC is derived from the B+ voltage on the Modulation Encoder (A37) and is used to power various IC's. A short circuit in any IC on the + 5VDC line will result in an open fuse F1.

M.3.1.3 B+ REG Fault

Disconnect primary power from the transmitter before checking components. With the supply's fuse removed, check from emitter to collector of the pass transistor, using an ohmmeter on a low Ohms range (recall that there is a rectifier diode across the pass transistor). If you read a short, remove the pass transistor to check the diode and transistor separately. Diode failure is unlikely, unless a reverse voltage has been accidentally applied at the regulator input.

If the pass transistor and protection diode check good, swap the suspected defective regulator IC with a known good IC.

If the regulator IC is not the problem, an ohmmeter should be used to locate a shorted load or defective IC.

M.3.2 Symptom: B- Fault

The troubleshooting procedure for the B- regulator circuit is the same for the B+ regulator. If the basic regulator circuit appears to be operational, check the following:

M.3.2.1 Modulated B- Supply Controls Not Adjusted Properly

Refer to the Tuning/Frequency Change Procedure in SECTION V, Maintenance, for adjustment procedures.

M.3.2.2 No -(Audio + DC) Signal From the Analog to Digital Converter

With program audio applied to the transmitter, check the B- Drive signal at TP14 for a -(Audio + DC) signal.

N.1 Introduction

This section describes the External Interface, and includes troubleshooting information.

The External Interface provides an interface between the transmitter control circuitry and any external control or monitoring equipment, including remote control equipment and extended control and monitoring panels. Interface circuits on the board provide isolation between the Controller and any connections made at TB1 and TB2. Diodes and transzorbs protect the transmitter from transient and improper voltages accidentally placed on external interface terminals.

The External Interface is located in the Center Control Compartment. External Interface terminal boards TB1 and TB2 are located just above the External Interface and are connected to the board with ribbon cables.

N.2 Principles Of Operation

Interface circuits include opto-isolated control inputs, analog voltage “monitor” outputs, open-collector “status” outputs, and resistive voltage dividers for external monitoring of Low Voltage Power Supply voltages. Terminal board TB3 provides audio input connections, and bipolar zener diodes for protection against transient voltages.

Zener diode regulators on the board provide +15 VDC and -15 VDC to operate IC’s on the board. Three-terminal regulators provide +15 VDC at 175 mA and -15 VDC at 175 MA for customer use when either relay contacts or open-collector transistor outputs are used as remote control inputs.

All front-panel meter readings, ColorStat™ panel status indications, and control functions (except the Remote/Local switch) are available at the External Interface.

Analog voltage samples are set at approximately +3.4 VDC when normal meter readings are present. This allows for high excursions in readings while still remaining under the 4-Volt limit of some currently available microprocessor-based remote control equipment.

N.3 Circuit Description

Refer to the External Interface Schematic, 839-7855-090, in the Drawing Package. Sheets 1 and 2 are schematic diagrams of all circuits on the printed circuit board. Sheet 3 provides application information and reference information, including simplified diagrams of each type of interface circuit, and interface circuit connections for all terminals on TB1 and TB2. In addition, terminal numbers and functions for TB1 and TB2 are silk screened on the inside of the Driver Compartment door.

Each TYPE of interface circuit is described in the following paragraphs. Sheet three of the schematic diagram provides a summary of information for each type of interface circuit, in the “Characteristic Key.” The “Type” for each description refers to the designations (A, B, C, D, E, F, G) in the Characteristic Key. Additional figures in this section also provide information on typical applications.

N.3.1 Status Outputs (Type A)

Refer to Sheet 3 of the External Interface Schematic Diagram.

Each status output is an open-collector output. When the action described by the name of the signal at that status output is active, the transistor will be turned on (saturated) and provide a current sink to ground for a positive voltage applied at that input. All Status Output transistors return to ground. Examples include:

a. “LOWER” Indicator: When the “LOWER” button on the transmitter is illuminated, the transistor between TB1 terminal 15 and ground is “ON”.
b. “LOW” Indicator: When the LOW power button on the transmitter is illuminated, indicating that the transmitter is in the LOW power mode, the transistor between TB1 terminal 20 and ground is “ON”.
c. “Supply Current Overload” indicator: When the “Supply Current” overload indicator on the ColorStat™ panel is RED, indicating a supply current overload, the transistor between TB2 terminal 25 and ground is “ON”.

N.3.1.1 Status Output Protection

Status outputs are protected against reverse voltage by a diode connected between the transistor collector and ground, with the diode’s anode at ground. This protective diode will conduct if a negative voltage is connected at the Status Output terminal on TB1 or TB2.

Status outputs are also protected against excessive voltage inputs at the Status Output terminal by a diode connected between the transistor and the +22 VDC unregulated supply. A capacitor from the transistor to ground provides bypassing for transient and RF currents.

Refer the notes for Characteristic Key A on Sheet 3 of the Schematic Diagram for additional information on Status Outputs, including current and voltage limitations.

N.3.1.2 Using Status Outputs

Refer to Figure N-1 for two possible output configurations.

N.3.2 Control Inputs (Type B)

All extended control inputs (remote control inputs) are optically isolated. Both sides of the input are isolated from ground, to allow flexibility in external input control circuits.

For each control input, both sides of the input terminals on TB1 or TB2 are isolated from ground and labeled (+) and (-).

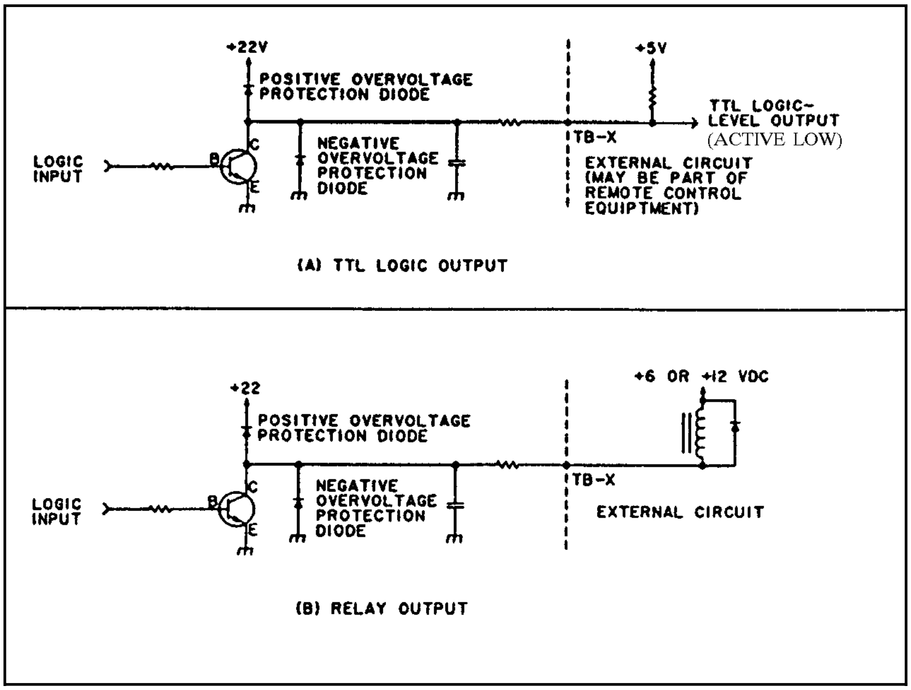

Figure N-1. External Interface,
Typical Status Output Circuits (817 1280 086)

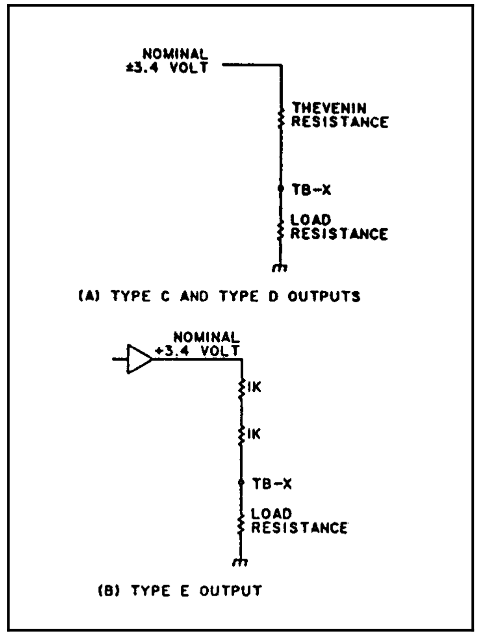

Figure N-3. Equivalent Circuits,
For Calculating Effect of Circuit Loading
on "Monitor Voltage" Outputs
(817 1280 088)

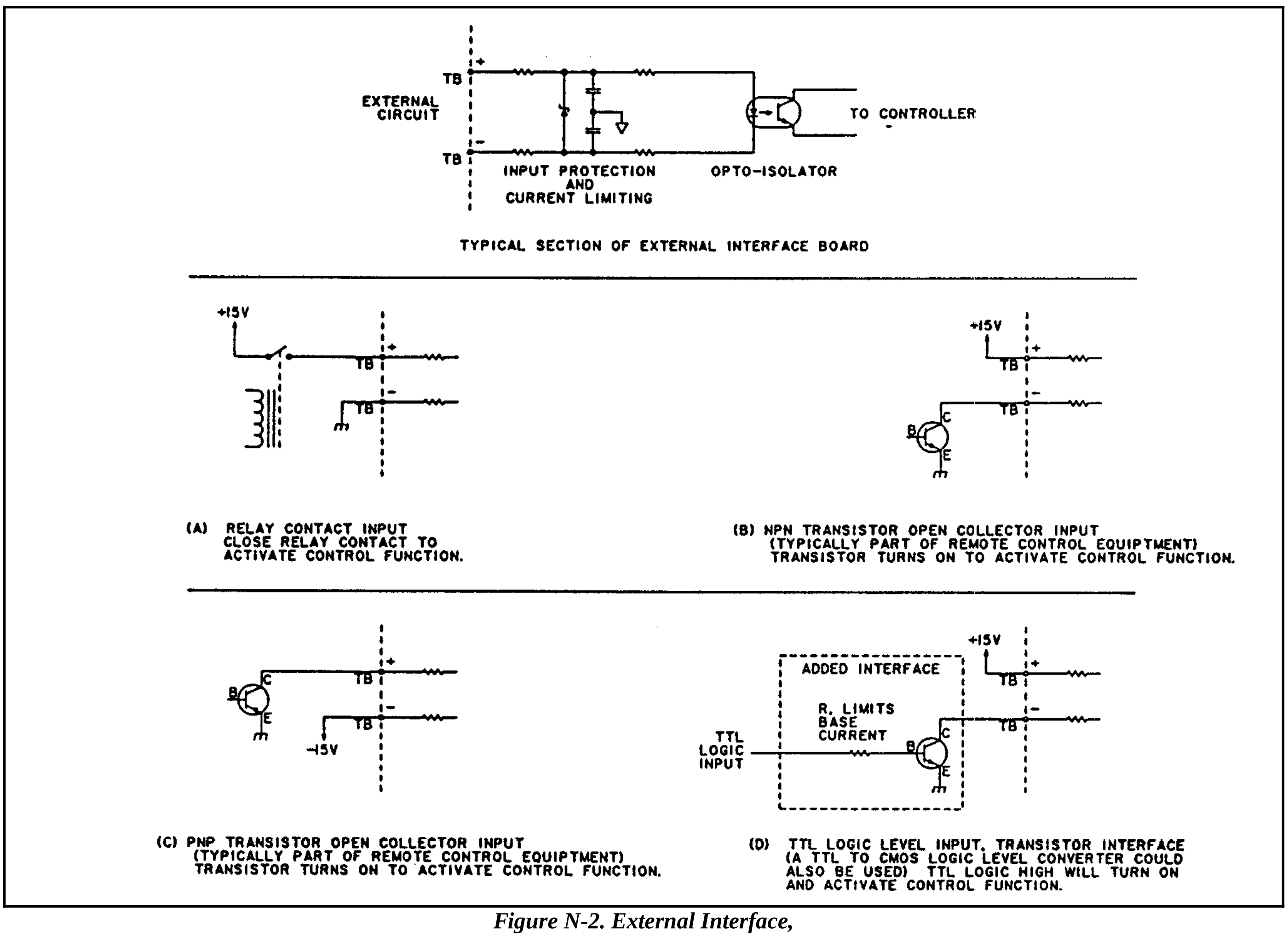

Figure N-2. External Interface,
Typical Control Input Circuits (817 1280 087)

N.3.2.1 Opto-isolator

The opto-isolator input is a light-emitting diode, with both sides above ground. When current flows, an internal LED illuminates and causes a photo transistor to conduct. This provides a current "sink" between the output terminals; each opto-isolator's photo-transistor is effectively part of a logic circuit on the Controller, including pull-up resistors. Refer to SECTION P, Controller, for additional information.

N.3.2.2 Control Input Requirements

To initiate or activate the control input, a momentary voltage (100 milliseconds or longer) must be applied to illuminate the opto-isolator's internal LED.

To prevent the transmitter control action from activating, the voltage input to the "Control Input" terminals must be less than +1 Volt). It is possible that voltages greater than +1 Volt could activate the control action, because of component tolerances. Voltages less than -1 Volt may cause component damage. Exceeding voltage or current limitations can over-dissipate the series resistors or damage the opto-isolator.

Refer to Sheet 3 of the Schematic diagram, Characteristic Key B, for additional requirements and limitations on control input current and voltage.

N.3.2.3 Protection

Series resistors limit current to the opto-isolator. When input voltage is +15 VDC, opto-isolator current is 40 mA. The resistor network, a transzorb, and bypass capacitors protect the opto-isolator input from transient voltages.

Figure N-2 shows three possible control input configurations.

N.3.3 Monitor Voltage Outputs

Monitor outputs include three types of outputs, including voltage divider outputs and monitor voltage outputs. Each type is described in following paragraphs.

N.3.3.1 Voltage-divider Outputs (Type C or Type D)

Voltage divider outputs are used to monitor the +22 VDC, -22 VDC, +8 VDC, and -8 VDC Low Voltage Supply outputs. Each output circuit consists of a resistive voltage divider, with a transzorb for over-voltage protection, and a bypass capacitor at the input. These monitor voltage outputs appear at TB2, terminals 35 through 38, and are all referenced to ground.

When there is no load, or a high impedance load, on the voltage divider, the output will be +3.4 VDC when the input voltage is at +22 VDC or +8 VDC, and -3.4 VDC when the input voltage is at -22 VDC or -8 VDC.

Any loading will reduce this sample voltage. Normally, remote control unit calibration will compensate for loading on the voltage divider outputs. However, if you know the load resistance and want to calculate the reduced nominal voltage, the Thevenin equivalent voltage and source resistance for each voltage divider output are given on sheet 3 of the schematic diagram; if you are not familiar with Thevenin equivalent circuits, see Figure N-3.

N.3.3.2 Operational Amplifier Buffered Outputs (Type E)

Refer to "Characteristic Key: E" on sheet 3 of the schematic diagram for a simplified schematic diagram, and to sheet two for complete schematic diagrams. There are six different parameters using this type of monitor voltage output:

a. Forward Power
b. Reflected Power
c. Supply Current
d. Supply Volts
e. RF Drive (Estimate)
f. Antenna VSWR
g. Bandpass Filter VSWR

The Forward Power, Supply Current, and Supply Volts outputs will be nominally +1.7 VDC when the transmitter is operating at 25 kW output power. These output levels are determined by sample circuits in other parts of the transmitter.

N.3.3.3 Circuit Description

Each analog signal monitor output is buffered by a section of U4, U5, U6 or U7 (half of U7 is not used). A 15-Volt transzorb and a bypass capacitor provide output protection.

N.3.4 External Interlock

A normally closed connection between TB1-1 and TB1-2 operates 24 VAC "External Interlock" relay K3, which has a 2 Volt-Ampere coil. Contacts and interconnecting wire or cables in the external interlock circuit must be handle this AC current, and total external interlock circuit resistance should be kept low to ensure reliable closure of K3. Refer to the Overall Schematic, 839-7855-151, and the DC Regulator schematic, 839-7855-163, for the entire interlock string.

NOTE

THE TRANSMITTER WILL NOT OPERATE IF THERE IS AN OPEN CIRCUIT BETWEEN THE EXTERNAL INTERLOCK TERMINALS, TB1-1 AND TB1-2.

N.3.5 Audio Input

The audio input terminal board, A28TB3, is located on the External Interface printed circuit board.

A balanced audio input is connected to TB3-2 and TB3-3. Terminal TB3-1 is at the transmitter cabinet ground. This will be the normal connection point for the audio input cable's shield. An additional AC coupled audio input circuit ground is provided at TB3-4.

A bipolar zener diode (CR30 and CR31) from each side of the balanced audio input to ground provides overvoltage protection.

N.3.6 Combiner Interconnect

Two BNC coaxial connectors, J7 and J8, are provided for interconnection to the combiner control unit when the transmitter is used in a combined transmitter installation. The Technical Manual for the Combiner Control unit will include information on using these connectors.

N.3.7 "PA TURN OFF" and "OFF CONTROL"

Terminals 21 and 23 on TB1 are for a "PA TURN OFF" connection, and TB1 terminals 33 and 35 are for "OFF CONTROL." Both are optically isolated control inputs, as described earlier in this section.

N.3.7.1 "PA TURN OFF"

The "PA TURN OFF" control input turns off all PA Modules through the modulation section of the transmitter. It does NOT turn off the +230 VDC PA Power Supply.

The "PA TURN OFF" control is intended to turn the RF carrier OFF during antenna pattern changes, antenna selection, or other times when transmitter RF output is switched. The "PA TURN OFF" control is not intended to be used for failsafe or for transmitter shut down.

As soon as the "PA TURN OFF" control input voltage is removed, the transmitter RF output will return to the power level determined by the HIGH, MEDIUM, and LOW switches and the raise/lower controls.

N.3.7.2 "OFF CONTROL"

The "Off Control" control input operates in the same way as the transmitter front panel "OFF" switch, by de-energizing the PA Power Supply primary contactor and resetting turn-on/turn-off control circuits.

The "OFF CONTROL" should be used any time the transmitter is to be turned OFF for any reason other than a brief interruption of RF output power during antenna switching or antenna pattern change operations.

N.3.8 External Interface Power Supplies

N.3.8.1 DC Voltage Supplies to the Board

Four unregulated DC voltages are brought from low voltage supply Power Distribution Board A39 to the External Interface. The +8 VDC and -8 VDC supplies are used only for external monitoring outputs. The +22 VDC and -22 VDC supplies are used for external monitoring outputs and are regulated to +15 VDC and -15 VDC for circuits on the External Interface and to supply voltages required for external interfacing.

N.3.8.2 Zener Diode Regulated +15 VDC and -15 VDC Supplies

Zener-diode regulated +15 VDC and -15 VDC supplies provide operating voltages for operational amplifiers U4, U5, U6 and U7.

N.3.8.3 Three-terminal Regulators

Three-terminal IC voltage regulators provide +15 VDC at up to 175 mA, and -15 VDC at up to 175 mA, for external use. These voltages are brought out at TB1-11 and 12 (TB1-10, 13 and 14 are ground connections), and can be used as voltage sources for control input circuits and for status output circuits.

These three-terminal IC voltage regulators are over-current protected, and their output voltages will decrease if excessive current is drawn. If these supplies are used for Status outputs, total current drain cannot exceed 175 mA from either supply.

N.4 Troubleshooting

N.4.1 Symptom: No Remote Control Inputs Operate

N.4.1.1 Possible Cause: Supply voltage for External Inputs Missing

If the +15 VDC from TB1-11 or the -15 VDC from TB1-12 is used, check for presence of this voltage. If the voltage is missing, check voltage regulator U6 for +15 VDC at its output and U9 for -15 VDC at its output. If there is no output, check the +22 VDC or -22 VDC input. If a customer-supplied battery or power supply is used, check its output voltage.

N.4.2 Symptom: Some Remote Control Inputs Do Not Operate

N.4.2.1 Possible Cause: Faulty Opto-Isolator, Faulty Transmitter Logic, or Faulty Remote Control Equipment

Monitor the dc voltage between the control input terminals on TB1 or TB2 and activate the remote control equipment. If the correct voltage appears between the terminals, the problem is in the transmitter. If the voltage is incorrect, the problem is a shorted opto-isolator input or the problem is outside the transmitter. To determine whether the opto-isolator or transmitter logic is at fault, monitor the voltage across the opto-isolator output terminals while activating the remote control input again.

If the voltage across the opto-isolator output terminals drops to less than 0.5 Volts, the opto-isolator is operating properly. Refer to SECTION P, Controller, for information on troubleshooting the Controller.

N.4.3 Symptom: Remote Status Outputs Do Not Operate

N.4.3.1 Possible Cause: No Supply Voltage For Status Circuits

A positive voltage through circuits external to the transmitter must be supplied to each status output used, at the proper terminal on TB1 or TB2. For each remote Status output there should be a positive voltage on the corresponding terminal on TB1 or TB2. Determine where the supply voltage for external status circuits comes from, then check that supply.

N.4.4 Symptom: Some Status Outputs Operate, But One Or More Does Not (fault Indication On Transmitter ColorStat™ panel But No Remote Status Indication)

N.4.4.1 Possible Cause: Problem In Transmitter Fault And Overload Logic

Use a voltmeter or logic probe to check the logic level (input voltage) to the status interface circuit on the External Interface. When a fault is present, the input at J6 should be logic HIGH and the transistor base should be about +0.6 to +0.7 VDC. If the input is not logic HIGH, the problem is in transmitter fault and overload logic. Most fault and overload logic is described in SECTION P, Controller and SECTION Q, LED Board.

N.4.4.2 Possible Cause: Problem is Outside the Transmitter

Check for voltage at the corresponding terminal on TB1 or TB2. When there is a "STATUS" indication (red LED or illuminated switch), the corresponding terminal should be LOW, because the transistor on the External Interface provides a current sink to ground. When there is no status indication, the terminal should be HIGH (close to the external supply voltage). Further troubleshooting depends on remote control unit or remote indicator circuits used.

N.4.5 Symptom: One Or More Remote Status Indications Remain “ON”; Transmitter Status Indication is Off (Green)

N.4.5.1 Possible Causes: Problem in Transmitter Fault and Overload Logic

Use a voltmeter or logic probe to check the logic level to the status interface circuit on the External Interface. When the transmitter “Status” indication is not ON, the input at J6 should be logic LOW. If the input is logic HIGH even when the transmitter status LED is green or the pushbutton switch is not illuminated, check transmitter fault and overload logic. Most fault and overload logic is described in SECTION P, Controller and SECTION Q, LED Board.

N.4.5.2 Possible Cause: Shorted Transistor

The status interface transistors are in DIP integrated circuit packages; pin-outs are shown on the External Interface schematic diagram.

Check for a transistor emitter-collector short by removing primary power from the transmitter, then disconnecting the external lead at TB1 or TB2. Use an ohmmeter to check for a short to the transmitter ground. A “good” transistor should read “open.”

N.4.6 Symptom: No Monitor Outputs (Analog Signal Outputs)

N.4.6.1 Possible Cause: No +15 VDC, Or -15 VDC, On External Interface

Each analog voltage to the monitor output terminals is buffered by a voltage follower. On-board zener diode regulators CR7 and CR8 provide +15 VDC and -15 VDC to operate the voltage followers. Failure of the zener diodes would result in no output from the op-amp. Failure of one zener diode would result in incorrect output or no output.

Table N-1. External Interface Board A28, Controls and Indicators

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
B1	TB3	Terminal board, for audio input connections.
A2	J7	Used only in combined transmitter installations. (RF to combiner).
A3	J8	Used only in combined transmitter installations. (RF from combiner).

P.1 Introduction

This section describes the Controller. Topics include Function, Location, Block Diagram Description and Circuit Descriptions.

The description is divided into functional groups of circuits, as follows:

a. Turn-on/Turn-off Control Logic.
b. Power Control Logic.
c. Interlock Status Fault Logic.
d. +5B Reset Circuit.
e. Power Supplies (+5, +15, -15 Volt regulators).
f. Supply Fault Logic.
g. Analog Metering Buffer/Drivers.
h. AC Power Recycle.

Refer to the Controller schematic, 843-5400-091, in the Drawing Package.

P.2 Function

The Controller has two primary functions: Local/Remote control of the transmitter ON/OFF sequence and power adjustment. Overload and Fault detection circuits on the LED Board generate inputs to these circuits to provide transmitter protection. Low voltage regulators supply +5 Vdc, +15 Vdc and -15 Vdc for circuits on the Controller and LED Board. Additional circuits include meter drivers for Forward Power, VSWR and Supply Voltage.

P.3 Location

The Controller is located on the back of the Center Control Compartment door.

P.4 Block Diagram Description

Refer to Figure P-1, “Block Diagram, Turn-On/Turn-Off Control Logic” and Figure P-3, “Power Control Section, Block Diagram”, for the following discussion.

The power control logic circuits accept Command Inputs and generate a “TURN-ON REQUEST” to the turn-on/turn-off control logic circuits. The power control logic also provides a 3-digit BCD (Binary Coded Decimal) power control output to the Analog Input Board.

Command inputs are OFF, HIGH, MEDIUM, LOW, RAISE and LOWER. Command inputs can be LOCAL, REMOTE, or FAULT-INDUCED. The front panel controls are LOCAL command inputs. Inputs from remote control equipment or extended control panels to the External Interface terminal board (TB1) are REMOTE inputs. The transmitter’s fault and overload sections can generate OFF commands, VSWR induced LOWER commands, or temperature induced LOWER Power commands.

The transmitter turn-on/turn-off control logic provides drive signals for step-start relays K1 and K2 and also provides logic signals to inhibit various overload functions during the step-start sequence and when the transmitter is OFF.

The transmitter has no filaments to warm up, so a “TURN ON REQUEST” from the power control logic immediately energizes K1 to start the PA Power Supply step-start sequence. Primary AC is initially applied to the transformer through surge limiting resistors. The Power Amplifier stage is held off during this time, so that the PA Power Supply is not loaded down as the filter capacitors charge. The operation of K1 is checked; if it has closed, the turn-on sequence continues. After a short time delay, rf drive level is checked. If drive is not correct, the transmitter is turned off immediately.

If rf drive level is correct, contactor K2 closes to bypass the limiting resistors and power control circuits become completely operational. After an additional short time delay, the “PA OFF” logic signal is released so that the transmitter begins operating at the selected power level (High, Medium or Low power).

If a fault occurs during the turn-on sequence, turn-on may either be aborted immediately or may time-out without completing the turn-on sequence.

An “OFF” input, also from the power control logic, immediately de-energizes high voltage supply contactors and generates logic signals to inhibit other transmitter functions. A Type 1 or Type 2 Fault input logic signal from the LED Board has the same effect as an “OFF” input. If an “OFF” or Type 1 or Type 2 fault signal occurs during the step-start (turn-on) sequence, the sequence is immediately stopped or aborted.

P.4.1 Transmitter Turn-on/Turn-off Control Logic

Refer to Figure P-1, Block Diagram “Turn-On/Turn-Off Control Logic.”

P.4.1.1 Transmitter Turn-on Sequence

When the HIGH, MEDIUM, or LOW switch is pressed, the button illuminates and contactor K1 energizes. After approximately 1.1 seconds, contactor K2 energizes and power output comes up to the preset level. After approximately one-half second, contactor K1 de-energizes.

a. COMMAND INPUT. When a HIGH, MEDIUM, or LOW power command is given (either a LOCAL or a REMOTE input), a “TURN-ON REQUEST” is generated by the Power Control logic.
b. TURN-ON REQUEST. The Turn-On Request (low-to-high transition) triggers the “B” input (pin 2) of U56A.
c. TURN-ON PULSE. When U56A is triggered, a 1.6 second logic HIGH “Turn-On Pulse” is generated at the Q output and drives step-start contactor K1 . A 1.6 second logic

WARNING: Disconnect primary power prior to servicing.

LOW "Inverted Turn-on Pulse" is generated at the Q-not output and generates a "Data Strobe" signal for the Analog Input Board data latches.

d. K1 HAS CLOSED. When K1 closes, an auxiliary contact places a +30 Vdc signal at the input of a de-bounce and logic level converter circuit Q10-8 and U59-6. U59-6 is a "K1 Has Closed-H" signal which:
   1. Resets "Underdrive Inhibit-B". Resets the underdrive comparator reference, on the LED Board.
   2. Starts a 0.3 second delay timer R96/C90.

e. K1 HAS CLOSED + 0.3 SECONDS. Approximately 0.3 seconds after the "K1 Has Closed-H" signal, delay timer circuit U59-12 provide a logic HIGH output which:
   1. Releases "Underdrive Inhibit-A". The logic HIGH input to U51-4 forces the output HIGH and activates the underdrive fault circuit on the LED Board.
   2. Starts a 0.8 second delay timer R65/C94. The output of the second timer is a "K1 HAS CLOSED + 1.1 SECONDS" logic HIGH signal.

f. K1 HAS CLOSED + 1.1 SECONDS. The 0.8 second delay logic HIGH output occurs (0.3 + 0.8) 1.1 seconds after the "K1 Has Closed" input. This logic HIGH signal:
   1. Generates a "K2 DRIVE" signal. The logic HIGH signal feeds OR gate U51-1, K2 Inhibit gate U53-5, Supply Fault gate U53-9 and K2 Drive transistor Q10-7. If no "INHIBIT K2-L" fault signal is present at K2 inhibit gate U53-6 and no "SUPPLY FAULT-L" fault signal is present at U53-8, the K2 Drive signal energizes step-start contactor K2.
   2. Generates a "RELEASE INHIBIT-H" signal, at U51-3, which enables the power control.

g. K2 HAS CLOSED. When K2 closes, a +30 Volt logic signal from the auxiliary contact is fed to the de-bounce and logic level converter circuits Q10-14 and U59-3. The output from the converter, a "K2 HAS CLOSED-H" signal:
   1. Latches K2. If no faults are present, the "K2 HAS CLOSED-H" pin 1 input to OR gate U51 holds the gate's output HIGH, and latches K2.
   2. Inhibits a new Turn-On Pulse. Inhibits U56A via pin 1, so that another power mode change (which generates another "TURN-ON REQUEST") cannot trigger another Turn-On Pulse.
   3. Starts a 150 millisecond delay timer. After 150 milliseconds, U59-10 output goes from HIGH to LOW.
   4. Releases "OVERDRIVE INHIBIT-L". The "OVERDRIVE INHIBIT-L" is released through U52-6 so that rf overdrive sensing circuits and air flow fault circuits on the LED Board are allowed to operate.
   5. Turns the PA Modules ON. The "PA OFF-L" signal from U53-3 goes HIGH, which turns the PA Modules ON.

h. At this time, approximately 1.2 seconds has elapsed since the "TURN-ON REQUEST", and the transmitter is "ON." The 1.6 second "K1 TURN-ON" pulse will continue to remain HIGH for approximately 0.4 seconds, then it will go LOW, K1 Drive will be removed, and K1 will de-energize.

P.4.1.2 Transmitter Turn-off Sequence

When the "OFF" button is depressed, the HIGH, MEDIUM or LOW light goes out, contactor K2 de-energizes, and power output drops to zero. A remote "OFF" command, a Type 1 Fault or Type 2 Fault induced "OFF" command causes the same circuit action as depressing the OFF button.

When a latched "OFF-H" signal is received from the power control logic, the following sequence takes place:

a. De-energizes K2. The "OFF-H" signal at U52-2 generates the "INHIBIT K2-L" signal. The "INHIBIT K2-L" signal:
   1. Turns OFF PA Power Supply. The logic LOW input at U53-5 inhibits the K2 Drive signal and K2 de-energizes, removing primary power from the PA Power Supply. The K2 drive signal is inhibited as long as the latched "OFF" command is present.
   2. Inhibits "TURN-ON REQUEST". The signal goes to the Power Control logic to prevent a "TURN-ON REQUEST" as long as the latched "OFF" command is present.
   3. Inhibits Overdrive and Air Flow Fault Sensing. The output of U52-6 goes LOW to inhibit the overdrive and air flow sensing circuits when the PA Modules are turned OFF.
   4. Turns PA Modules OFF. The output of U53-3 goes LOW to generate a "PA OFF-L" command to the power amplifier. The PA is held OFF as long as the latched "OFF" command is present.

b. When K2 de-energizes its auxiliary contact opens and the "K2 IS CLOSED-H" line goes LOW. This causes the following circuit actions:
   1. Removes K2 Latching Signal. The "K2 IS CLOSED-H" input to U51-2 goes LOW. K2 cannot energize again until another "TURN-ON REQUEST" starts the turn-on sequence again.
   2. Inhibits Power Change. The output of gate U51-3 goes LOW, removing the "Release Inhibit-H" signal and inhibiting the power change circuitry.
   3. Holds PA OFF. The U59-10 delay circuit and gates U52-6 and U53-3 generate the "PA OFF-L" signal until K2 energizes again.
   4. Inhibits Air Flow and Overdrive Fault Sensing. The U59-10 delay circuit and U52-6 generate the "OVERDRIVE INHIBIT-L" signal.
   5. Inhibits Underdrive Fault Sensing. The U51-6 gate generates the "UNDERDRIVE INHIBIT A" signal.
   6. Removes Turn-On Pulse Inhibit. The output of U54-6 goes LOW to allow U56-13 to generate a turn-on pulse when the "OFF" command is removed and a "TURN-ON REQUEST" is generated.

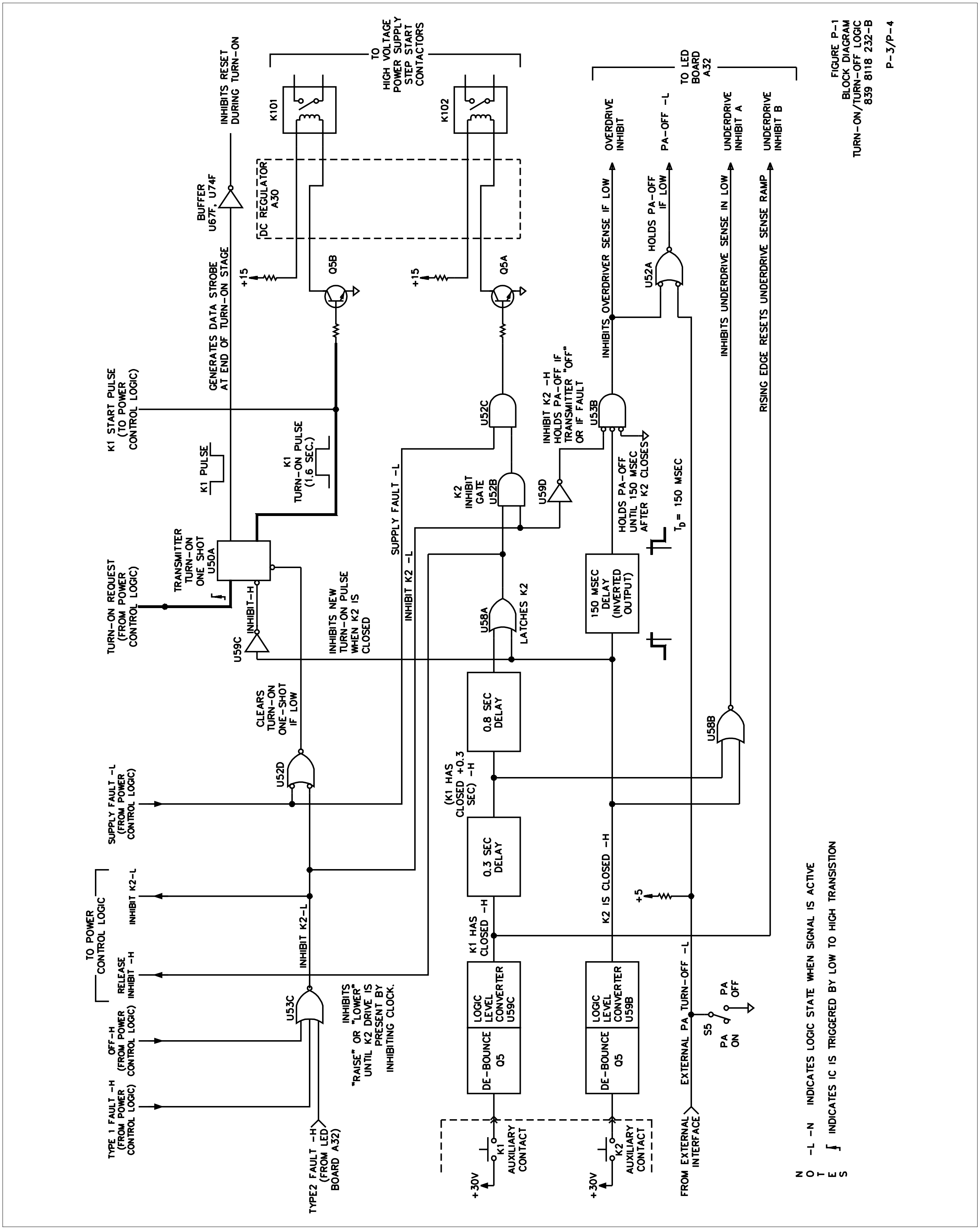

Figure P-1
Block Diagram Turn-On/Rurn-Off Control Logic

WARNING: Disconnect primary power prior to servicing.

P.4.1.3 TYPE 1/TYPE 2 FAULT Inputs

These inputs generate an "INHIBIT K2-L" signal at U52-8 and cause the same circuit action as described for "Transmitter Turn-Off." If K2 has not yet energized, a "CLEAR-L" signal at U53-11 clears the Turn-On one-shot which stops the turn-on pulse and de-energizes K1. Further action is as follows:

a. TYPE 1 FAULT: A TYPE 1 FAULT generates a latched OFF command.

b. TYPE 2 FAULT: A TYPE 2 FAULT generates an OFF command, then recycles the transmitter ON after approximately 2.4 seconds. If the fault is repeated, the TYPE 2 FAULT becomes a TYPE 1 FAULT and generates a latched OFF command. TYPE 2 FAULTS includes rf overdrive, rf underdrive, and supply current overloads.

P.4.2 Transmitter Power Control Logic

Normal logic flow will be described for a local or remote control LOW, MEDIUM or HIGH input. The RAISE/LOWER control inputs are active only if the transmitter is already ON in the LOW, MEDIUM, or HIGH power level mode.

Refer to Figure P-2, Power Control Logic, Simplified Diagram; Figure P-3, Power Control Section Block Diagram; and Figure P-4, Controller, Command Input Circuit.

a. CONTROL INPUT Occurs. A LOW, MEDIUM or HIGH control logic HIGH input is generated from a front panel button or from a remote control input.

b. INPUT CIRCUITS: The logic HIGH input turns on a transistor switch input circuit which generate a logic LOW output to Switch Debounce U45.

c. SWITCH DEBOUNCE: Possible "contact bounce" from the input is eliminated.

d. PRIORITY ENCODE/DECODE SELECT: Approximately 20 milliseconds after a control input occurs, a single "priority selected" command appears at decoder U42 output. A decoder output is present only while a control input is present. The RAISE/LOWER decoder output commands are active only if the transmitter is already ON. The decoder output OFF, HIGH, MEDIUM, LOW commands are applied:
   1. To Power Level Change Gate U57, pins 9, 10, 12, and 13.
   2. To Power Level Latch U40.

e. POWER LEVEL CHANGE PULSE. A HIGH, MEDIUM, or LOW command is applied to the delay and pulse generator circuit and the inhibit power level change gate U57. This generates a Power Level Change pulse about 20-30 milliseconds after it appears at the Decoder output. When a pulse occurs, it goes to circuits which:
   1. Clock the Power Level Latch U40.
   2. Generate a Data Strobe pulse (U13-8 and U62-10).

f. POWER LEVEL LATCH: The HIGH, MEDIUM, or LOW command appears as a logic HIGH output from U40 when the latch is clocked by the Power Level Change pulse.

g. INHIBIT GATES: The inhibit gates prevent the LOW, MEDIUM or HIGH command from generating a "TURN ON REQUEST" signal if there is FAULT present. The command then goes to:
   1. Turn-On Request Gate, to generate a "TURN-ON REQUEST" to the turn-on/turn-off control logic.
   2. Status Indicator Circuits, to illuminate the front panel button and provide remote status output.
   3. Counter Input Gates, to route clock pulses to the correct counter when a RAISE or LOWER command is given.
   4. Multiplex Address Inputs, to select correct BCD output for power level chosen.

h. Turn On Request Gate (U52-12): The latched LOW, MEDIUM or HIGH command to the inputs of U52 will cause the output to go LOW. This LOW signal is inverted by U55-12 and becomes the "TURN-ON REQUEST-H" signal to the Turn-On/Turn-Off logic.

i. Multiplex (U21-U23, U13-U15 and U33-U35): The latched LOW, MEDIUM or HIGH command immediately selects the multiplexed address of up/down counter U6, U7, or U8. The counter contains a user programmed 12-bit BCD number to set the LOW, MEDIUM or HIGH power level on the Analog Input Board.

j. Up/down counter input gates (U2, U14 and U26): The latched LOW, MEDIUM or HIGH command enables the corresponding counter input gates. These gates route a clock pulse to the UP or DOWN inputs of the HIGH, MEDIUM or LOW BCD counters when a RAISE or LOWER command is generated.

k. Up-down counters: There are three up-down counters, one each for HIGH, MEDIUM and LOW power levels. Outputs and inputs are:
   1. OUTPUTS: Each up-down counter always has a 12-bit BCD output (the last power output data set in that counter), unless the backup supply fails. If the transmitter is in the HIGH, MEDIUM, or LOW power level mode, that counter's output is selected by the Multiplex and goes to input latches on the Analog Input Board.
   2. INPUTS: Each counter can count UP or DOWN when clock pulses are sent to its count-up or count-down input, and transmitter power changes as the counter "counts."

The clock pulse will change the BCD number stored in the counter, thereby changing the power level of the LOW, MEDIUM or HIGH position. If the transmitter is OFF or if a RAISE or LOWER command is not present, there is no clock pulse to any counter.

P.4.2.1 Power Level Change, with the Transmitter ON:

When power level is changed by pressing the HIGH, MEDIUM, or LOW button while the transmitter is ON, the switch will illuminate and the transmitter power output will change. In the turn-on/turn-off circuit, a new "TURN-ON REQUEST" is received from the Power Control logic, but U56A is inhibited at pin 1 by the “K2 IS CLOSED-H” signal. There are no other signal changes in the turn-on/turn-off control logic and no contactors operate.

P.4.2.2 Clock Circuit

Switch Debounce IC U45 generates a 200 Hz clock signal which is applied to divide-by-eight frequency divider U38 and U24. The 25 Hz signal is then delayed by U50 and fed to the inputs of the counter gates. The clock is inhibited by U1-6 until contactor K2 is energized.

When a RAISE/LOWER command enables the BCD counters, the clock signal is present on the UP or DWN input to change the BCD number, and is fed to the Data Strobe Gate through U1-3/8/11.

P.4.2.3 Data Strobe Circuit

Inputs to Data Strobe gate U13-8 are from the clock signal, the power level change pulse and the K1 start pulse. The output of U13-8 is delayed 100 microseconds by the C119 delay circuit, then strobes the digital power data latches on the Analog Input Board when:

a. The transmitter is turned ON. The inverted K1 Start Pulse generates the Data Strobe signal.
b. A Power Level Change occurs. The Power Level Change pulse from U57-6 generates the Data Strobe signal.
c. The RAISE/LOWER command is active. The clock signal for the up/down counter generates the Data Strobe signal.

P.4.2.4 Interlock Fault Circuit

The Interlock Fault Circuit gates the interlock inputs and generates an “INTLK FAULT-H” output which is gated with the TYPE 1 FAULT input to generate a Fault Induced OFF command. The TYPE 1 FAULT output also is applied to U52-11 to inhibit contactor K2. Inputs to the Interlock Fault Circuit are:

a. Door Interlock. Generates an OFF command if any interlocked door on the transmitter is open.
b. External Interlock. Generates an OFF command if any external interlocked component is not in a safe condition.
c. Interlock String. Generates an OFF command if there is loss of supply voltage to the external and door interlock circuits.

P.4.2.5 Supply Fault Circuit

The Supply Fault Circuit monitors the low voltage regulators on the Controller. If any regulator fails, the circuit will generate a “SUPPLY FAULT-L” signal which:

a. Inhibits the command signal decode IC U42. This prevents any command input from being recognized.
b. Inhibits the Power Level Change gate U57-6. This prevents any command input from being clocked into Power Level Latch U40.
c. Clears the Power Latch circuits on the Analog Input Board. This brings the power control data lines to zero.
d. Clears the turn-on one-shot IC U56A-13. This prevents generation of a K1 turn-on pulse.
e. Inhibits K2. This will de-energize the K2 contactor if the transmitter is ON.

P.5 Turn-on/Turn-off Control Logic: Circuit Descriptions

The following paragraphs describe operation of one-shot, input, and delay timer circuits in the Turn-On/Turn-Off Control Logic.

Refer to the Controller Schematic, 843-5400-091, in the Drawing Package.

P.5.1 “K1 Turn-on One-Shot” (Monostable U56A-13)

U56A is one-half of a 74HC123 dual monostable multivibrator, or “one-shot.” In the “normal” state, U56-13 “Q” output is LOW and U56-4 “Q-not” output is HIGH. When the one-shot is triggered, a 1.6 second logic HIGH pulse is generated at U56-13 and a 1.6 second logic LOW pulse is generated at pin 4. The pulse width is determined by an R-C network at pin 15, the “RC” input.

When the one-shot is INHIBITED, it cannot be triggered, but if an INHIBIT input occurs during a one-shot pulse, the 1.6 second pulse will be completed. When the one-shot is CLEARED, the output pulse is stopped immediately; the “Q” output goes LOW and the “Q-not” output goes HIGH.

P.5.1.1 TRIGGER:

If no fault or inhibit signals are present, the one-shot is TRIGGERED by one of two methods:

a. A low to high transition at U56-2 “B” input. This Trigger transition is the rising edge of the “TURN-ON REQUEST-H” logic signal from the power control section.
b. A low to high transition at the “clear” input, assuming “A” input is low and “B” input is high. This trigger transition is the rising edge of the delayed supply fault from the local regulators.

P.5.1.2 CLEAR:

A FAULT or an “OFF” command will CLEAR the one-shot during the step-start cycle, and will prevent it from triggering again. When U56-3 “CLR” input goes LOW, the “Q” output goes LOW and the “Q-not” output goes HIGH. The 1.6-second “Turn-on” pulse is stopped immediately, aborting the turn-on sequence, and K1 de-energizes. If a fault or “Off” command holds the CLEAR input LOW, the one-shot cannot trigger again. (A fault or “Off” command also de-energizes K2). The following conditions cause a CLEAR-L input and clear U56A:

a. SUPPLY FAULT-L, to U53-12
b. INHIBIT K2-L, to U53-13

The “INHIBIT K2-L” at U52-8 is generated by any of three conditions:

1. TYPE 1 FAULT-H, at U52-10
2. TYPE 2 FAULT-H, at U52-9
3. OFF-H at U52-11

WARNING: Disconnect primary power prior to servicing.

P.5.1.3 INHIBIT:

The one-shot is INHIBITED if the “A” input is HIGH, or the “CLEAR” input is LOW. The following conditions INHIBIT U56A:

a. “A” input HIGH: U56-1 “A” input goes high when K2 is latched. This prevents a power mode change from generating a new turn-on pulse while the transmitter is operating.

b. “CLEAR” input LOW: Refer to the previous paragraph for Fault conditions which cause a “Clear-L” input.

P.5.2 One-Shot Trigger and Operation During Transmitter Turn-on

a. When a HIGH, MEDIUM or LOW command is latched into U40, the “OFF” output U40-2 goes from HIGH to LOW. If no faults are present, the “INHIBIT K2” signal at gate U52-8 is HIGH, and the ”CLEAR” signal at gate U53-11 is HIGH. The one-shot can trigger.

b. At the same time, a HIGH, MEDIUM or LOW command is latched into power control mode latch U40, and the corresponding output goes from logic LOW to logic HIGH. The “INHIBIT K2” signal at inputs of power control gates U39-6/8/11 is HIGH. One of the gate outputs goes HIGH, and one input to Turn-On Request gate U52-12 goes HIGH. This generates a “TURN ON REQUEST-H” logic HIGH signal.

c. Turn-on one-shot U56A triggers, and generates the 1.6 second turn-on pulse.

d. When K2 closes, about 1.1 seconds after the beginning of the “Xmtr Turn-On Pulse,” its auxiliary contact closure generates a “K2 Has Closed-H” signal, which forces U56-1 “A” input HIGH. This inhibits the one-shot, so that it cannot be triggered again.

P.5.2.1 Logic Levels At U56A Inputs and Outputs

When the transmitter is OFF, U56-1, U56-2 and U56-3 are all LOW. When the transmitter is ON, these three inputs are all HIGH.

P.5.2.2 Contact De-bounce And Logic Level Converter Circuits (Q10-8 and U59-6, Q10-14 and U59-4).

These circuits are both the same. The following description describes the circuit for the “K1 Aux Contact” input.

When the auxiliary contact closes, +30 Vdc is applied to J7-15 and voltage divider R91 and R92. Diode CR16 protects the transistor input, resistor R93 limits base current and C106 provides filtering.

Transistor Q10-8 is a logic level converter. When the K1 auxiliary contact is open, Q10 is OFF and the collector voltage is approximately +5 Vdc (logic HIGH). When K1 energizes, the auxiliary contact is closed and Q10 is turned ON. The collector (pin 8) voltage goes to approximately zero Volts (logic LOW). Because of the capacitor on Q10-9, the waveform at the collector has a long “rise” and “fall” time. Schmitt trigger U59-6 provides an output with a short rise and fall time. The output of U59-6 is logic LOW when the contactor is OFF, and logic HIGH when the contactor is ON. This output is the “Underdrive Inhibit B” signal which resets the “Underdrive Fault” detector. Refer to Section Q, LED Board, for a description of Underdrive Fault circuits. The output of U59-6 also drives the 0.3 second delay circuit.

P.5.3 Delay Circuits: Description

P.5.3.1 0.3 Second Delay Timer: Delay On/fast Off (R96, R97, C90, and CR18).

When the auxiliary contact of K1 closes, the delay circuit input from U59-6 goes HIGH and capacitor C90 charges through R96. Diode CR18 is reverse biased at this time. After approximately 300 milliseconds, the voltage across C90 triggers U59-1, and U59-2 output goes LOW. This logic LOW is inverted at U59-12.

This is the “Underdrive Inhibit A” signal which turns on the detection circuit on the LED Board through OR gate U51-6. It is at this time that Drive level begins to be measured, and if it does not come up in a predetermined manner, a Type 2 Fault will be generated.

When K1 opens again, U59-6 goes LOW and capacitor C90 discharges through diode CR18 and resistor R97 to quickly “reset” the delay timer.

P.5.3.2 0.8 Second Delay Timer (R65, C94, U62-2/4).

When the 0.3 second delay circuit output at U59-12 goes HIGH, capacitor C94 charges to +5 Vdc through R65. After approximately 0.8 seconds U62-2 goes LOW. The logic LOW is inverted at U62-4. The 0.3 second and 0.8 second delays add, so that U62-4 generates a logic HIGH signal 1.1 seconds after K1 closes. This logic HIGH signal is an input to OR gate U51, so that U51-3 goes HIGH to generate a “K1 has closed + 1.1 second delay-H” signal. This signal generates the K2 drive signal at U53-6 and the “Release Inhibit-H” signal to allow raise/lower functions to operate.

P.5.3.3 150 Millisecond Delay (R74, C108, and U59-10)

This delay circuit operation is the same as operation of the 0.8 second delay, except for the shorter R-C timer constant. This delay starts when contactor K2 energizes to complete the step-start sequence. At the end of this delay, the “PA TURN-OFF” signal from gate U53-3 to the LED Board is released, allowing the PA Modules to turn on.

P.5.4 PA Off And Overdrive Inhibit Gate U52-6

The output of U52-6 is HIGH only if all three inputs are LOW. If any input goes HIGH, the output goes LOW. The inputs are:

a. Pin 3 is grounded, holding it LOW

b. When the transmitter is OFF, the “K2 is closed + 150 millisecond delay” input to U52-4 is HIGH. This forces the output LOW and provides “PA Off” and “Overdrive Inhibit” outputs. These hold the PA off and inhibit Overdrive Sensing and Air Flow fault circuits on the LED Board.

c. When an OFF command, Type 1 Fault or Type 2 Fault generates an “Inhibit K2” signal, U52-5 goes HIGH. This forces the output LOW and provides early PA Off and Overdrive Inhibit.

P.5.5 PA Turn-off (U53-3, U52-6, and S2)

The PA Turn-off circuit generates a logic LOW output at U53-3. This is one input to the Modulation Encoders through the LED Board that turns the PA Modules OFF by clearing all latches. Refer to SECTION Q, LED Board, and SECTION L, Modulation Encoder, for descriptions of PA turn-off circuits on those boards.

Refer to the bottom of sheet 1 of the Controller Schematic, 843-5400-091, in the Drawing Package for the following discussion.

P.5.5.1 Gate U53-3

If either input pin 1 or 2 to gate U53-3 is logic LOW, the output will be a "PA OFF-L" signal. If BOTH inputs to gate U53-3 are logic HIGH, the output will be HIGH. Inputs to Gate U53-3 are:

a. At pin 1: EXTERNAL PA TURN-OFF (active LOW), from the External Interface, and PA OFF (active LOW) from PA OFF switch S2.
b. At pin 2: PA OFF (active LOW) signal from gate U52-6.

P.5.5.2 "PA Off" Gate, U52-6

If any one or more inputs to U52-6 are HIGH, the output will be LOW, and a "PA OFF-L" signal will always appear at U53-3. If all three inputs to U52-6 are LOW, output U52-6 will be HIGH to generate a "PA OFF" signal.

P.6 Power Control Logic: Circuit Description

Refer to the Controller Schematic, 843-5400-091, in the Drawing Package. The Power Control Logic generates a "Turn On Command" to the Turn-0n/Turn-Off control logic and selects the correct BCD data for the selected power level.

P.6.1 Command Inputs

Command (Control) Inputs are shown in the upper left part of Sheet 1 of the Controller Schematic Diagram. Figure P-4 is a simplified diagram of a Command Input circuit.

When a Command Input is active it generates a logic LOW input to the Switch Debounce integrated circuit, U9.

P.6.1.1 Local Control Inputs

Each Local Control input is from the front panel switch on the Switch Board/Meter Panel assembly. On the Controller, the six local control inputs go to the four sections of transistor array Q7, and to Q6B and Q6-2/6.

Each local control input drives the transistor through a 10K Ohm series resistor and a pull-down resistor to ground. When the front panel switch is open, the pull-down resistor holds the transistor OFF. When the switch is depressed, +15 Vdc is applied from the switch to turn the transistor ON and the collector goes LOW.

P.6.1.2 Extended Control Inputs

Each extended control input comes from an opto-isolator on the External Interface. A REMOTE input turns the opto-isolator ON and pulls the collector line to ground (unless the LOCAL/REMOTE switch is in the LOCAL position). The opto-isolator output is paralleled with the corresponding Local Control input transistor. When it turns on it pulls the input to the switch de-bounce IC or the corresponding input to OR gate U58 LOW.

P.6.1.3 Fault-induced Inputs

Three transmitter "Fault" conditions provide power level "Command" inputs. Each "Fault" condition turns on a transistor in parallel with the Local Control input and Extended Control input transistors, so that a "Fault" induced command will also pull the corresponding switch de-bounce IC input LOW. Fault-induced commands include:

a. VSWR/TEMP INDUCED LOWER COMMAND. A Logic HIGH input from the VSWR/TEMP Fault circuits turns on Q5-1.
b. TYPE 1 FAULT INDUCED OFF COMMAND. Either a "TYPE 1 FAULT-H" signal from the LED Board or an Interlock Fault will cause the output of OR gate U51-8 to go HIGH and turn transistor Q5-7 on.

P.6.2 Switch De-bounce (U45)

The Switch De-Bounce IC includes six independent "contact bounce eliminator" sections and an internal "clock" oscillator. Each input is pulled "HIGH" by an internal pull-up resistor to the +5 Vdc supply. A command pulls the input LOW to activate the input. The de-bounce IC is used to ensure a stable logic output from the input circuits.

P.6.2.1 Internal "Clock" Oscillator

The oscillator frequency is approximately 200 Hz and is set by the 0.01 uf capacitor connected between U45-7 and U45-9. The clock output is also available at pin 9, and is buffered by U54-3 for use in other sections of the power control circuits.

P.6.2.2 "Contact Bounce Eliminator" Operation

Each section of the MC14490 requires a "clean" input (contact "bounce" has stopped) for 3 to 4 clock cycles before the output can change state. Any "Command" input must therefore be held LOW for at least 20 milliseconds before the contact bounce eliminator provides a command (logic LOW) to the rest of the circuit.

P.6.3 Priority Encode/Decode

The Priority Encode/Decode circuit ensures that if two command inputs occur at the same time, only the one with the higher priority will be executed. An "OFF" command has the highest priority, and a "LOW" command has the lowest. Command priorities, from highest to lowest, are as follows:

a. OFF ...... Highest priority
b. LOWER
c. RAISE
d. HIGH
e. MEDIUM
f. LOW ..... Lowest priority

An "OFF" command will override any other command.

P.6.3.1 Priority Encoder and Decoder: Circuit Description

The priority encode circuit uses an eight-to-three line Priority Encoder (U44), a three-to-eight line decoder (U42), and three inverters (U43).

The encoder U44 is enabled at all times, and the decoder U42 is configured so that a single logic input at pin 4 enables or disables the decoder.

P.6.3.1.1 Encoder

For each encoder input (D2 through D7), there is a corresponding binary "code" on the three output lines (A0 through A2). If more than one input is active (logic LOW), the highest priority input will determine the output "code." When a higher priority input occurs, the output lines will immediately change to the new binary code required by the new input. The encoder, therefore, selects the highest priority input and provides its binary code on the three output lines.

P.6.3.1.2 Inverters

The encoder output signals are inverted by U43-8/10/12, then go to the decoder "select" inputs (A, B, and C).

P.6.3.1.3 Decoder

When U42 is enabled at pin 4, it will convert the encoded 3-bit logic signal at the A, B, and C inputs back to a logic LOW signal on one output. If more than one command occurs at the same time, only the highest priority command will appear at the decoder output. If NO commands are active, all decoder outputs will be HIGH.

P.6.3.1.4 Inhibit Decode One-shot (U56B)

Decoder operation is inhibited by U56-5 for approximately .25 seconds after any OFF command is given. This prevents any new command from operating, and prevents rapid ON/OFF cycling of the transmitter PA Power Supply.

When an "OFF" command is latched by U40, the "OFF" output at U40-2 goes HIGH. The "OFF" signal is buffered by U39-3 and fed to one-shot timer U56-10. The positive-going transition triggers output U56-5 HIGH and inhibits the decoder for .25 seconds.

The Q output remains high during the one-shot's time-out (.25 seconds), unless a supply fault clears the one shot. The time-out (pulse width) is determined by resistor R62 and capacitor C82 at U56-7. If a Supply Fault logic signal is generated during this time, U56-11 goes LOW and immediately clears the one-shot, causing the Q output to go LOW again.

P.6.3.1.5 Decoder U42 Outputs

Only one decoder output can be active at a time, at the Y2 through Y7 outputs of U42. When any command is present that output is logic LOW. If no command is present, all six outputs will be HIGH. Because commands are only pulses (except for "Raise" and "Lower" commands), all outputs will be HIGH most of the time.

The OFF, HIGH, MED, and LOW outputs from the decoder go directly to 4-input OR gate U57-8 and then to the "Power Level Change" circuit which generates a delayed pulse to "strobe" the Power Level Data latches on the Analog Input Board.

P.6.3.1.6 Inverters (U41-2/4/6/8/10/12)

All six Decoder outputs are inverted by the six sections of Hex Inverter U41. When a command is present the inverter output is logic HIGH. The inverter outputs for "Raise" and "Lower" commands are not latched, and go to Up/Down Counter input gates. "Raise" and "Lower" commands are active as long as the RAISE or LOWER button is held, a remote command input is present, or when the VSWR Induced Lower command is present.

Inverter outputs for Power Level commands OFF, LOW, MEDIUM, or HIGH go to Power Level Latch U40. The "Off" command also goes Q5-13.

P.6.4 "Power Level Change" Pulse

Each time a new Power Level Command is decoded, a delayed "Power Level Change" logic LOW pulse is generated by this circuit. This pulse clocks the Power Level Latch (U40) so that the new power level is stored, and is one of several signals that strobe the latches on the Analog Input Board to store the new BCD power output data.

Whenever a new power level is decoded by U42, a 20 millisecond delay timer starts (R44/C77/U55-4B) and at the end of that time-out, a 10 millisecond Power Level Change pulse (Logic LOW) is generated at the output of U57 which latches the command in U40. Transistor circuit Q5-14 starts a new Power Level Change pulse immediately if an OFF command is generated while the LOW, MEDIUM or HIGH command is still present at the input (this turns the transmitter off if a Type 1 Fault occurs during turn-on).

P.6.4.1 Inhibit

A "Supply Fault-L" output from the regulator fault summary circuit inhibits U57-6 and prevents a "Power Level Change" pulse.

P.6.4.2 Data Strobe

The Power Level Change pulse is "OR'ed" with other logic signals in U13-8 (shown on sheet 3 of the schematic) to form the Data Strobe pulse. This pulse clocks the digital power level data latches on the Analog Input Board.

P.6.5 Power Level Latch (U40)

The OFF, LOW, MEDIUM, and HIGH commands are short pulses. The power level latch U40 stores the power mode information, that is, it "remembers" the last command. The latch supply voltage is the +5B memory backup supply. This ensures that the current "Power Level" information is still available to restore transmitter operation after a power failure.

P.6.5.1 Power Level Latch "Clear"

The power level latch is CLEARED only if the backup supply voltage decreases to near the level where latch operation becomes unreliable and integrity of stored information would be compromised. The latch "CLEAR" input is a "RESET-L" signal from the +5B Reset circuit (U37).

P.6.6 Latched "Off" Command

When an "OFF" command is stored, a logic HIGH output appears at U40-2. This output is buffered by U39-3 and goes to:

WARNING: Disconnect primary power prior to servicing.

a. The trigger input of "Decode Inhibit" one-shot U56-10 to inhibit the decoder for .25 seconds and prevent transmitter turn-on during that time.
b. "Inhibit K2" gate U52-11 to de-energize the PA Power Supply contactors.

P.6.7 Power Level Latch Outputs

The LOW, MEDIUM, and HIGH power mode commands from U40 go through the AND gates in U39 to:

a. Power control up-down counter gates.
b. Indicator circuits.
c. The "Turn-On" request gate.

P.6.8 Inhibit Gates U39-3, U39-6 AND U39-8

The output of each AND gate is logic HIGH only if both inputs are HIGH. One input to each gate is the LOW, MEDIUM or HIGH power level logic signal from U40. The second input is from the "INHIBIT K2" line from U52-8. If this line is HIGH, the output of U40 appears at the gate output. If the inhibit line is LOW, the AND gate outputs are forced LOW and any output from U40 is inhibited from going to any other circuits.

P.6.9 Turn-on Request Gate (U52) and Inverter (U55)

A "TURN ON REQUEST-H" signal is generated each time a new power level command is latched unless the "INHIBIT K2" signal from the turn-on/turn-off logic blocks the latch outputs. The three "power level" logic outputs from U40 are fed to U52-1, 2, and 13. When a power level is selected, one of the three inputs goes HIGH and U52-12 goes LOW. The signal is inverted at U55-12 to generate the "TURN ON REQUEST-H" signal. The LOW to HIGH transition triggers U56 in the turn-on/turn-off control section. The following events then happen simultaneously:

1. The Step-start sequence begins
2. The Oscillator output is switched ON
3. The DC Regulator circuits are enabled
4. The Driver Encoder/Temp Sense Board turns the Driver Modules ON

P.6.10 Up-Down Counters: Setting and Storing Digital Power Data

This section includes Up-down Counters, Counter Control Gates, and Inhibit Circuits. Each power level circuit includes a set of up-down counters, counter control gates, and inhibit circuits. This section generates and stores three 12-bit BCD (Binary Coded Decimal) power output control signals.

P.6.10.1 Up-Down Counters U6-U8, U18-U20, and U30-U32

Refer to Sheet 3 of the Controller Schematic Diagram for the following discussion.

Each counter has a four bit BCD output, and counts from "0" to "9". The counter "counts" when a low-to-high transition occurs at the "count up" or "count down" input (pins 5 and 4). There are three sets of Up-Down Counters, one set for each power mode, as follows:

a. HIGH: U8 (1's), U7 (10's), U6 (100's).
b. MEDIUM: U20 (1's), U19 (10's), U18 (100's).
c. LOW: U32 (1's), U31 (10's) and U30 (100's).

The output of each set of counters is a 3-digit BCD (Binary Coded Decimal) digital power control signal. To raise or lower power, a series of clock pulses is applied to either the UP or DOWN input of the "ones" digit counter.

P.6.10.2 "Carry"

When counting UP, each counter goes to "9," then goes back to "0" and begins counting up again. When the counter goes from "9" to "0," a "carry" output is generated; the "carry" goes to the

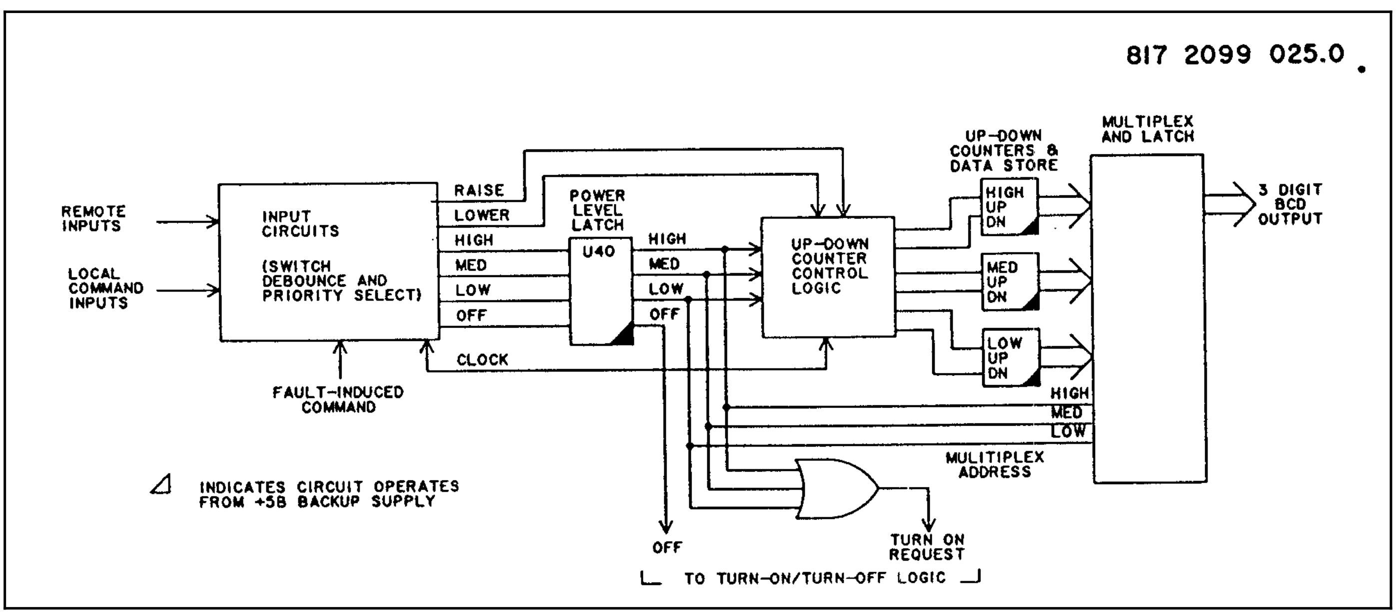

Figure P-2. Power Control Logic: Simplified Diagram
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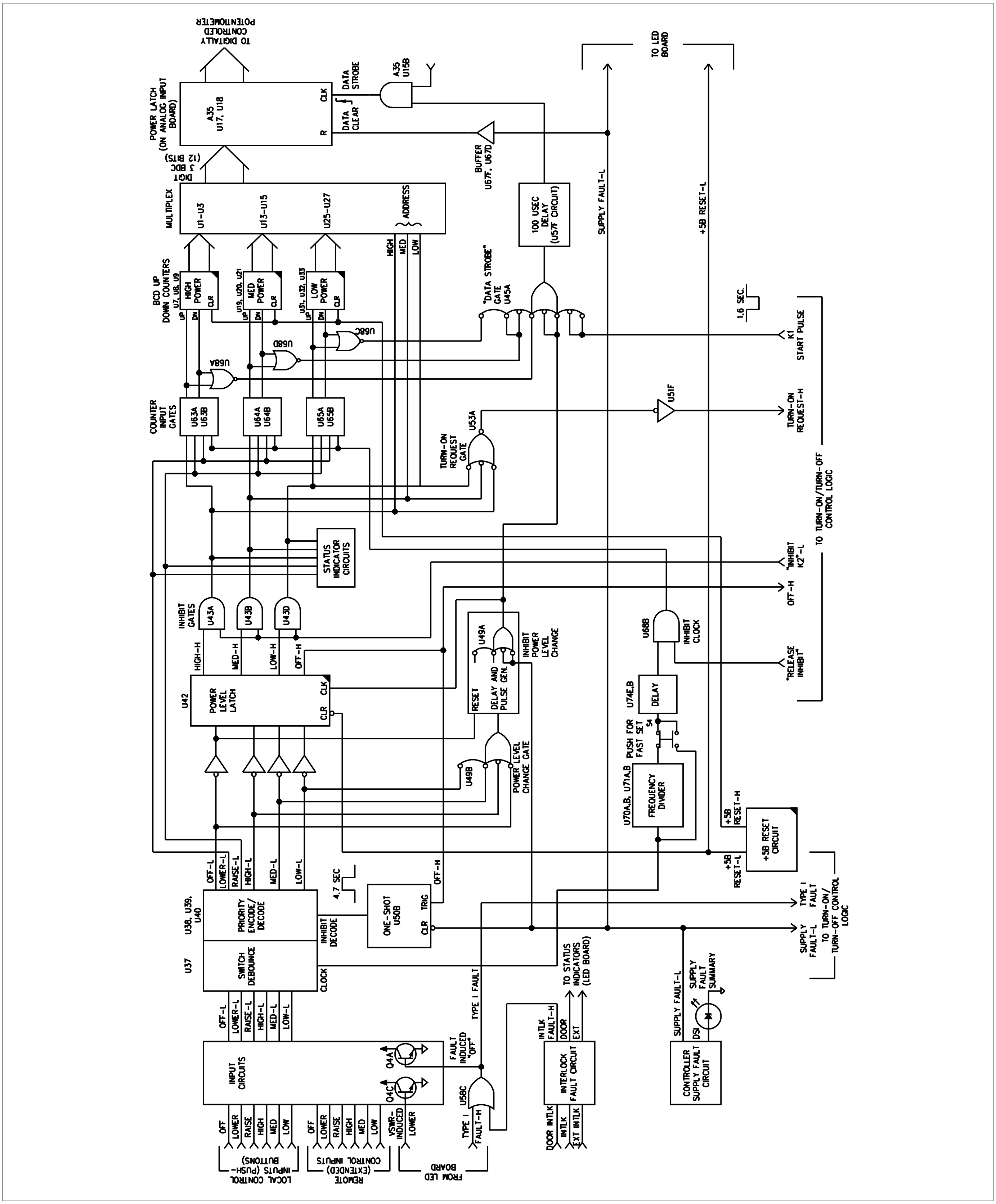

Figure P-3
Block Diagram Power Control Section

count "up" input of the next counter. For the "one's" counter, the carry increments the "ten's" counter one digit; the "ten's" carry output increments the "hundred's" counter.

P.6.10.3 "Borrow"

When counting DOWN, each counter generates a "Borrow" output when it goes from "0" to "9". The "borrow" output goes to the next counter's count "Down" input so that the next counter counts "down" one digit.

P.6.10.4 Up-down Counter "Clock"

The counters count up or down when a low-to-high logic TRANSITION occurs at one of the clock inputs.

The Clock input for the counters is from the "Switch Debounce" IC, U45. The 200 Hz clock frequency is divided down to 24 Hz, by U38 and U24. The lower clock frequency changes power slowly enough for accurate adjustment.

P.6.10.5 Power Control Data "Memory"

As long as supply voltage is present, the outputs of the up/down counters do not change unless the clock is applied. The supply voltage for the counters is from the +5B backup supply, so that the power control data is "remembered" when primary AC is removed.

P.6.10.6 Power Control "Clear"

Each counter has a CLEAR input. When the CLEAR input is HIGH, the BCD output goes to "000." If the +5B backup power supply voltage goes too low for reliable counter or memory operation, the +5B Reset circuit generates a logic HIGH signal which resets the counters. The counters can operate at a supply voltage as low as +2 Vdc. The +5B Reset signal is generated when the backup supply voltage drops to approximately +3.1 Vdc.

P.6.11 Up-Down Counter Control Gates (U1, U2, U14, U26)

Up-down counter control gates route the clock pulse to the proper counter input, depending on which Power Level has been selected and whether "Raise" or "Lower" is active. There are six gates, one for each counter input, as follows:

a. U2-6: High Power level RAISE (count up)
b. U2-8: High Power level LOWER (count down)
c. U14-6: Medium Power level RAISE (count up)
d. U14-8: Medium Power level LOWER (count down)
e. U26-6: Low Power level RAISE (count up)
f. U26-8: Low Power level LOWER (count down)

The counter control gates are four-input NAND gates. Each gate output is LOW only if all four inputs are HIGH. The output is forced HIGH if any one or more inputs are LOW. All inputs are labeled on the Controller Schematic diagram.

P.6.11.1 Gate Inputs

The four inputs to each counter control gate are:

a. CLOCK pulse
b. RAISE-H or LOWER-H logic signal.
c. HIGH, MEDIUM, or LOW power level select signal
d. INHIBIT signal

The clock pulse train alternates between HIGH and LOW states. Clock pulses will appear at a gate's output only when:

a. The Inhibit-L input is HIGH
b. The Raise or Lower input is HIGH
c. The power level select input is HIGH
d. The transmitter is ON

P.6.12 Data Strobe Gates (U1-3/8/11 and U13-8)

Whenever an up-down counter is counting, each clock pulse generates a "Data Strobe" signal for the power control data latches on the Analog Input Board. Clock pulses for each power level are applied to three sections of U1. The outputs of these three gates feed U13-1/4. The output of U13-8 is delayed and inverted at U62-10 to form the Data Strobe signal.

P.6.13 Up-Down Counter "Inhibit" Circuits

Inhibit circuits stop counter operation at "000" and "999". The "LO" circuits generate a logic LOW inhibit when counter output reaches "000." The "HI" circuits generate a logic LOW inhibit when counter output reaches "999". Inhibit circuits include the following:

a. HI-HI circuit: U3
b. HI-LO circuit: U5, U4, U25-6
c. MED-HI circuit: U15
d. MED-LO circuit: U17, U16, U25-4
e. LOW-HI circuit: U36
f. LOW-LO circuit: U34, U35, U25-2.

P.6.13.1 HI-LO, MED-LO, and LO-LO Inhibit

The "LO" inhibit is easiest to understand. Zero power is decimal "000" or BCD "0000/0000/0000"; all bits are zero (logic LOW). For any other power, at least one the 12 BCD bits will be one (logic HIGH). A logic LOW inhibit signal must be generated when all bits are zero. The "LO" inhibit must be LOW when all binary bits are zero, otherwise the output must be logic HIGH.

The "HI-LO" inhibit circuit (U5, U4 and U25) will be used as an example; the "MED-LO" and "LO-LO" inhibit circuits are the same. Each bit of the 12 bit BCD signal goes to inverter U5 or U4. All inverters have open-collector outputs, and all 12 outputs go to the input of inverter U25-5. Resistor R13 pulls U25-5 HIGH if all 12 inverter inputs are LOW. This will cause U25-6 to go LOW and inhibit U2. When any of the 12 inverter inputs are HIGH, U25-5 will be pulled LOW and U25-6 will go HIGH to enable U2.

P.6.13.2 HI-HI, MED-HI, and LOW-HI Inhibit

The "HI" Inhibit must generate a logic LOW signal when the BCD output is "999". To understand these circuits examine the Binary Coded Decimal numbers below:

0 = 00005 = 0101

1 = 00016 = 0110

2 = 00107 = 0111

3 = 00118 = 1000

4 = 01009 = 1001

WARNING: Disconnect primary power prior to servicing.

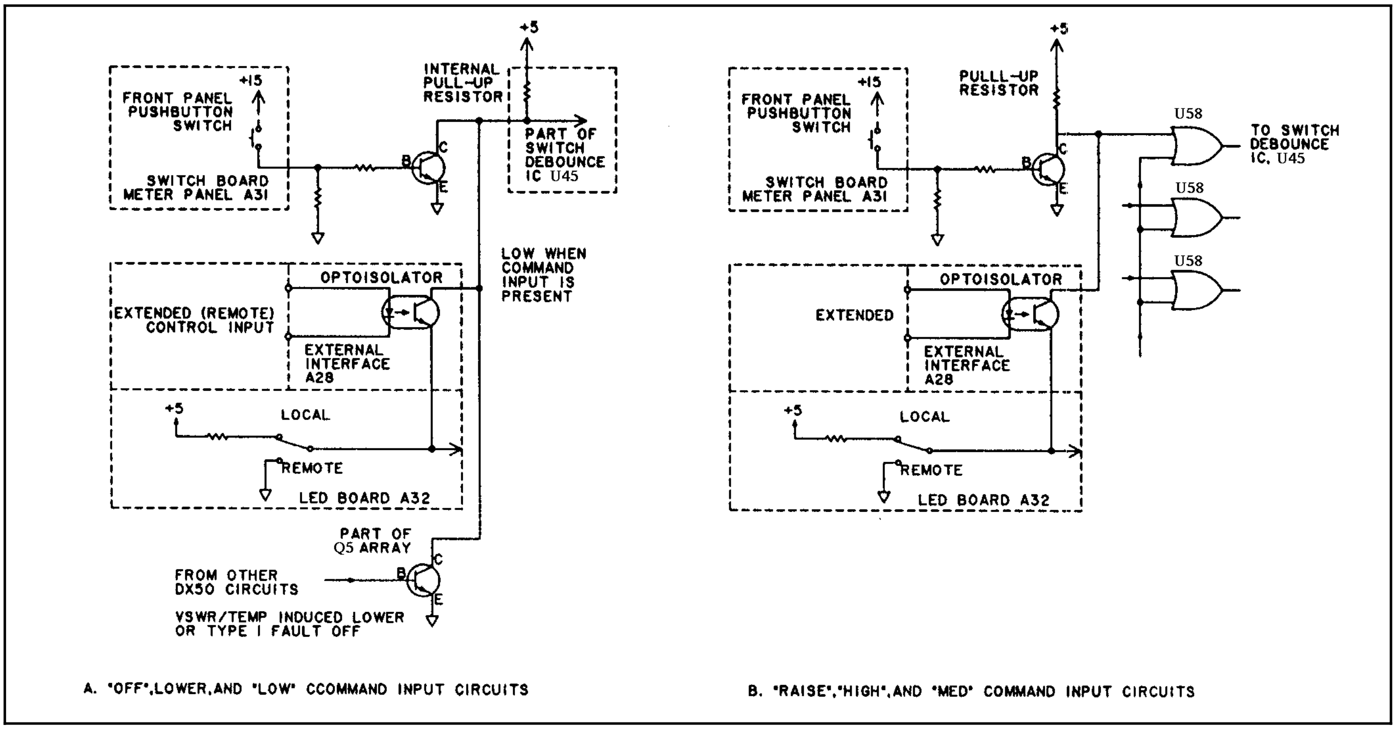

Figure P-4. Controller Board, Command Input Circuit
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If the first bit and the last bit are BOTH HIGH, the decimal digit must be a "9". To identify "999", six bits must be checked.

For the High power mode BCD output, these are bits H1 and H4, H5 and H8, and H9 and H12. If these six bits are all HIGH the decimal number is "999". When all six bits are HIGH a logic LOW "inhibit" signal is needed at the inhibit input of the up counter control gate.

An 8-input NAND gate, U3, is used for the "HI-HI" inhibit gate. Three inputs are tied together for the 6-input gate required. Gates U15 and U27 perform the same function for the "MED-HI" and "LOW-HI" inhibit functions. (See sheets 3 and 4 of the Controller schematic).

P.6.13.3 Power Limit Jumpers

The maximum LOW power setting may be limited to one-quarter power by setting JP5 to position 2-4 and JP6 to position 1-3. The maximum MEDIUM power setting may be limited to one-half power by setting JP3 and JP4 to position 2-4.

P.6.13.4 Up-Down Counter Outputs

Each up-down counter has a 4-bit BCD output, representing one decimal digit of the 3-digit power control signal. The digits are designated by a letter (H, M or L) indicating the power level, and a number indicating the significance of the bit. For example, the High Power output bits are H1 through H12.

"H1" is the Most significant bit, "H12" is the least significant bit. H1 through H4 represent the first decimal digit, H5 through H8, the second, and H9 through H12, the third. Examples:

Decimal Number	BCD Bits: H1-H4
500	
678	

Up-down counter outputs go to "Inhibit" gate inputs and to Multiplex inputs.

P.6.14 Multiplex and Output Buffers For BCD Power Data (U9-U11, U21-U23, and U33-U35)

The multiplex selects the LOW, MEDIUM or HIGH BCD Power Data output to the Analog Input Board. Multiplex inputs include the 12-bit BCD data, and three "Address" lines (HIGH, MEDIUM and LOW).

The multiplex uses one buffer for each bit of all power levels.

P.6.14.1 Tri-state Buffers

Refer to Figure P-5. Tri-state buffers have three output states:

a. HIGH: Output pulled to the + supply
b. LOW: Output pulled to ground
c. OPEN: High Impedance output

The output state is controlled by the "C" input. If "C" is HIGH, the output logic state is the same as the input logic state: either HIGH or LOW.

If the "C" input is LOW, the output is effectively an OPEN CIRCUIT.

Refer to the Controller Schematic Diagram and also to Figure P-5. Note that for each bit of the BCD digital power data, three tri-state buffer outputs are tied together. For example, bit H5, bit M5, and bit L5 buffer outputs are tied together.

Only one buffer output for each bit is active at any time; the other two will be in the high impedance "off" state. All three buffer outputs can also be "off" (for example, with the transmitter "OFF" or with power level latch outputs inhibited). The HIGH, MEDIUM, or LOW buffer output is selected by making the "C" input for that buffer HIGH and leaving the others LOW.

For each power level (HIGH, MED, or LOW), all 12 buffer "C" inputs are connected together, and these three common connection lines are the "address" lines. For example, the "High Power Level" logic signal from power level latch U40 addresses all "C" inputs for the High Power Level buffers U9, U10 and U11. When this address is logic HIGH, the 12-bit BCD output is the BCD data from the High Power up-down counters.

Figure P-6 shows the Controller output and Analog Input Board digital power data input circuit for BCD Bit 1. Note that whenever all three buffers for a bit are in their "High Impedance" state, the latch inputs on the Analog Input Board will be pulled LOW by a resistor to ground. If the three multiplex address lines are all LOW, the latch inputs are all zero.

P.6.15 "Data Strobe" Output and Delay (U13-8, U62-10)

The "Data Strobe" signal strobes (clocks) the Power Control data latches on the Analog Input Board. The data latches "clock," the new data, on a low-to-high transition of the data strobe signal. Data strobe pulses are generated by:

a. "K1 Start Pulse" from U56-13. This is a 1.6 second logic LOW pulse, and "data strobe" occurs at the end of this pulse (at the end of the step-start cycle).

b. "Power Level Change" pulse from U57-8. This is a logic LOW pulse, and "data strobe" occurs at the end of the pulse.

c. Up/down counter Clock pulses from U1-3/8/11. The up/down counter also counts on the rising pulse edge, so the "Data Strobe" pulse is delayed approximately 100 microseconds by R2-C119 before the rising pulse edge strobes the data latches on the Analog Input Board.

The "Data Strobe" signal is delayed, to allow the up/down counters time to operate before the power data latches on the Analog Input Board are strobed. A 100 microsecond pulse delay circuit is made up of R-C network R2-C119 and Schmitt trigger U62-10/11.

When U13-8 is LOW, capacitor C119 discharges through R2 and inverting Schmitt trigger U62-10 is HIGH. When an input to U13-8 goes LOW, U13-8 goes HIGH, and C119 charges through R2. After about 100 microseconds, U62-10 goes from HIGH to LOW.

P.6.16 Power Control Status Indicator Drivers (U46, U47)

"Status Indicator" driver circuits are shown on sheet 3 of the Controller Schematic, 843-5400-091, on the left side of the sheet. Status indicator drive outputs are:

a. RAISE, LOWER, HIGH, MEDIUM, LOW status: Logic HIGH inputs illuminate indicator lamps in the buttons on the transmitter front panel.

b. RAISE, LOWER, HIGH, MEDIUM, LOW status: Provide logic signals to the External Interface for remote or extended control panel indications.

c. HIGH and MEDIUM status outputs: Operate Modulation Monitor Sample level relays on the Output Monitor through the LED Board.

P.6.16.1 Logic Buffers

Integrated circuits U46 and U47 are logic level down converters, used as buffers. For each status output, one buffer section drives the External Interface through a current-limiting resistor, and a second buffer section drives an indicator lamp circuit. For HIGH and MEDIUM status, a third buffer output goes to the Output Monitor through the LED Board.

P.6.16.2 Front Panel Indicator Lamp Drivers

Each indicator lamp in the front panel switch is connected between sections of Q3 and Q6 and +15 Vdc on the Switchboard/Meter Panel. When the transistor base is logic HIGH, the transistor turns on and illuminates the indicator lamp.

P.6.17 Clock Inhibit Gate (U1-6)

Inputs to the Clock Inhibit Gate, U1-6, shown on sheet 3 of the Controller schematic diagram, are the Clock signal at U1-5 from the clock frequency divider and the "Release Inhibit-H" signal at U1-4 from the turn-on/turn-off control circuits.

The Clock Inhibit gate prevents clock pulses from triggering the up-down counters during the transmitter step-start cycle, so that the "Raise" and "Lower" functions cannot operate. The "Release Inhibit-H" input is logic LOW during the step-start cycle and forces the inhibit gate's output to remain LOW.

P.6.18 Clock Frequency Divider and Delay (U24, U38, and U50-4/10)

The clock frequency divider circuit is shown on sheet 1 of the Controller schematic diagram.

When "Raise" and "Lower" command is used to change power, the rate at which power changes must be slow enough so that the operator can easily adjust power to the desired level, particularly when using remote control and remote power readout. The clock frequency from the switch debounce oscillator is divided by eight, using three flip-flop "divide by two" circuits, to permit precise power adjustment.

P.6.18.1 Fast Power Set (S1)

A "Fast Power Set" momentary contact pushbutton switch, S1, bypasses the divider circuit and allows power changes to be made quickly.

P.6.18.2 Clock Pulse Delay

U50-10 drives the R/C circuit R40 and C759. This circuit and Schmitt trigger U50-4 delay the clock pulses by approximately 500 microseconds to debounce the momentary pushbutton switch S1.

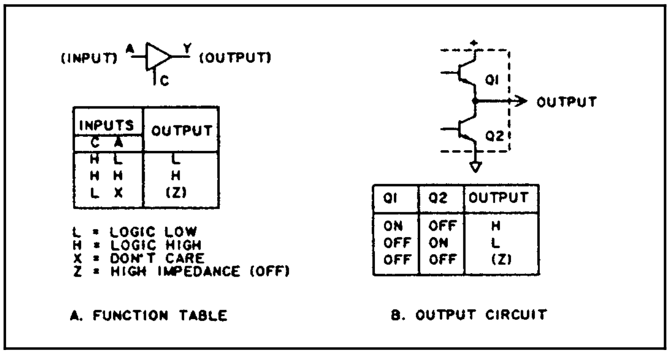

Figure P-5. Tri-State Buffers (817 1280 094)

P.7 Interlock Status Logic: Circuit Description

Interlock Status logic is shown on Sheet 1 of the Controller schematic diagram. Figure P-7 is a simplified diagram of Interlock Status Logic.

The Interlock circuits and Interlock Relay K3 are shown on the Transmitter Overall Schematic Diagram, Sheet 2. Part of the +30 Vdc "Interlock Status" circuit appears on the DC Regulator Schematic Diagram. A simplified diagram of the interlock circuits (but not interlock logic) is in SECTION M, DC Regulator.

P.7.1 Interlock Status Logic: Inputs

Refer to Interlock Status Logic: Simplified Diagram, Figure P-7, in this section. There are three inputs to the Interlock status logic on the Controller:

a. Door Interlock (Logic HIGH if "Fault")

b. External Interlock (Logic HIGH if "Fault")

c. Interlock String (Logic LOW if "Fault")

P.7.1.1 Door Interlock Input

Door interlocks include the Driver Compartment inner access door, the Center Control Compartment RF Amp inner access door and the Left Control Compartment RF Amp inner access door.

When all doors are closed, the door interlock switches ground the "Door Interlock" input to Q9-2. If one or more doors are open, +30 Vdc is applied to the "Door Interlock" input on the Controller, through a resistor on the DC Regulator.

The "Interlock String" circuit applies a logic HIGH from the +30 Vdc supply for the interlock "fault" inputs.

P.7.1.2 External Interlock Input

External interlocks include enclosures with rf power inside, such as phasor cabinets; air or water flow interlocks on dummy loads; interlocks on rf power contactors; and any other external interlocks which may be required by your system.

The "External Interlock" at External Interface TB1-1 and 2, is a 24 Vac circuit. A closed circuit must be provided between these terminals to energize interlock relay K3. When K3 is energized, the "External Interlock" input to the Controller is grounded through a contact on K3. If the circuit between TB1-1 and 2 opens, relay K3 de-energizes, and a logic HIGH is applied to the "External Interlock" input on the Controller from the +30 Vdc supply through a resistor on the DC Regulator.

P.7.1.3 Interlock String Input

The Interlock String protects against the loss of interlock sensing. The loss of +30 Vdc disables the Door and External inter-

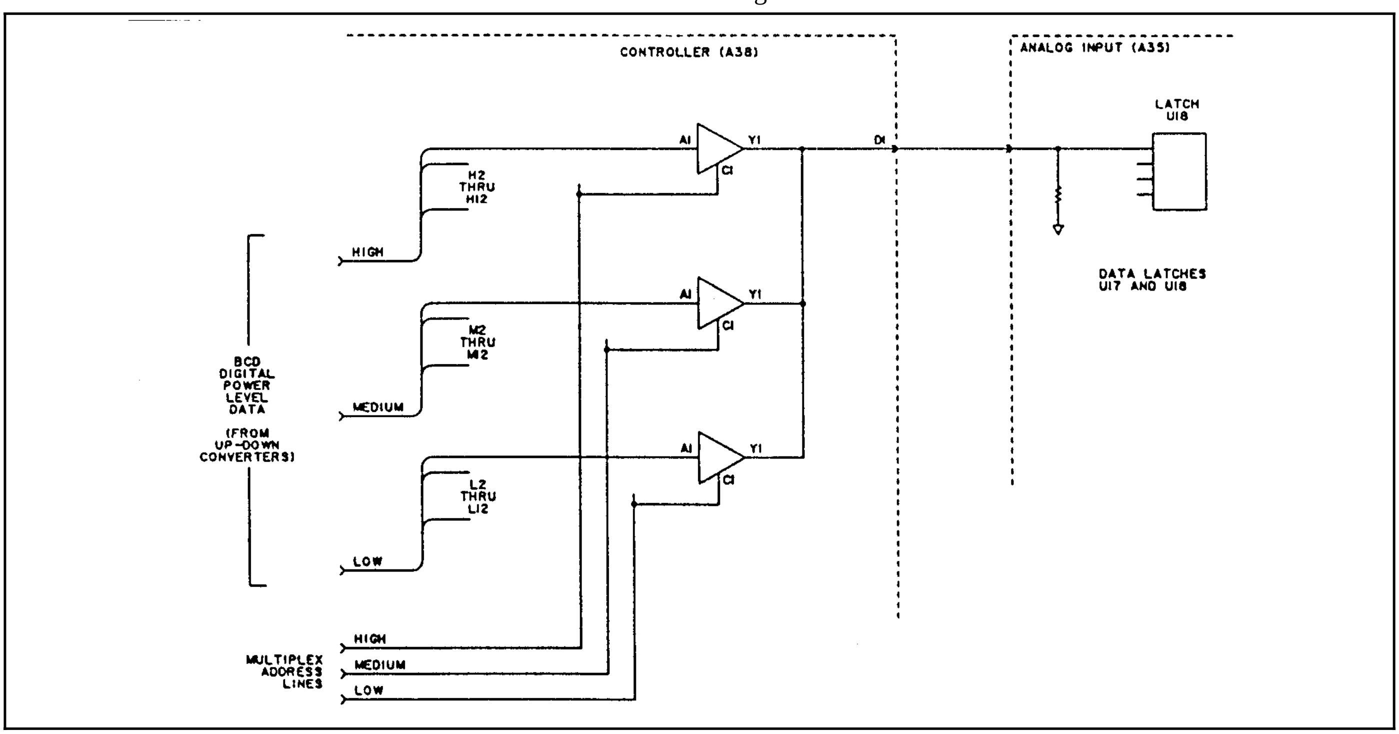

Figure P-6. Multiplex & Latch, Simplified Diagram
817 1280 095

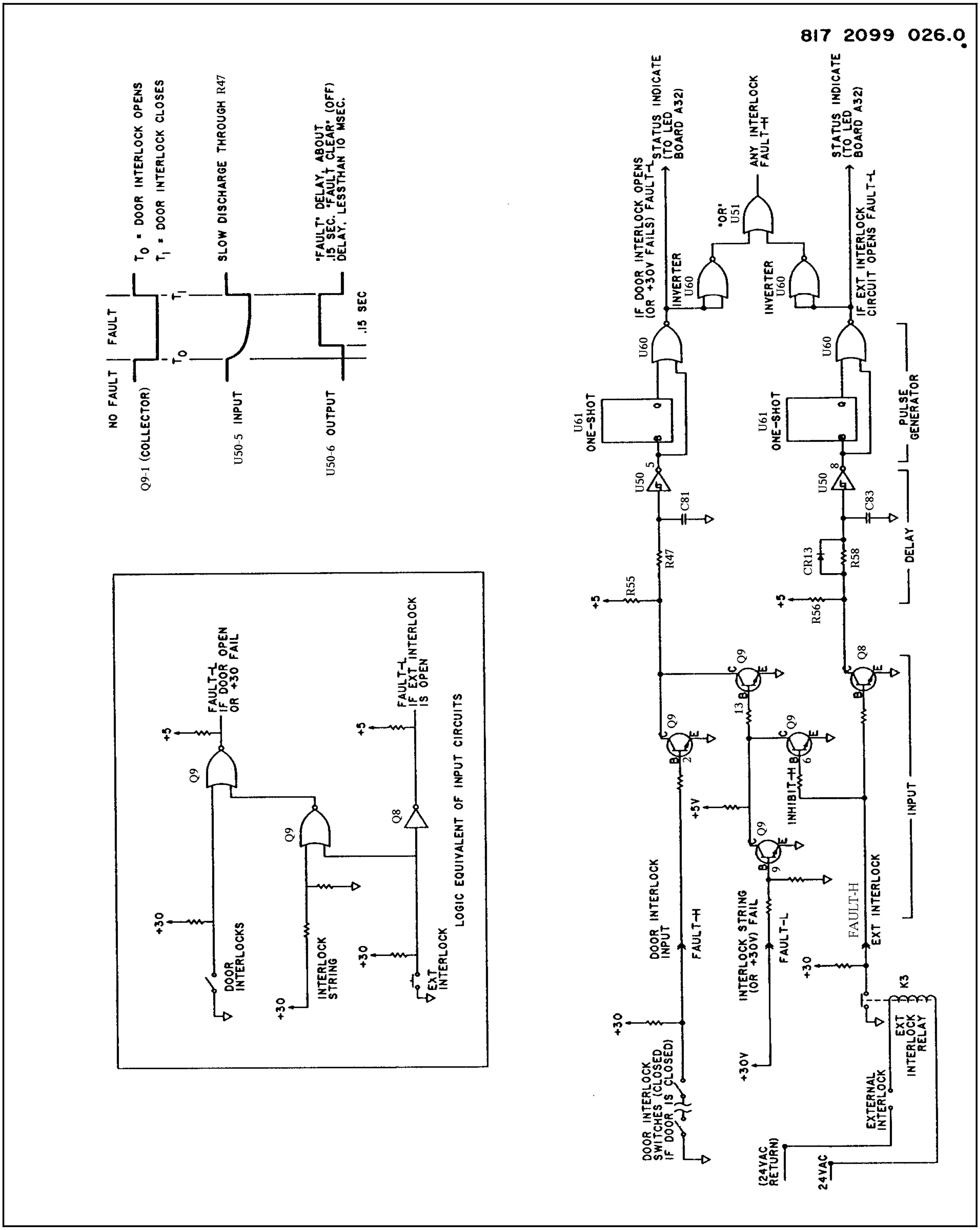

Figure P-7. Controller Board, Interlock Status Logic Simplified Diagram (817 2099 026) lock inputs. If the +30 Vdc supply fails, an Interlock Fault output is generated which turns the transmitter OFF.

P.7.2 Interlock Status Logic: Outputs

There are three outputs from interlock fault logic on the Controller:

a. Door Interlock Status. To status indicator circuits on the LED Board. If a Door interlock is active, the DOOR INTERLOCK LED on the ColorStat™ panel will be RED.
b. External Interlock Status. To status indicator circuits on the LED Board. If an External interlock is active, the EXT. INTERLOCK LED on the ColorStat™ panel will be RED.
c. Interlock Fault-H. To Type 1 Fault gate U51-8. If either a Door or an External interlock is active, the Type 1 Fault gate will generate an OFF command and inhibit PA Power Supply contactor K2.

P.7.3 Interlock Status Logic: Basic Circuit Description

Both the Door and External interlock circuits are similar and can be divided into the following stages:

a. Input transistor
b. Delay circuit
c. Pulse stretcher, one-shot
d. “OR” gate

P.7.3.1 Input Transistor: Function

The input transistors convert the signal from the Interlock String, Door Interlock and External Interlock relays into the correct logic signal for the interlock circuits on the Controller.

P.7.3.2 Delay Circuit: Function

The DELAY prevents an “OFF” command when AC power fails and interlock relay K3 de-energizes. A fault-induced “Off” command would prevent the transmitter from recycling back ON when AC power returns. The delay is long enough (about 0.15 second) to allow +5 Volt supplies to discharge, disabling command input circuits. A diode in the delay circuit provides a “fast” reset (about 10 milliseconds) when the interlock fault clears.

P.7.3.3 Pulse Stretcher: Function.

The pulse stretcher ensures that any interlock fault generates a “Fault” output that is long enough to latch the transmitter OFF.

P.7.3.4 “NOR” Gate: Function

The “OR” gate output goes LOW (“Fault output”) either when the pulse stretcher “Fault” output is present or when an “Interlock Fault” exists or both. The Interlock Fault output will then be present for as long as an interlock fault is present (but for at least the pulse stretcher’s 0.5 second output if the interlock fault is only momentary).

P.7.4 External Interlock: Normal Operation

When the External Interlock is closed (no fault present), the base of Q8 is grounded (logic LOW) and Q8 is OFF. The collector goes HIGH and charges C83 to approximately +5 Vdc through R56 and R58. The input to U50-9 is HIGH and U50-8 is LOW. The pulse stretcher “B” input U61-10 is LOW, and the “Q” output U61-5 is LOW. Both inputs to U60-2 and U60-3 are LOW and U60-1 is HIGH.

P.7.5 Door Interlock: Normal Operation

When the Door Interlock is closed (no fault present), Q9-2 is grounded (logic LOW) and the transistor is OFF. The collector goes HIGH and charges C81 to approximately +5 Vdc through R47 and R55. The input to U50-5 is HIGH and U50-6 is LOW. The pulse stretcher “B” input of U61-2 is LOW, and the “Q” output U61-13 is LOW. Both inputs to U60-5 and U60-6 are LOW and U60-4 is HIGH.

P.7.5.1 Interlock Gate circuit

Each interlock circuit output from U60-1 or U60-4 is logic HIGH when there is no interlock fault. Each output goes to the LED Board status indicator circuits at J7-37 and J7-35, and to the “Interlock Gate” circuit U51-11 and U60-10/13.

The output of U60-4 is inverted to logic LOW at U60-10 and U60-1 is inverted to logic LOW at U60-13. These signals are gated together by U51 and the normal output at U51-11 will be logic LOW. This logic LOW is fed to U51-10. The other input to U59-9 is a TYPE 1 Fault input from the LED Board. During normal operation, U51-8 will be logic LOW.

If a Door or External Interlock occurs, the output of U51-11 will go HIGH and generate a latched OFF command through Q5-7. The interlock fault will also turn OFF (Inhibit) K2 through U52-8.

The output of U51-8 will go HIGH and energize Q5-6 to generate a latched OFF command.) output from U60-4 and the “External Interlock Fault” (Fault LOW) output from U60-1 are inverted by U60-10 and U60-13 (two-input gates with the inputs tied together to use as inverters). The inverted, logic HIGH if fault signals go to OR gate U51-10. A Door Interlock Fault or an External Interlock Fault (or both) will cause an “Interlock Fault” logic HIGH output from U51-8.

P.7.6 External Interlock: Fault Condition

An External Interlock fault generates a HIGH input at J5-13 and turns Q8 ON. The collector goes LOW and discharges C83 through R133 which generates the 0.15 second delay. The output of U50-8 will go HIGH and trigger pulse stretcher U61B-5. This pulse ensures that the “Fault-L” output will remain for at least 0.5 second. The pulse width is determined by the RC network at the one-shot’s “CR” terminal. The HIGH input to U60-2 and U60-3 will bring U60-1 LOW. The LOW input will force U60-13 HIGH.

P.7.7 Door Interlock: Fault Condition

A Door Interlock fault generates a HIGH input at J5-15 and turns Q9 ON. Q9-1 goes LOW and discharges C81 through R47 which generates the 0.15 second delay. The output of U50-6 will go HIGH and trigger pulse stretcher U61A-13. This pulse ensures that the “Fault-L” output will remain for at least 0.5 second. The pulse width is determined by the RC network at the one-shot’s “CR” terminal. The HIGH input to U60-6 and U60-5

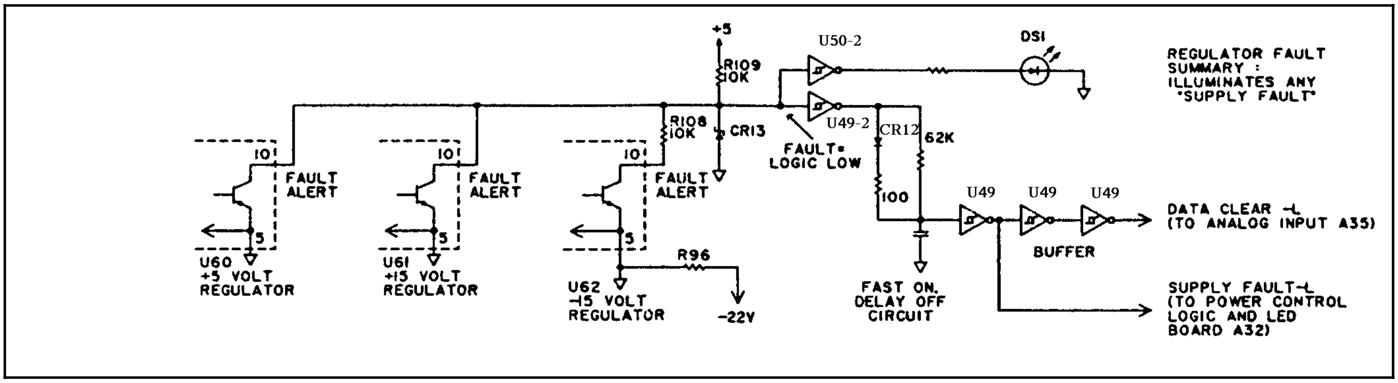

Figure P-8. Control Board "Supply Fault" ("Regulator Fault") Circuit, Simplified Diagram (817 1280 097)

will bring U60-4 LOW. The LOW input to U60C will force U60-10 HIGH.

P.7.7.1 Interlock Gate circuit

Each interlock circuit output from U60-1 or U60-4 is logic LOW when there is an interlock fault. Each output goes to the LED Board status indicator circuits at J7-37 and J7-35, and to the "Interlock Gate" circuit U51-11, U60-10, U60-13.

The output of U60-4 is inverted to logic HIGH at U60-10 and U60-1 is inverted to logic HIGH at U60-13. These signals are gated together by U51 and the output at U51-11 will be logic HIGH if either circuit indicates a fault. This logic HIGH is fed to U51-10. The other input to U59-9 is a TYPE 1 Fault input from the LED Board. During a TYPE 1 Fault or Interlock fault, U51-8 will be logic HIGH. This HIGH generates a latched OFF command through Q5-7 and inhibits K2 through U52-8.

The output of U51-8 will go HIGH and energize Q5-7 to generate a latched OFF command.

P.7.8 Interlock String Operation

An "Interlock String" fault causes a "Door Interlock" fault indication. To prevent an External Interlock fault from causing a Door Interlock fault status output, Q9-7 "inhibits" the Interlock String input to the Door Interlock status circuit.

P.7.8.1 "Interlock String" Input

The "Interlock String" input circuit consists of two sections of Q9. ("Inhibit" transistor Q9-7 will be described later; for now, assume that it remains OFF; that is, its collector is an open circuit.)

The Interlock Status input is normally a logic "HIGH" input when interlock relay K3 is energized. The logic HIGH to Q9-9 turns the transistor ON and the collector is pulled LOW. This will turn Q9-13 OFF, and bring the collector HIGH.

P.7.8.2 "Interlock String" Fault

An interlock string failure removes the +30 Vdc input to R87. Resistor R84 grounds Q9-9 and turns the transistor OFF. The collector goes HIGH, Q9-14 goes LOW to start the delay timer and after approximately 0.15 seconds a Door Interlock Fault output is generated.

P.7.8.3 "Inhibit" Transistor Q9-7

Transistor Q9-7 prevents an "Interlock String" fault caused by de-energizing External Interlock relay K3 from generating a "Door Interlock" status indication. When an "External Interlock fault-H" input occurs, both "Ext Intlk" input transistor Q8 and "Inhibit" transistor Q9-7 turn ON. Because Q9-7 is "ON," it pulls the collector line LOW, INHIBITING the "Intlk String Fault-H" input to Q9-13.

P.8 +5B Reset Circuit

The +5B Reset circuit is shown on Sheet 1 of the Controller schematic diagram, along the top. The circuit uses two sections of an LP339 low-power comparator.

All circuits supplied from the +5B backup supply are specified to operate reliably at supply voltages as low as +3 Vdc. If the +5B supply voltage drops below this value, the +5B RESET circuit generates two RESET signals: "+5B RESET-L", a logic LOW signal and "+5B RESET-H", a logic HIGH signal. These signals reset all latch outputs to zero.

The inverting input of comparator U37-1, at pin 6, is a +1.22 Volt reference voltage from zener diode CR8. The non-inverting input, at pin 7, is a sample of the +5B voltage from voltage divider R19-R20. Feedback resistor R32 introduces some hysteresis, so that the "Fault" outputs occur when the +5B supply drops below approximately +3.1 Vdc and clear again when the +5B supply increases above approximately +4.2 Vdc.

P.8.1 +5B Reset-L Output (U37-1)

The output of U37-1 goes LOW when the +5B supply drops below the comparator threshold, and provides the "+5B RESET-L" logic output.

P.8.2 +5B Reset-H Output (U37-14)

The input to U37-8 is the "+5B RESET-L" signal, and the non-inverting input is the +1.22 Volt reference. When U37-1 generates a "+5B RESET-L" Fault output, the output of U37-14 goes from zero to approximately the +5B supply voltage. This output is the "+5B RESET-H" logic signal.

WARNING: Disconnect primary power prior to servicing.

P.9 Power Supplies

On-board regulators supply +5 Vdc for all logic circuits on the Controller, and +15 Vdc and -15 Vdc for the analog meter drivers. A "+5B" back-up supply, which supplies all critical memory circuits when the transmitter's primary power fails or is turned off, is also located on the Controller.

These supplies also provide operating and backup voltages for LED Board. Sheet 5 of the Controller schematic diagram shows the voltage regulator circuits and "Supply Fault" logic circuits.

P.9.1 Voltage Regulator Integrated Circuits

Refer to SECTION M, DC Regulator, for descriptions of the voltage regulator circuits using UC3834 linear voltage regulator IC's.

P.9.2 +5B (Backup) Supply

The +5B supply includes BT1, BT2 and BT3 (optional back-up batteries), a one farad energy storage capacitor C44, diodes CR6 and CR7, and current limiting resistors R17 and R18. This circuit is shown on sheet 5 of the Controller schematic diagram.

P.9.2.1 Energy Storage Capacitor

The back-up supply uses a one farad low-voltage storage capacitor C44. The capacitor is charged from the +5 Vdc supply, through diode CR6 and resistor R17.

If the +5 Vdc supply is not active, either because of AC power loss or a supply fault, diode CR6 is reverse-biased. Capacitor C44 discharges only into the circuits on the Controller and LED Board. Total current drain on the back-up supply is less than 1 milliampere, so that the capacitor alone can maintain memory for two hours or more.

NOTE

All Integrated Circuits supplied by the +5B backup supply are low-power devices. Do not replace these IC's with devices from other logic families.

P.9.2.2 Back-up Supply Capacitor Charge Time

If the transmitter has been off for a long period of time and the back-up supply capacitor is discharged, it will take approximately one minute for the capacitor to charge.

NOTE

If back-up supply capacitor C44 has discharged, the transmitter control circuits will not respond for approximately one minute after first applying transmitter power. It will then be necessary to set HIGH, MEDIUM, and LOW power levels again.

P.9.3 Battery Back-up

If memory back-up for extended periods is required, AA batteries should be installed. Diode CR7 prevents reverse current flow into the batteries. DO NOT USE RECHARGEABLE BATTERIES, SUCH AS NiCad BATTERIES. This circuit is not designed to recharge batteries. Ordinary carbon batteries can be used, but alkaline batteries are recommended, as they are less likely to leak and their longer "shelf life" will be an advantage in this low-current application.

NOTE

Do not install back-up batteries unless C44 is charged (+5B voltage at TP6 is greater than 4.5 Volts). Current drain from the batteries into C44 will shorten battery life.

P.9.3.1 Replacing Batteries

Because of the very low current drain, the life of back-up batteries BT1, BT2, and BT3 should approach the battery shelf life. It is recommended that batteries be replaced yearly.

P.10 Supply Fault Circuits

Figure P-8 is a simplified diagram of the Supply Fault circuit on the Controller. If output voltage of any of the three voltage regulators is more than 10% low or 10% high, the regulator generates a "Fault Alert." A "Fault Alert" from any one of the three regulators on the Controller generates the following outputs:

a. Regulator Fault Summary: Illuminates LED DS1
b. "Data Clear-L" logic signal to Analog Input Board.
c. "Supply Fault-L" logic signal to power control logic, turn-on/turn-off control logic, and the LED Board.

"Supply Fault-L" and "Data Clear-L" logic signals are generated as soon as a "Fault Alert" output occurs, but are held LOW for approximately .25 seconds after the last Fault Alert on the board clears. This "off" delay is part of the AC Recycle function. When AC power returns after a power failure, the AC Recycle automatically turns the transmitter back ON at the same power level and output as before the power failure. This will occur if no other faults are detected and if the power has not been off long enough for the +5B back-up supply to discharged. The +5B supply retains power level and output power data memory for at approximately two hours with no batteries installed.

P.10.1 Regulator "Fault Alerts"

The fault alerts connect to a common line, which is logic HIGH when no supply faults exist and logic LOW if one or more regulators have active "Fault Alert" outputs. This supply fault line goes to a "Regulator Fault Summary" indicator and to a "Fast on-slow off" delay circuit.

If all "Fault Alert" outputs are "HIGH" the inputs to inverters U49-2 and U50-2 are pulled to +5 Vdc by R36. If a +5 Vdc or +15 Vdc supply "Fault Alert" is present, the inputs to U49-2 and U50-2 will be logic LOW. If the -15 Volt supply "Fault Alert" is present, R35 and R109 form a voltage divider and Schottky diode CR11 conducts to clamp the inputs to U49-1 and U50-1 at a few tenths of a Volt negative.

P.10.2 "Regulator Fault Summary" Indicator, DS1

When there are no Fault Alerts, inverter U50-2 is LOW and DS1 is off. When a "Fault" occurs in one or more regulators, U50-2 goes HIGH and illuminates DS1.

P.10.3 "Fast On-Slow Off" Delay Circuit (U49-4)

This delay performs an "AC Power recycle" function. When AC power returns after a power failure, the "slow off" holds the

Supply Fault logic outputs LOW until all Controller power supply voltages are normal. This allows time for other transmitter supplies to reach normal voltages and clear the Type 1 fault induced “off” command before a “power level latch” inhibit is removed.

P.10.3.1 “Fast On”

When a supply fault occurs, the output of U49-2 goes HIGH and charges capacitor C71 through diode CR12 and a 100 Ohm resistor R37. When the rising voltage across C71 goes above the threshold of inverting Schmitt trigger, U49-4 goes LOW.

P.10.3.2 “Slow Off”

When the supply fault clears, the output of U49-2 goes LOW and capacitor C71 discharges through R38. Inverting Schmitt trigger U49-4 remains LOW until the voltage across C71 drops below the trigger threshold again. This provides a “delay off” for the Data Clear and Supply Fault logic signals.

P.10.4 “Data Clear-L” signal

Two inverters, U49-6/10, are used together as a non-inverting logic buffer to provide a “Data Clear” signal to the Analog Input Board. The “Data Clear-L” signal will clear all BCD information in the power control latches.

P.10.5 “Supply Fault-L” signal to LED Board

The “Supply Fault-L” signal is sent to the LED Board at J8-11 (sheet 1 of the Controller schematic). The signal is used to trigger the “VSWR Self-Test” circuit and to clock any overloads present on AC restart.

P.11 Analog Metering Buffer/Drivers

Sheet 6 of the Controller schematic diagram includes operational amplifier buffer/drivers, and voltmeter multiplier resistors, for analog metering. All buffer/drivers are configured as voltage followers, with gain of 1, high impedance inputs, and low impedance outputs.

P.11.1 Forward and Reflected Power Metering

Signals for the front panel and remote metering are supplied by U65. Input signals for these circuits come from the Output Monitor through the LED Board. Outputs of these circuits go to the Switch Board/Meter Panel and the External Interface.

P.11.2 VSWR Detector Null Metering (U64)

Four voltage followers buffer the Output Network VSWR Null and Load Network VSWR Null signals. U64-14 and U64-1 drive the front-panel multimeter on the transmitter, and voltage multiplier resistors R67 and R68 are in series with the op-amp’s low impedance output. U64-7 and U64-8 drive the external interface, and have voltage dividers at their outputs.

P.11.3 Supply Volts Metering (U63C)

Only one section of U63 is used, and is shown on sheet 5. This voltage follower drives both the front panel multimeter, through voltmeter multiplier resistor R54, and the External Interface, through voltage divider R70 and R78

P.12 AC Power Recycle (Recycle “On” After Power Failure)

When primary AC is restored after a power failure, the transmitter will automatically recycle ON at the same power level and operating condition as before the power failure, unless the power failure was long enough to discharge the +5B “memory back-up supply.”

The AC Power Recycle function can be divided into two parts:

a. First, the latched power level generates a turn-on request when an “inhibit” is released.

b. Second, when power is first applied to the transmitter, a fault-generated “off” command is generated but is not latched because the latch “clock” signal is inhibited.

P.12.1 Generates Turn-on Request

The power level at the time of the power failure is still latched in power level latch U40. When all supplies are up to normal voltage and the “Fault” input clears, the “inhibit” inputs of the three power level inhibit gates go high. The output of the gate for the power level latched in U40 (HIGH, MEDIUM or LOW) goes HIGH, and generates a“Turn-On Request” to U56-2. When the “Supply Fault” delay returns U56-3 to HIGH, the transition begins the step-start sequence.

P.12.2 Inhibited OFF command

When AC power comes back on, various regulated power supplies on printed circuit boards generate “Supply Fault” outputs until the supplies are within 10% of their normal output voltage. As long as any “Supply Fault” signal is present, a “Type 1 Fault” signal input is present to the turn-on/turn-off control logic.

This “fault” also generates an OFF command, but this is not clocked into the power level latch because the “clock” pulse is inhibited, by the delayed “Supply Fault.”

Until the transmitter power supplies come up to normal voltage, “Supply Fault” logic outputs generate a Type 1 Fault. The “Type 1 fault” generates an “OFF” command to Q5-6 from the output of U51-8. The command is decoded and sent to power level latch U40. However, it is not latched because the “Clock” input to the latch is inhibited until approximately five seconds after the Controller regulator outputs reach their normal voltages.

The “OFF” command is INHIBITED when pins 1 and 2 of gate U57 are held LOW, by the “Supply Fault-L” signal. This forces the latch’s output HIGH so that the clock signal is inhibited from latching U40.

P.12.3 Supply Fault-L, Five second “Off” delay

Input commands, including the fault-induced “Off” command, cannot be latched during the five-second delay. During this delay, the outputs of digital Power Data latches U17 and U18 on the Analog Input Board are also held at zero by the “Data Clear-L” signal generated from the “Supply Fault-L.” The PA Supply should be ON by the end of this five-second delay. The power output is still zero, and a “Data Strobe” is generated when the “Data Clear-L” signal is removed.

WARNING: Disconnect primary power prior to servicing.

SUMMARY: When AC power fails while the transmitter is operating, the current power level, and digital power output data, are stored in the power level latch (U40) and in the up-down counters, which operate from a memory back-up supply (+5B supply). Within a few tenths of a second after power returns, a "Turn-on Command" is generated by the local (Controller) supply regulator fault logic to start the step-start and turn-on sequence. This request is generated after regulators on various boards are up to normal voltage and all "Supply Fault" (undervoltage) logic signals are cleared.

The "Supply Fault" signals also generate a Type 1 Fault induced "OFF" command, but a five-second delay in the Controller supply fault circuit inhibits this command so it is not latched. The Controller "Supply Fault-L" signal also causes a "Data Clear-L" which clears the data latches on the Analog Input Board. When the Data Clear goes HIGH after the five-second delay, the low-to-high transition generates a "Data Strobe" pulse to latch digital power data.

Table P-1. Controller Board A38, Controls & Indicators

COMPONENT	FUNCTION/DESCRIPTION
BT1, BT2, BT3	Battery holders for three 1.5 Volt AA cells, for optional long-term battery back-up for +5B supply. (DO NOT USE RECHARGEABLE BATTERIES).
DS1	Red LED illuminates if one or more voltage regulators provides a Fault Alert (+5, +15 and -15 V supplies fail).
F3	Protects +8 Volt unregulated supply if +5 V supply short circuit failure occurs.
F1	Protects +22 Volt unregulated supply if +15 V supply short circuit failure occurs.
F2	Protects -22 Volt unregulated supply if -15 V supply short circuit failure occurs.
S1	Depress S4 for Fast Power Set; may be used when initially setting Low, Medium and High power levels if an extended power failure or internal memory reset has cleared power setting information.
S2	In PA Off position, provides PA Off logic signal to modulation encoder to turn all PA modules off without turning off +230 Volt high voltage supply.

Table P-2. Controller Board A38, Test Points

TEST POINT	FUNCTION/DESCRIPTION
TP2	Test point for regulated +5 V.
TP3	Test point for regulated +15 V.
TP7	Test point for regulated -15 V.
TP6	Test point for +5B memory back-up supply voltage.
TP8	Ground.
TP1	Ground.
TP5	Ground.
TP4	Ground.

Q.1 Introduction

This section describes the LED Board, and includes circuit functions and descriptions.

The LED Board includes fault and overload detection circuits, logic and status indicator latches, and drivers for both front-panel and remote status indicators. The transmitter ColorStat™ panel indicators are mounted on the LED Board.

Q.2 Location

The LED Board is located on the back of the Center Control Compartment door. The ColorStat™ panel LED indicators are mounted on the back of the LED Board.

Q.3 Transmitter Fault Types

The fault and overload circuits in the transmitter can be grouped into "FAULT TYPES," depending on the action taken when a fault is detected. The following paragraphs describe each fault type, the corrective action taken when the fault occurs, and fault indications. Refer to table Q-1 for a list of faults and overloads by fault type.

Q.3.1 Type 1 Fault: Turns Transmitter Off

Type 1 faults generate an "OFF" command and remove the +230 VDC by de-energizing the PA Power Supply contactors. The transmitter must be manually turned back "ON" after the fault is cleared. The appropriate ColorStat™ panel LED will latch RED.

Q.3.2 Type 2 Fault: Recycles Transmitter Off/On One Time

Type 2 Faults may be temporary. To determine if they can be cleared, Type 2 Faults de-energize the PA Power Supply contactors for approximately one second, then turn the transmitter back "ON" by starting a normal step-start cycle. Type 2 Faults also cause the transmitter ColorStat™ panel indicator to latch red.

Q.3.2.1 Repeated Type 2 Faults Become Type 1 Faults

If the same fault is detected as soon as the transmitter is cycled back ON, it becomes a Type 1 Fault and turns the transmitter "OFF."

Q.3.3 Type 3 Fault: Lowers Transmitter Power

A Type 3 Fault will reduce transmitter power until the fault condition is within limits.

Type 3 Faults occur when repeated VSWR "hits" occur in a short period of time, indicating high reflected power, or if the PA module temperature reaches dangerous levels. The temperature monitor circuit on the Driver Encoder/Temp Sense Board will begin a "Temperature Induced Lower" command to reduce power until the temperature level is within limits. For a VSWR lower condition, the appropriate indicator on the ColorStat™ panel will latch RED. For Temperature Induced Lower" condition, the OVER TEMP LED on the Driver Encoder/Temp Sense Board will latch RED to indicate power reduction has occurred.

A single VSWR trip does not lower transmitter power, but generates a Type 4 fault and turns the PA OFF for 14 to 19 milliseconds. If the VSWR fault is caused by an arc, lightning, static discharge, or other transient condition, the cause of the VSWR fault will clear. Single VSWR trips cause a 0.5 second RED indication on the ColorStat™ panel or a 0.5 second remote "VSWR" indication.

A REMOTE "Type 3 Fault" indication is also available to signal the operator that transmitter power has been lowered.

Q.3.4 Type 4 Fault: Applies PA Turnoff

A Type 4 Fault will turn the RF OFF, zero output power, but the PA Power Supply will remain energized. This fault sends a "PA Off" logic signal to the Modulation Encoder and Analog Input Board to clear all power control data and turn all RF Power Amplifier modules OFF. A Type 4 Fault causes a RED indication on the ColorStat™ panel until the fault is corrected.

Q.3.5 Type 5 Fault: Clears Modulator Data

A Conversion Error from the Analog to Digital Converter will clear all Digital Data to the Modulation Encoders and result in a PA OFF condition, similar to a Type 4 Fault. The "Conversion Error" LED on the ColorStat™ panel will turn RED.

Q.3.6 Type 6 Fault: PA Module Blown Fuse Indication

A Blown Fuse indication is caused by any PA Module with a blown fuse. The indication is present only when the PA Power Supply is energized. The indication is not latched and resets when the module is repaired or substituted by FlexPatch™ procedure.

Q.4 Block Diagram Description

The Block Diagram description of the LED Board refers to Figure Q-1, "LED Board Block Diagram."

The LED Board contains Fault and Overload circuits, which can be divided into blocks or sections by "Fault Type." For most faults, there are FAULT DETECTION or FAULT SENSING circuits, LOGIC circuits, STATUS INDICATOR circuits and an EXTERNAL STATUS output.

Type 1, Type 2, Type 3, and Type 4 faults cause ACTION in other sections of the transmitter. For each of these Fault Types there is an OR function and one or more signal outputs to other parts of the transmitter. Other faults provide only FAULT INDICATIONS on the ColorStat™ panel.

Fault and Overload circuits are reliable and generally trouble-free. Therefore, maintenance staff will have few opportunities to become familiar with circuit operation by troubleshooting. If circuit or component failures occur, the Block Diagram is useful for isolating the problem to a particular circuit.

Q.4.1 Type 1 Faults

If any Type 1 Fault Detection circuit on the LED Board senses a fault, OR gate U32 provides a logic HIGH output. If the output of U32 goes HIGH, or if a Type 2 fault repeats when the transmitter cycles back ON, U19-8 goes logic HIGH. Pulse stretcher and OR gate U70A ensure that a “Type 1 Fault-H” to the Controller section turns the transmitter OFF and prevents the transmitter from turning back ON for approximately 1 second or for as long as the Type 1 Fault is still present.

“RESET A” and “RESET B” inputs to Type 1 Fault logic reset the LED indicators on the ColorStat™ panel. The fault detection circuits clear and remove the “Fault-H” output when the Fault is cleared; they do not clear the fault indication on the ColorStat™ panel. Clearing the fault will not reset the status indication; the RESET button on the ColorStat™ panel must be depressed, or a

Table Q-1. DX 25U Fault Types

TYPE 1	TURNS PA POWER SUPPLY OFF (Manual Restart Required)
EXT	External Interlock
AIR	Air Flow Fault
DOOR	Door Interlock
SUPPLY FAULT	PA Power Supply Protection
OVER VOLTAGE	PA Power Supply Overvoltage Protection
CABLE INTERLOCK	Modulation and Driver Encoder Cables
B+	DC Regulator B+ Regulated Fault
B-	DC Regulator B- Regulator Fault
+5V	Output Monitor +5V on board Regulator Fault
+15V	Output Monitor +15V on board Regulator Fault
REPEATING TYPE 2 FAULT	See NOTE below
TYPE 2	TURNS PA POWER SUPPLY OFF (Recycles Back ON)
UNDER DRIVE	RF Drive Level to PA LOW
OVER DRIVE	RF Drive Level to PA HIGH
OVER CURRENT *	PA Power Supply +230 Vdc Overload
* Transmitter will attempt to limit current first, then shut off high voltage if limiting is not sufficient.	
NOTE: If Type 2 fault condition is still present when the transmitter cycles back on,or repeats within 2.4 seconds after the transmitter cycles back on, it becomes a Type 1 fault and will require a manual restart.	
TYPE 3	LOWER POWER OUTPUT
BANDPASS VSWR	Output Monitor detects sucessive VSWR’s
ANT. VSWR	Output Monitor detects sucessive VSWR’s
TEMPERATURE	Driver Encoder/Temp Sensor detects an over temperature condition
TYPE 4	PA TURN OFF ONLY (PA Kill only, High Voltage Remains ON)
BANDPASS VSWR	Output Monitor detects one shot VSWR
ANT. VSWR	Output Monitor detects one shot VSWR
+15V	A/D Converter on board +15V Regulator Fault
-15V	A/D Converter on board -15V Regulator Fault
+5V	A/D Converter on board +5V Regulator Fault
+15V	Analog Input on board +15V Regulator Fault
-15V	Analog Input on board -15V Regulator Fault
TYPE 5	CLEAR MODULATOR DIGITAL AUDIO DATA
CONVERSION ERROR	A/D Converter
TYPE 6	FAULT DISPLAY ONLY
RF AMP	PA RF Amplifier Fuse Blown

WARNING: Disconnect primary power prior to servicing.

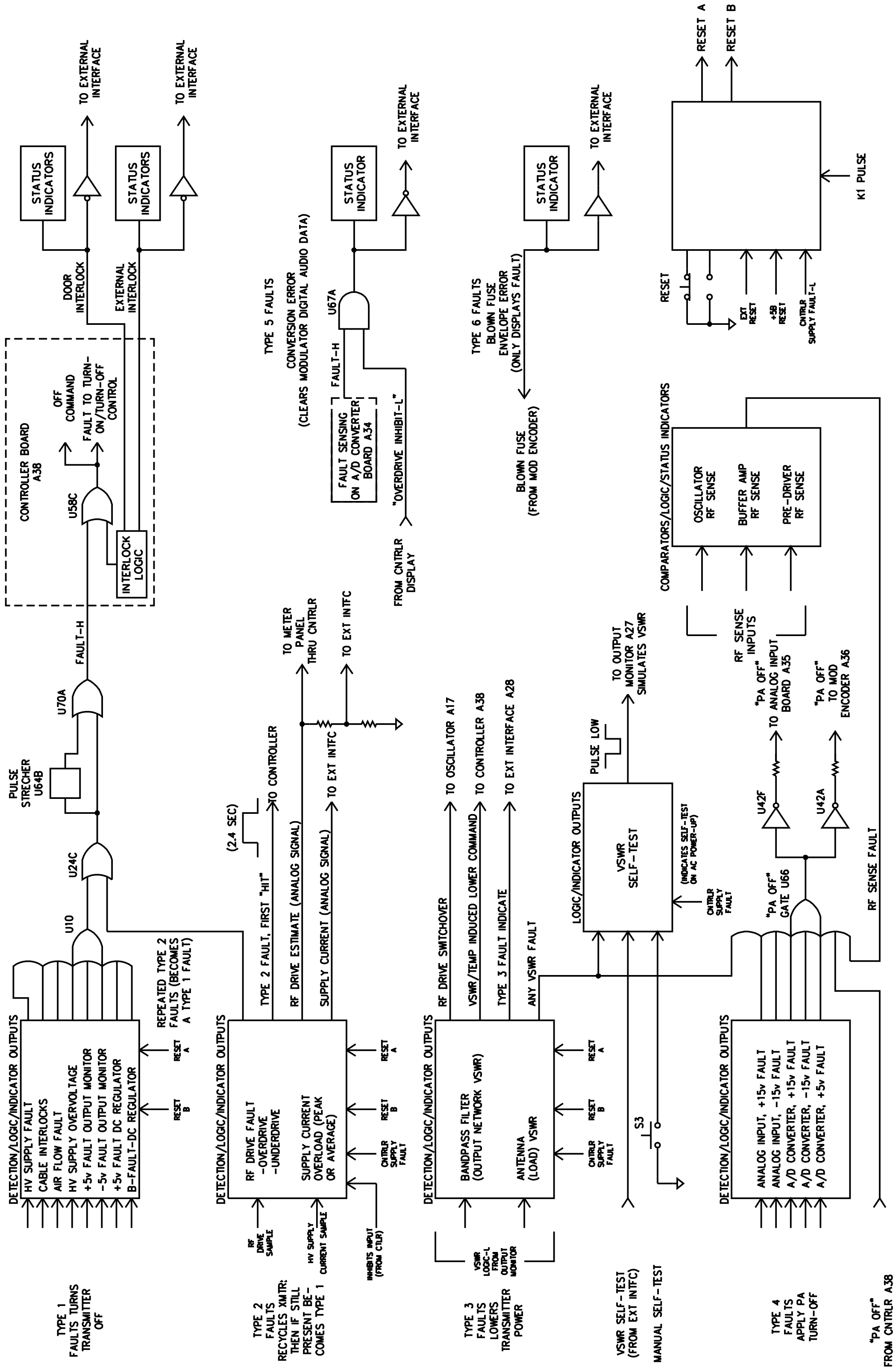

Figure Q-1
LED Board Block Diagram

WARNING: Disconnect primary power prior to servicing.

remote "Reset" control input must be received to reset fault INDICATIONS.

Q.4.2 Type 2 Faults

An RF Overdrive, RF Underdrive or a Supply Current Overload generates a "Type 2 Fault" signal, a logic HIGH pulse approximately 1 second long. This pulse goes to the turn-on/turn-off logic on the Controller to cycle the transmitter OFF and then back ON. If the same fault occurs again when the transmitter is cycled back ON, a "Fault-H" output goes to U19-10. The Type 2 fault then becomes a Type 1 fault and turns the transmitter OFF.

An "RF Drive Estimate," an analog voltage, is also derived from the Underdrive Fault Sense circuit. This voltage provides an uncalibrated RELATIVE RF DRIVE indication on the front panel multimeter and also provides an uncalibrated remote "RF Drive Estimate" reading.

A "Supply Current" sample, an analog voltage, is derived from the Supply Current Overload sense circuit for remote current metering.

Inhibit inputs from the Controller operate during transmitter turn-on. These inputs disable fault sensing until RF drive has time to stabilize and prevent false indications when AC power is initially applied or is re-applied to the transmitter.

The "Reset A" and "Reset B" function is the same as for Type 1 Faults.

Q.4.3 Type 3 Faults

Type 3 Faults are VSWR faults or Temperature Induced LOWER faults. Single VSWR "hits" simply turn the PA OFF for 14 to 19 milliseconds, by a "VSWR-H" logic pulse to "PA Off" OR gate U40. Long-term reflected power causes repeated VSWR "hits" which lower transmitter power until the reflected power is below the VSWR detector threshold. A "VSWR/Temp Induced Lower" logic signal to the Controller operates the LOWER command.

Inputs to "Type 3 Fault" VSWR logic on the LED Board are logic LOW pulses from the Output Monitor, and a logic HIGH input from the Driver Encoder/Temp Sense Board.

In addition to the "VSWR-H" logic pulse to PA Off Gate U40, the VSWR Logic on the LED Board also generates an RF Drive Switch-over logic signal, a VSWR/Temp Induced Lower Command, a remote "Type 3 Fault" status indication logic output, and a "VSWR-H" logic signal to the VSWR Self-Test circuits.

A "Controller Supply Fault-L" input disables fault circuits to prevent false indications when AC power is initially applied or is re-applied.

The "Reset A" and "Reset B" function is the same as for Type 1 Faults.

Additional descriptions for circuits using the output from the VSWR Fault Logic can be found as follows:

a. RF Drive Switch-over signal: Refer to SECTION A, Oscillator.

b. VSWR Induced Lower: Refer to SECTION P, Controller.

The VSWR Self-Test circuit checks the VSWR Fault logic by simulating a VSWR signal from the Output Monitor phase detector output. The VSWR Fault logic circuit is checked each time AC power is initially applied or re-applied. There is also a Manual SELF TEST button on the ColorStat™ panel to check the operation of the circuit at any time.

NOTE

Depressing this button will cause a PA OFF command, and output power will momentarily decrease.

Q.4.4 Type 4 Faults

Type 4 faults include all supply faults on the Analog Input Board and Analog to Digital Converter. A supply fault on either board affects the digital data to the PA modules. A Type 4 Fault generates a "PA Off" output to the modulation encoder and turns all PA modules OFF.

Q.4.5 Type 5 Faults

Type 5 Faults are Conversion Error faults generated by circuits on the Analog to Digital Converter and then sent to a status indicator circuit on the LED Board. For a description of Conversion Error fault circuits, refer to SECTION K, Analog to Digital Converter.

Q.4.6 Type 6 Faults

Type 6 Faults are Blown Fuse faults from an open B+ fuse on a PA Module. A PA Module failure results in missing "Steps" that make up the modulated RF signal. Blown Fuse faults generate a "Fault" status indication to alert the operator of a Fault condition, but do not result in any change in the operation of the transmitter.

Q.4.7 RF Sense Circuits

RF Sense circuits on the LED Board operate "Oscillator," "Buffer," and "Predriver" indicators on the ColorStat™ panel. If RF output is present at each stage, all three status indicators are GREEN. If a stage fails, the status indicator for that stage will be RED.

Q.4.8 Reset Circuit

The RESET circuit resets Type 1, Type 2 or Type 3 Fault LED INDICATIONS on the ColorStat™ panel. Fault DETECTION circuits act whenever a fault is present, whether the LED indication has been "reset" or not. As soon as a fault is cleared, the transmitter can be turned back ON, even if the indication has not been "reset."

As long as a Type 1 Fault is present, the transmitter will remain OFF and cannot be turned back ON (except for "Supply Fault" and "Overvoltage" faults which will turn the transmitter OFF during or immediately after the step-start sequence if still present).

For Type 2 faults, the transmitter can be turned ON again, but if the cause of the fault remains (Supply Overload, Overdrive or Underdrive), the Type 2 fault circuits will operate again.

Type 3 Faults lower power and do not turn the PA Power Supply OFF. A fault indication indicates that the power output has been decreased.

NOTE

"ON" and "OFF" refer to the PA Power Supply (+230 VDC, +115 VDC and +60 VDC). The Low Voltage Supply, (+30 VDC, +22 VDC, +8 VDC, -22 VDC and -8 VDC), remains ON whenever main AC power is present and Low Voltage Supply circuit breakers CB1 and CB2 are ON.

Refer to Figure Q-2, simplified diagram of the RESET circuit and RESET function, for the following description.

Q.4.8.1 Reset Circuit Inputs

The reset circuit clears fault indications on the ColorStat™ panel and remote fault indications whenever:

a. The RESET button on the ColorStat™ panel is pressed.
b. A remote "RESET" command is received from the External Interface.
c. A "+5B Reset" signal is generated by the +5B reset circuit on the Controller.

Other Reset Circuit Inputs include:

a. INHIBIT RESET (during turn-on): An inverted "K1 START PULSE" from the Controller is logic LOW during step-start, and prevents any indication from being "reset."
b. CONTROLLER SUPPLY FAULT-L: When AC power is first applied, the "Supply Fault-L" input holds "Reset B" LOW to inhibit false triggering until after the 1 second Supply Fault delay.

Fault indication latches all operate from the +5B supply, so that any fault indications "latched" before a power failure will remain latched unless the "+5B Reset" circuit operates.

The RESET circuit also operates from the +5B back-up supply. If the +5B voltage decreases, the "+5B Reset" will clear all fault indications before latch operation becomes unreliable.

Q.4.8.2 Reset Circuit Outputs

The Reset Circuit has two outputs, "Reset A" and "Reset B." Both outputs are logic LOW during a reset, but the "Reset B" LOW-to-HIGH transition is delayed slightly and occurs after the "Reset A" LOW-to HIGH-transition. The two outputs function as follows:

a. "Reset A" CLEARS all fault indication latches.
b. "Reset B" CLOCKS any fault which is still present into the latches again when the RESET command is released.

Q.4.8.2.1 "Reset A" And "Reset B" Operation

When a RESET command is generated, "Reset A" goes LOW, and clears all fault status indication latches. At the end of the RESET command, "Reset A" goes HIGH. After approximately 60 nanoseconds "Reset B" goes HIGH. If the fault is still present, the fault detection circuit output and one Retrigger Gate input are still HIGH. When "Reset B" goes HIGH the Retrigger Gate output also goes HIGH and triggers the latch again.

Q.4.8.3 Latch Outputs

The following description refers to Figure Q-3, "Latched Fault Status Indications, Simplified Diagram." Only the latch outputs are shown in the figure.

During normal operation, the latch NOT-Q output is HIGH, and is inverted to provide a logic LOW output to the External Interface. The Q output is LOW when there is no latched fault, and is inverted to a logic HIGH signal which illuminates the GREEN section of the LED.

A LOW-to-HIGH TRANSITION at the CLOCK input from a fault detection circuit causes the Q output to go HIGH and the NOT-Q output to go LOW, illuminating the RED LED section and turning off the green section. The "D" and "Preset" inputs are held HIGH, through a resistor to +5 VDC.

Type 1, Type 2, and latched Type 3 FAULT indications can be RESET by depressing the RESET button on the ColorStat™ panel or by providing a remote "Reset" command; the indications will then change from RED to GREEN if the fault has cleared. If the fault is still present, the status indicator will change to RED again when the RESET button is released or when the remote "Reset" command ends.

EXCEPTIONS: DOOR INTERLOCK and EXTERNAL INTERLOCK status indications clear as soon as the door is properly closed or the cause of the external interlock is corrected.

To summarize LATCH operation:

a. A LOW-to-HIGH TRANSITION at a latch CLOCK input generates a RED FAULT indication.
b. A logic LOW at a latch CLEAR input resets the fault indication GREEN.

Q.4.8.4 Retrigger Gate Operation

The output of the Retrigger gate is a LOW-to-HIGH transition at the Latch CLOCK input when:

a. A FAULT is detected and "Reset B" is HIGH (there is no "Reset B" in progress), OR
b. "Reset B" goes from LOW to HIGH while a fault is still present (the fault detection circuit output is HIGH). Reset B goes from LOW to HIGH:
   1. At the end of a manually generated "Reset" pulse.
   2. On initial application or re-application of AC power, when the "Controller Supply Fault-L" logic signal goes from LOW to HIGH.

If a "+5B Reset" is generated, there will be no voltage for the fault detection circuits or for most other logic, and the fault detection circuit outputs will all be LOW. The latches will be cleared.

Q.5 Circuit Descriptions

Refer to the LED Board schematic, 839-7855-184, in the Drawing Package and to simplified diagrams in this section, as noted.

WARNING: Disconnect primary power prior to servicing.

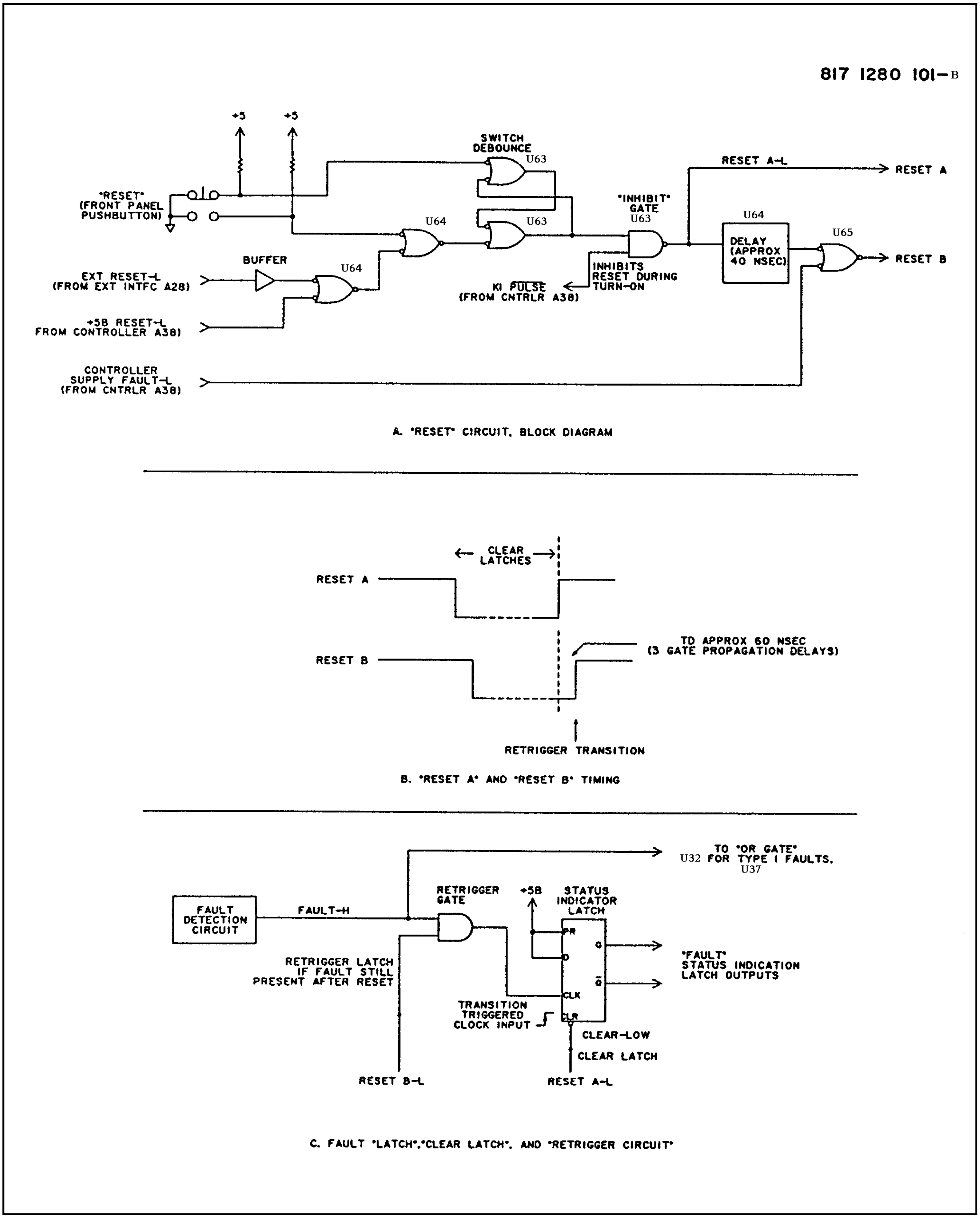

Figure Q-2. Reset Circuit, Simplified Diagram
817 1280 101-A

Q.5.1 Reset Circuit

The reset circuit is on sheet 1 of the LED Board schematic diagram, 839-7855-184, in the Drawing Package. The circuit includes gates U63, U64, and U65, and two U66 inverting Schmitt triggers.

Q.5.1.1 External Reset/+5B Reset

Either an "EXT RESET" or a "+5B RESET" logic LOW input will cause U64-11 to go LOW. The EXT RESET input is from an opto-isolator on the External Interface. This will pull the input of the buffer and one input to U64 LOW when a remote "Reset" command is given. The "+5B RESET" is a logic LOW signal from the +5B Reset circuit on the Controller.

When U64-11 goes LOW, U64-3 is forced LOW, and U63-11 is forced HIGH. This is the "RESET-H" logic signal when either an "EXT" reset or a "+5B Reset" occur.

Q.5.1.2 "Reset" Switch

The RESET switch is on the ColorStat™ panel. Depressing the RESET switch also generates a RESET-H logic signal at U63-11.

Q.5.1.3 Switch De-bounce

A switch de-bounce function is performed by U63 pins 8 and 11 for the RESET inputs.

Q.5.1.4 Inhibit Gate

Inhibit gate U63-6 blocks any "Resets" during the transmitter's step-start cycle. When the turn-on/turn-off logic on the Controller provides a "K1 Drive" pulse for step-start contactor K1, the logic LOW "K1 NOT-pulse" holds U63-6 HIGH.

Q.5.1.5 Reset A

U63-6 is the "Reset A-L" signal which clears the status indicator latches.

Q.5.1.6 Reset B

The "Reset A-L" signal is delayed approximately 60 nanoseconds plus the gate propagation delay through U65-6. The delayed "Reset B" retriggers the fault indicator latch if a fault is still present after a "Reset".

Q.5.2 Type 1 Fault Circuits

Type 1 Faults turn the transmitter OFF, by providing a Type 1 Fault logic HIGH signal to the turn-on/turn-off logic on Controller. The following paragraphs will first describe Type 1 Fault logic, from fault detection circuit outputs, and then will describe fault detection circuits for each Type 1 fault.

Type 1 Fault circuits described in this section include:

a. Air Flow Fault.
b. PA Power Supply Fault
c. PA Power Supply Overvoltage.
d. Cable Interlock Fault
e. Output Monitor, +5 Volt Supply Fault.
f. Output Monitor, -5 Volt Supply Fault.
g. DC Regulator, B+ Supply Fault.
h. DC Regulator, B- Supply Fault.

Additional Type 1 Fault circuits described in other parts of this Technical Manual include:

a. Door Interlock logic: Refer to SECTION P, Controller.
b. External Interlock logic: Refer to SECTION P, Controller.
c. Repeated Type 2 Faults become Type 1 Faults, and are described later in this section, as "Type 2 Faults."

Q.5.2.1 Type 1 Fault Logic

Type 1 Fault logic on the LED Board is shown on sheet 1 of the LED Board schematic, 839-7855-184, at grid locations C1 through C3.

Type 1 Fault logic includes OR gate U32, OR gate U19-8, "pulse stretcher" U42-9, and OR gate U50-3. The "Type 1 Fault-H" output from U50-3 goes to the Controller.

Eight-input OR gate U32 has inputs from eight fault detection circuits. If any Type 1 fault occurs, a logic HIGH signal at an input causes U32 output to go HIGH. The "Type 1 Fault" output goes to pin 9 of two-input OR gate U19. The second input is a logic HIGH signal if a "repeated Type 2 Fault" occurs.

Pulse stretcher U42-9 and OR gate U50-3 ensure that any Type 1 Fault will generate at least a 2.4 second transmitter turn-off pulse.

Q.5.2.1.1 Pulse Stretcher U42-9

During normal transmitter operation, the Q output of U42-9 is LOW, and the NOT-Q output is HIGH so that capacitor C103 is charged and holds the CLEAR input HIGH. The "D" and "PR" inputs are always held HIGH, so that a LOW-to-HIGH transition at the Clock input will trigger the latch. When a Type 1 Fault is detected, the LOW-to-HIGH transition at the U42-11 CLOCK input triggers the latch. The Q output goes HIGH and the NOT-Q output goes LOW. Capacitor C103 discharges through resistor R125. When the voltage across C103 goes low enough, U42 "CLEARS." When U42 clears, the Q output goes LOW again and the NOT-Q output goes HIGH. The output of U50-3 will be HIGH if the Q output is HIGH, if a "Type 1 Fault-H" is present, or if both inputs are HIGH. The LED Board "Type 1 Fault" output will be high for 2.4 seconds, or as long as the Type 1 Fault is present, whichever condition lasts longest.

Q.5.2.2 Air Flow Fault Sensing

The Air Flow Fault circuit includes an air flow sensing unit, U62 on the Driver Encoder/Temp Sense Board, and logic on the LED Board. A "Reduced air flow" fault occurs if one fan fails or if the air flow is reduced to the level caused by the failure of one of the four fans. The AIR LED on the ColorStat™ panel will turn AMBER and the transmitter will continue to operate normally.

An "Air Flow Fault" occurs if two fans fail or there is insufficient air flow to properly cool the RF Amplifier modules. The AIR LED on the ColorStat™ panel will turn RED and the transmitter will turn OFF. Causes of insufficient air flow include fan failure, incorrect blower motor phase, missing or loose panels on the back of the transmitter.

Q.5.2.3 "Air Flow Fault" Logic

Air Flow Logic includes:

a. INHIBIT gate U20-6. The Inhibit Gate output is the "Air Flow Fault," logic HIGH signal to Type 1 Fault OR gate U32.

WARNING: Disconnect primary power prior to servicing.

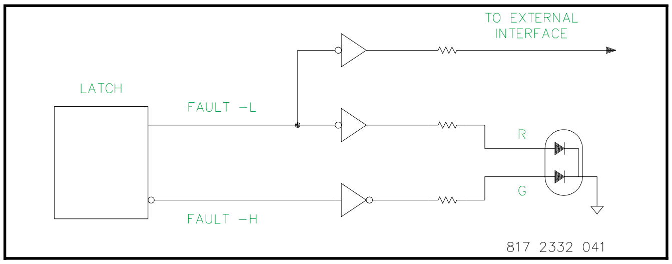

Figure Q-3. Latched Fault Status Indicators, Simplified Diagram

b. Inhibit circuit U21 pins 4, 6, and 8, U20-3, and U63-3. The "Inhibit" input is the "Overdrive Inhibit" from the Controller turn-on/turn-off logic. The "Inhibit" logic:
   1. Inhibits Air Flow Fault sensing when the transmitter is OFF, during turn-on, and for a few seconds after turn-on to allow air flow to be established.
   2. Turns the "AIR LED" OFF for approximately 20 seconds after the PA turns on. This prevents a GREEN indication from being displayed until air flow is established.

c. Status Indicator latch and indicator drive circuits U34-11, U35-5, U62 pins 8 and 11, U54 pins 8 and 10.

d. Status indicator "Inhibit" gates U62 pins 8 and 11. These gates turn off the ColorStat™ indicator for a short time after initial turn-on.

Q.5.2.3.1 *Reduced Air Flow*

If reduced air flow is detected by circuits on the Driver Encoder/Temp Sense Board, J5-6 will go to logic HIGH. This will force the output of U60 HIGH and illuminate the RED segment of DS22 through U62-11 and U54-8. The combination of the RED and GREEN segments will produce an AMBER indication on the ColorStat™ panel. This provides visual indication of a developing air flow problem. The transmitter will operate normally under this condition, and no fault is triggered.

Q.5.2.3.2 *Insufficient Air Flow*

The output from the airflow switch U17 on the Driver Encoder/Temp Sense Board is logic HIGH for a fault. U20-4 is the output from the airflow switch and the other input is an "Inhibit-L" input if the transmitter is OFF and for 20 seconds after turn-on.

The Inhibit-L at U20-5 will force the output LOW even if a fault occurs. When the Inhibit is removed and pin 5 goes HIGH, a normal air flow logic LOW signal from U17 holds U20-4 LOW, and an air flow FAULT-H causes U20-6 to go HIGH. The U20-6 FAULT-H output goes to Type 1 Fault gate U32 and to the status indicator circuit.

Q.5.2.3.3 *"Air Interlock" Status Indicator Circuit*

The Status Indicator circuit consists of Reset Retrigger AND gate U34-11, latch U35-5, inhibit gates U62-8 and U62-11, indicator drivers U54-8 and U54-10, reduced air flow gate U37, and AIR indicator LED DS22.

When a FAULT is latched, the Q output of U35 is HIGH and is fed through U37 to U62-13. The output of U62-11 is LOW and is inverted to a HIGH by U54-8, which illuminates the RED section of indicator DS22. The LOW NOT-Q output turns off the green section of DS22. The LOW NOT-Q output is inverted by U54-6 to provide an AIR FAULT-H logic signal to the External Interface.

Q.5.2.3.4 *Inhibit "Air Interlock" Status Indication (Gates U62 pins 8 and 11)*

When the transmitter is first turned ON and the Overdrive Inhibit is released, the "Inhibit" logic in the Air Flow circuit generates a 20 second logic LOW pulse which goes to U62-12 and U62-10. This logic LOW pulse holds both NAND outputs HIGH, preventing any status indication (either green or red).

Q.5.2.3.5 *Inhibit Logic*

The inhibit logic prevents an air flow fault from being sensed for 20 seconds after transmitter turn-on, to allow air flow to be established, and also turns off the Air Interlock status indicator during this time. Air flow fault circuit "inhibit" logic includes delay circuit U21 pins 4 and 6, gate U20-3 to provide an "Inhibit fault sensing" signal, invertor U21-11, and gate U63-3 to provide an "Inhibit indication" signal. The Inhibit Logic has one input and two outputs:

a. INPUT: "Overdrive Inhibit-L," from the turn-on/turn-off logic on the Controller. If the transmitter is OFF this input is logic LOW; approximately 1 second after the beginning of the turn-on step-start cycle the OVERDRIVE INHIBIT goes HIGH and releases the inhibit.

b. OUTPUT: "Inhibit Air Fault Sense-L," which inhibits Air Interlock Fault sensing. When the transmitter is OFF U20-3, is LOW. Approximately 20 seconds after the OVERDRIVE INHIBIT is released, the "Inhibit Air Fault Sense" is released and goes HIGH.

c. OUTPUT: "Inhibit Indicate-L." This output, from gate U63-3, is LOW for 20 seconds after the OVERDRIVE INHIBIT is released, then goes HIGH. The "Inhibit Indicate" turns the AIR Interlock indicator OFF for 20 seconds after the PA Power Supply is energized. Delay circuit U21-4/8 provides a "delay on - fast off" function, and operates as follows:
   1. When the transmitter is OFF, the delay circuit input (Overdrive Inhibit) is LOW, invertor U21-6 is HIGH, capacitor C71 is charged, and inverting Schmitt trigger U21-4 is LOW.
   2. When the "OVERDRIVE INHIBIT" is released and goes HIGH, U21-6 goes LOW and capacitor C71 begins discharging through R99. After approximately 20 seconds, the voltage across the capacitor drops below the threshold, and U21-4 goes HIGH. As long as the transmitter is ON, U21-4 remains HIGH.
   3. Diode CR9 provides a "fast off" function. The OVERDRIVE INHIBIT goes LOW when the transmitter turns OFF and U21-6 goes HIGH. The logic HIGH charges capacitor C71 through CR9 and R96.

Q.5.2.3.6 *Air Fault Sense Inhibit*

Gate U20-3 generates the "Air Fault Sense Inhibit" logic signal. When the transmitter is OFF, the OVERDRIVE INHIBIT and

Delay output are both LOW, both AND gate inputs are LOW, and U20-3 is LOW. When the Overdrive Inhibit is released (goes HIGH), U20-1 goes HIGH but U20-2 remains LOW for an additional 20 seconds because of the delay circuit. When the delay circuit output goes HIGH, gate U20-3 goes HIGH and Air Interlock Fault sensing is enabled.

When both inputs to U63-3 are HIGH, the “AIR” LED on the ColorStat™ panel is enabled through U62-8/11.

Q.5.2.4 PA Power Supply Protection Circuit

The PA Power Supply protection circuit protects three phase transformer T1 against a phase imbalance. Causes of transformer phase imbalance include a high or low phase voltage or loss of one phase.

Normally, the 12-phase power supply has a ripple frequency 12 times the power line frequency (that is, 600 Hz or 720 Hz). A phase imbalance causes a ripple component at two times the line frequency (100 Hz or 120 Hz). The input to the Power Supply Protection circuit is a sample of the +115 VDC supply ripple, from Fuse Board A24. The protection circuit includes a band-pass filter to detect 100 to 120 Hz, a peak detector, a comparator, and a delay circuit. The “delay” circuit prevents transient conditions from generating faults.

The Power Supply Protection circuit is shown on sheet 1 of the LED Board schematic diagram, 839-7855-184, at the top of the page, and includes three sections of both U1 and U27, U43, U14-4, U21-10/12, and U20-8.

Q.5.2.4.1 “PA Power Supply Ripple” Sample

On the LED Board, U1-14/8/7 make up a three-section active filter with a pass-band from approximately 95Hz to 126Hz. “Power Supply Protection Sensitivity” adjustment R86 adjusts the gain of non-inverting amplifier stage U27-14.

The input to U27-10, at test point TP9, is a power supply ripple sample, and the output, at test point TP10, is a DC sample of the peak input voltage.

A voltage divider, R135-R141, sets the reference voltage at the inverting input of U43 and is measured at TP11. If the ripple component increases sufficiently, the signal input at the non-inverting input becomes greater than the reference voltage and the output of U43-7 will go to logic HIGH.

Q.5.2.4.2 Delay Circuit

When a FAULT is detected, the output of U43 goes HIGH and forces U20-9 HIGH. A delay circuit consisting of R103, C76, U21-10/12 prevent the other input, U20-10, from going HIGH for approximately 1.5 seconds. This delay prevents transient conditions on the power line from causing “fault” outputs.

Q.5.2.5 PA Power Supply “Overvoltage” Circuit

The PA Power Supply Overvoltage sensing circuit is shown on Sheet 4 of the LED Board schematic diagram (at grid locations B6-B8). A voltage divider on Fuse Board A24 provides a sample of the +230 VDC supply to the non-inverting input of voltage comparator U1-1 on the LED Board. The inverting input of the comparator is a fixed reference voltage derived from the +15 VDC regulated supply.

Normally, the sample is lower than the reference voltage, and the comparator output goes to -15 VDC. Diode CR3 clamps the voltage to the input of Logic Level Down Converter U14-3. The down converter output is a TTL level logic LOW signal to “Main Power Supply: Over Voltage” status indicator circuit.

If the supply voltage exceeds the preset threshold, the output of comparator U1A goes to +15 VDC, then is converted to a TTL level logic HIGH signal by U14-2. The logic HIGH input to the status indicator latch circuit (U34-9 and U35-11) causes a Latched RED “Fault” indication on the ColorStat™ panel until the latch is reset.

Q.5.2.6 “Cable Interlock” Circuit

The “Cable Interlock” circuit indicates a fault when:

a. An RF amplifier module is missing or not fully inserted into the motherboard.
b. Cables between the Modulation Encoder and Combiner/Motherboards are disconnected or loose.
c. Cables between the DC Regulator and Modulation Encoders are disconnected or loose.
d. The cable between the Modulation Encoder and LED Board is disconnected or loose.

The “Cable Interlock” fault sensing circuit on the LED Board is shown on Sheet 1 of the LED Board schematic diagram, at grid locations F3-F6. The circuit consists of U4-12, R36, C24 and U4-10.

A “Cable Interlocks-H” fault signal from the Cable Interlock logic on the Modulation Encoder is inverted by U4-12, filtered by R36-C24, and inverted by U4-10 to send a “Fault-H” logic signal to Type 1 Fault gate U32 and to Cable Interlock status latch circuit U34-1 and U18.

Q.5.2.7 Output Monitor and DC Regulator Regulated Supply Fault comparator circuits

The Output Monitor and DC Regulator regulated supply fault comparator circuits are shown on Sheet 1 of the LED Board schematic. Figure Q-8 includes simplified diagrams.

The comparators operate from a single +5 VDC supply. When a “fault” is sensed, the comparator output goes to +5 VDC through a pull-up resistor.

The non-inverting input of each comparator is a fixed positive reference voltage, derived from the Controller +5 VDC regulated supply. All “Type 1” comparator reference inputs are tied together and come from a common voltage divider. If a supply fault occurs the inverting input voltage goes below the reference voltage and the comparator output goes HIGH.

Regulated voltage faults from the Output Monitor and the DC Regulator are “Type 1 Faults”. The fault inputs are applied to the inverting inputs of comparator U61. The non-inverting inputs are supplied by a fixed reference voltage. A fault will bring the input line LOW and trigger the comparator. The Type 1 “Supply Fault” comparator outputs have capacitors to ground to prevent transient voltages from causing false “Type 1” faults.

Q.5.2.7.1 Regulator Fault Alert Outputs

For a description of regulator IC operation and faults which cause a “fault alert” refer to SECTION M, “DC Regulator.”

When there is no fault, the “Fault Alert” output is an open circuit. When a voltage regulator senses a supply “fault,” the internal “Fault Alert” transistor conducts, effectively connecting the Fault Alert output to the regulator internal ground. For POSITIVE supplies, this is the transmitter ground. For NEGATIVE supplies, the internal regulator “ground” goes to the unregulated negative input voltage through a small resistance.

Q.5.2.7.2 Output Monitor +5 VDC Fault

The “Fault Alert” input from the +5 VDC regulator on the Output Monitor is applied to J3-21. If a +5 VDC fault is detected, the input line will go LOW to trigger U61-2.

Q.5.2.7.3 Output Monitor -5 VDC Fault

The “ Fault Alert” input from the -5 VDC regulator on the Output Monitor is applied to J3-19. If a -5 VDC fault is detected, the input line will go LOW to trigger U61-1.

Q.5.2.7.4 DC Regulator B+ Fault Input

This input is driven by a TTL level logic driver which is part of the Supply Fault circuit on the DC Regulator (refer to SECTION M, DC Regulator, for more information). A B+ supply fault causes the logic driver output to go LOW, and comparator U61-13 generates a Type 1 Fault.

Q.5.2.7.5 DC Regulator Modulated B- Supply Fault

This negative supply input has a pull-up resistor on the DC Regulator. The “no fault” input to the LED Board is positive and the “sense” input circuit uses a voltage divider to ground on the LED Board. A Modulated B- supply “Fault Alert” causes the LED Board “fault” input to go negative, and Schottky diode CR17 protects the comparator input by clamping it to ground.

Q.5.2.8 “Door Interlock” And “External Interlock” Status Indication Circuits

These Status Indication circuits are shown in the upper right section of Sheet 6 of the LED Board schematic diagram. Both circuits are the same. Interlock Fault circuits are on the Controller, and are described in SECTION P, Controller.

When no interlock faults are present, the “Interlock Status” input to the LED Board is logic HIGH. Buffer/Driver U55-10/12 output goes HIGH and illuminates the GREEN section of the bicolor status LED. U46 invertor output pins 2,4, 6, and 8 go LOW, the RED section of the LED is off, and a logic LOW signal goes to the External Interface.

When an interlock FAULT is present, the “Interlock Status” input is logic LOW. The Buffer/Driver output goes LOW and the GREEN LED section is OFF. Both invertor outputs go HIGH, illuminating the RED LED section and sending a “Fault-H” signal to the External Interface.

Q.5.3 Type 2 Fault Circuits

Type 2 Faults include RF Overdrive, RF Underdrive, and Supply Current Overloads.

Type 2 Faults are usually temporary or transient conditions, such as current overloads caused by overmodulation. Turning the PA Power Supply OFF may correct the condition, so Type 2 Faults cycle the transmitter OFF, then back ON.

Q.5.3.1 Type 2 Fault Action

A Type 2 fault executes the following steps:

a. Turns the PA Power Supply OFF.
b. After 1 second, turns the PA Power Supply ON again and starts another timer (a second time-out).
c. For 2.4 seconds after starting the turn-on sequence, watches for a repeated fault condition.
   1. IF THE FAULT CONDITION REPEATS WITHIN THE 2.4 SECOND TIME-OUT: Initiate a Type 1 Fault which turns the transmitter OFF.
   2. IF THE FAULT DOES NOT REPEAT WITHIN THE 2.4 SECOND TIME-OUT: All status indications and transmitter operation return to normal.

Q.5.3.2 Type 2 Fault Status Indications

When a Type 2 Fault occurs, the ColorStat™ panel “Overload Indicator” will latch in a RED condition until it is manually reset.

Q.5.3.3 Type 2 Fault Detection: Circuit Description

Type 2 Fault Detection circuits are shown on Sheet 3 and 4 of the LED Board schematic diagram. The following paragraphs describe RF OVERDRIVE, RF UNDERDRIVE, and SUPPLY CURRENT OVERLOAD fault sensing circuits. Following the descriptions, “Type 2 Fault” logic and status indication circuits are described.

Q.5.3.4 RF Drive Detection Circuits

An RF Drive sample from the RF Splitter is applied to the primary of transformer T1. A resistor-inductor network across the primary provides loading and broad-banding, and capacitors across the two secondaries also provide loading. The two secondary windings, CR5 and CR6 and an R-C filter each provide a DC sample for the associated fault detector comparator.

Q.5.3.4.1 RF Overdrive Fault Detector: U2B

The DC RF drive sample is applied to the non-inverting input of U2-2. A reference voltage at U2-4 is set with Overdrive Threshold control R41. Under normal operation, the reference voltage is greater than the “rf drive sample” and the comparator output is LOW. If the “RF drive sample” voltage is greater than the reference voltage, the output is pulled HIGH by R44.

Q.5.3.4.2 RF Underdrive Fault Detector: U2-1

The DC RF drive sample is applied to the inverting input, U2-6. The reference voltage is adjusted by R67 and is applied to the non-inverting input, U2-7. During normal operation, the RF drive sample voltage is greater than the reference voltage and the comparator output is LOW. If the RF drive sample voltage drops below the reference voltage, U2-1 is pulled HIGH by R56. This provides a logic “Fault-HIGH” input to U10-2 through Inhibit Gate U9-11.

Q.5.3.4.3 Comparator Voltage Ramp, “Underdrive Inhibit A,” and “Underdrive Inhibit B”

When the transmitter is first turned ON, the Underdrive Threshold reference voltage is zero, and begins increasing as capacitor C50 charges. RF drive also begins increasing, but the comparator output is inhibited from registering a fault. After approximately 0.3 seconds, the Underdrive "Inhibit" is released. If RF drive is correct, the RF drive sample voltage will be greater than the reference voltage by this time. If RF drive is low, an Underdrive Fault will cycle the transmitter OFF, the "Underdrive" LED on the ColorStat™ panel will turn AMBER, and the transmitter will recycle back ON. If RF drive is still low on the second try, the transmitter will turn OFF and the "Underdrive" LED will turn RED.

Q.5.3.4.4 *"Underdrive Inhibit A" and "Underdrive Inhibit B" Logic Signals*

When the transmitter is turned "ON", the step-start circuit applies AC to the PA Power Supply and supply voltage begins coming up. If there are no faults, step-start contactor K1 auxiliary contact provides a "K1 has closed" LOW-to-HIGH transition on the "Underdrive Inhibit B" signal line. After a 0.3 second delay, the "Underdrive Inhibit A" line also goes HIGH.

Q.5.3.4.5 *Underdrive Reference Voltage Ramp*

Capacitor C50 charges through resistor R72 to provide a reference voltage "ramp" for the underdrive threshold comparator. The "Underdrive Inhibit B" LOW-to-HIGH transition resets the ramp as follows: The "Underdrive Inhibit B" LOW-to-HIGH transition is differentiated by capacitor C151 and resistor R177 to provide a current pulse which turns Q1 ON and discharges ramp capacitor C50.

Q.5.3.4.6 *"Underdrive Inhibit A" and Inhibit Gate U9-8*

During first part of the step-start cycle, the "Underdrive Inhibit A" line is LOW. This logic LOW signal at U9-9 holds the output LOW, even if the comparator output goes HIGH. Approximately 0.3 seconds after step-start contactor K1 closes, "Underdrive Inhibit A" goes HIGH so that if RF drive is low a Type 2 Fault is generated.

Q.5.3.4.7 *"RF Drive Relative/Estimate": U57-8*

The RF Drive Relative/Estimate provides a RELATIVE (UNCALIBRATED) indication of RF drive level.

The "RF Drive Estimate" analog voltage goes to the Switch Board/Meter Panel, for the "Relative RF Drive" reading on the front panel multimeter. An "RF Drive Estimate" analog voltage is also available at TB1-7 for a remote "RF drive estimate" output.

The RF Drive Estimate uses a DC voltage from the "RF Underdrive" sample circuit, and provides an uncalibrated indication of RF level at the RF splitter. Buffer U57-8 provides two analog output signals. Refer to sheet 4 of the LED Board schematic diagram; U57-8 is shown at location D5.

Q.5.3.5 Supply Current Overload

Supply Current Overload circuits are shown on Sheet 3 of the LED Board schematic diagram at grid location E7. Either a PEAK CURRENT OVERLOAD or an AVERAGE CURRENT OVERLOAD will cause a Supply Current Overload.

The voltage drop across current shunt SH1 is amplified by U57-7. The current shunt is between the negative side of the PA Power Supply and ground and is also the shunt for the 100 Ampere "supply current" meter. Voltages at the differential amplifier input are small; 50 millivolts across the shunt corresponds to 100 Amperes of supply current.

Q.5.3.5.1 *Peak Current Overload*

Comparator U2-14 senses peak current overloads. The comparator voltage reference is set by "Peak Current Threshold" control R68. Normally the comparator output is LOW but if peak supply current exceeds the preset threshold, the comparator output goes HIGH.

Q.5.3.5.2 *Average Current Overload, And Remote Supply Current Metering Output*

Resistor R155 and capacitor C125 form a low-pass filter to remove audio frequency components from the supply current sample, so that only the average supply current remains at the input of voltage follower U57-1. The voltage follower provides an Average Supply Current output to the External Interface, for remote "Supply Current" metering.

The voltage follower also goes to the noninverting input of comparator U2-13. The inverting input is a reference voltage set by R42, the Average Current Threshold control. If average current exceeds the preset threshold, the comparator output goes HIGH.

Average current limiting is accomplished by feeding the comparator output to the Analog Input Board at J9-37. The output pulses of comparator U2-13 are integrated and produce a feedback signal that reduces the power output if PA current increases to an unsafe level.

The Peak and Average overload detector outputs are fed to "OR" gate U19-6. If either a peak current overload or an average current overload is detected, the output of OR gate U19-6 goes HIGH, triggering one-shot U11 in the Type 2 Fault Logic.

Q.5.3.6 Type 2 Fault Logic: Circuit Description

Figure Q-4(a) is a simplified diagram of Type 2 Fault Logic, which is the same for RF Overdrive, RF Underdrive, and Supply Current Overload faults. Type 2 Fault logic includes two one-shots, an AND gate for repeated faults, and a fault latch circuit.

Type 2 Fault logic for each of the three Type 2 Faults include the following IC sections:

a. RF Overdrive: One-Shots U10A (1 sec) and U30A (2.4 sec), AND gate U16-8, gate U31-6, and fault latch U52A.
b. RF Underdrive: One-Shots U10B (1 sec) and U30B (2.4 sec), AND gate U16-3, gate U31-3, and fault latch circuit U51B.
c. Supply Current Overload: One-Shots U11A (1 sec) and U11B (2.4 sec), AND gate U16-11, gate U31-8, and fault latch circuit U52B.

Q.5.3.6.1 *First One-Shot (1 second)*

When a Fault is detected, a LOW-to-HIGH transition at the first One-Shot input triggers the one-shot. A one-second logic HIGH pulse is generated at the Q output and a one-second logic LOW pulse is generated at the NOT-Q output.

The logic HIGH pulses from all three one-shot "Q" outputs provide a "Type 2 Fault-H" input to the turn-on/turn-off logic on the Controller. For each Fault Logic circuit, the logic HIGH pulse also goes to the Repeat Fault AND gate.

The logic LOW pulse from the NOT-Q output goes to status indicator circuits and to the "B" input of the second one-shot.

Q.5.3.6.2 Second One-Shot(2.4 seconds)

At the end of the one-second logic LOW pulse from the first one-shot, the LOW-to-HIGH transition triggers the second one-shot. Only the Q output is used, and the one-shot generates a 2.4 second logic HIGH pulse which goes to the status indicator circuits and to the Repeat Fault AND gate.

Q.5.3.6.3 Repeat Fault "AND" Gate

Figure Q-4(b) shows logic timing diagrams which may help when reading the following discussion. The AND gate inputs are the Q outputs from the first and second one-shots. During normal transmitter operation, both inputs are LOW. When a Type 2 Fault is detected, the first one-shot Q output goes HIGH, but the other AND gate input remains LOW. After one second, the first one-shot Q output goes LOW, the second one-shot is triggered, and its Q output goes HIGH. The AND gate still has one LOW and one HIGH input, so its output is still LOW.

When the second one-shot is triggered, the AND gate is set to detect a repeat fault; if the first one-shot is triggered during the one second logic HIGH pulse from the second one-shot, both AND gate inputs will be HIGH and its output will go HIGH.

The "Repeated Fault-H" logic signal goes to an OR gate and becomes a "Type 1 Fault-H" input to Type 1 Fault Gate U19-8. The Repeated "Fault-H" logic signal also goes through the Reset Retrigger gate to the Fault Latch.

Summary

A fault triggers the first one-shot which generates a pulse that cycles the high voltage OFF for one second. then turns the PA Power Supply back ON. The end of the first one-shot time-out triggers the second one-shot and "arms" the Repeat Fault AND gate. If no further faults are detected, the second one-shot times out, and no further action is taken. If a second fault is detected before the end of the second time-out, the AND gate output goes HIGH, providing a Type 1 Fault and clocking the Status Indicator latch.

Q.5.3.6.4 Type 2 Fault Status Indication Circuits

Status Indication circuits are the same for all three Type 2 Faults; Figure Q-4(c) is a simplified diagram and Table Q-2 gives the combinations for the fault status circuits. Each circuit includes an AND gate, an Invertor/Driver for the RED LED section, an Invertor/Driver for the External fault status output, an OR gate, and a bicolor LED.

There are four possible conditions for each Type 2 Fault ColorStat™ panel LED:

- GREEN: Normal indication.
- AMBER: Occurs when the Type 2 Fault is detected. Both the RED and GREEN sections of the bicolor LED are ON.
- OFF: Occurs during the 2.4 second timeout period.
- RED: Occurs if the Type 2 Fault is detected again before the 2.4 second timeout.

Q.5.4 Type 3 Fault Circuits

Type 3 Faults LOWER transmitter power but do not turn off the PA Power Supply. A "Type 3 Fault" can be generated by two conditions:

- Repeated VSWR "hits"
- The heat sink temperature of PA Module RF1 or RF2 exceeds a pre-set limit.

The "Type 3 Fault" logic on the LED Board is driven by VSWR sensing circuits on the Output Monitor and temperature sensing circuits on the Driver Encoder/Temp Sense Board.

- VSWR related Type 3 Faults latch one or both RED "VSWR" indicators on the ColorStat™ panel ON.
- Temperature related Type 3 Faults latch the RED "OVER TEMP LED" on the Driver Encoder/Temp Sense Board ON.

Q.5.4.1 VSWR Logic

A VSWR problem which creates a Type 3 Fault occurs when a serious impedance mismatch causes high reflected power. This can happen as the result of a problem in the transmitter output network or in the transmitter load — normally an antenna system. This will cause a repeat VSWR "hit" as soon as the PA OFF command is released. The repeated VSWR faults occur as follows:

a. A VSWR "hit" generates a momentary PA OFF command to turn off the RF output, then the transmitter cycles back ON. For many VSWR fault conditions, removing RF voltage will clear the condition and the VSWR fault will not repeat.
b. If the VSWR condition is still present when the transmitter cycles back ON, another VSWR "hit" will occur, and the PA OFF command will turn off the RF output again.
c. If repeated VSWR trip cycles occur within a fixed time period and the condition does not clear, a Type 3 Fault will begin to lower transmitter power.

VSWR Detectors and Logic on the Output Monitor generate a 14 millisecond logic LOW pulse when a Bandpass Filter VSWR (Output Network VSWR) is detected, and a 19 millisecond logic LOW pulse when an Antenna VSWR (Load VSWR) is detected. VSWR logic on the LED Board generates a logic signal and status indicator output for each detected VSWR fault. Additional logic signals are generated if a large number of VSWR faults occur in a short time, indicating a serious impedance mismatch.

VSWR Logic on the LED Board is described in the following paragraphs. VSWR Detectors and logic are described in SECTION H, Output Sample Board and Output Monitor.

Q.5.4.1.1 Single VSWR Action

Refer to Figure Q-5, VSWR Logic, Simplified Diagram, or to sheet 2 of the LED Board schematic diagram. For each SINGLE VSWR fault, logic on the LED Board generates the following signals:

FOR EITHER A BANDPASS FILTER OR AN ANTENNA VSWR:

a. PA OFF: NOR gate U3-10 generates a "VSWR Fault-L" signal to PA OFF gate U40, to hold the PA off for 14 msec or 19 msec.

WARNING: Disconnect primary power prior to servicing.

b. RF DRIVE SWITCH-OVER: NOR gate U3-10 is also a VSWR Fault - L signal to one-shot U28A which generates a “RF Drive Switch-Over” pulse to the Oscillator.

c. VSWR SELF-TEST CIRCUIT INPUT: NOR gate U3C output also provides a “VSWR Fault-L” signal to the VSWR Self-Test Circuit.

BANDPASS FILTER VSWR:

a. 0.5 Second RED “Bandpass Filter VSWR” status indication on the ColorStat™ panel.

b. 0.5 Second External “Bandpass Filter VSWR” status indication (at TB1-8).

ANTENNA VSWR:

a. 0.5 Second RED “Antenna VSWR” status indication on the ColorStat™ panel.

b. 0.5 Second External “Antenna VSWR” indication (at TB1-9).

Q.5.4.1.2 *Multiple VSWR Fault Action*

If enough repeated VSWR “trips” occur, the LED Board VSWR logic will take further action, as follows:

a. A Status Indicator latch will provide a latched VSWR indication on the ColorStat™ panel until the status indicator circuits are RESET.

b. A VSWR-Induced LOWER command will be generated. The VSWR-Induced Lower command goes to the Power Control logic on the Controller. Power will be lowered until the reflected power is below the 1500 Watt peak envelope power VSWR detection threshold.

Q.5.4.2 VSWR Logic: Circuit Descriptions

The following description refers to Figure Q-5, VSWR Logic Simplified Diagram. VSWR logic is shown on Sheet 2 of the LED Board schematic diagram.

The “Bandpass Filter” VSWR signal input goes through gates U3-1 and U3-4, and “Delay” U19-11. If both “Bandpass Filter” and “Antenna” VSWR problems are detected at the same time, the two logic LOW inputs to gate U3-1 cause its output to go HIGH. The logic HIGH input to “Inhibit” gate U3-4 holds its output LOW so that only the “Antenna” VSWR fault will be detected. The gate propagation time of gate U19-11 provides a slight delay to match the delay through U3-1.

The “Antenna” VSWR signal is inverted by U3-13. The invertor output is a logic HIGH pulse when a VSWR fault is detected, and goes to VSWR NOR gate U3-10 and Antenna VSWR one-shot U12A.

Q.5.4.2.1 *“NOR” Gate: U3-10*

When either a Bandpass Filter VSWR fault or an Antenna VSWR fault is detected, U3-10 goes LOW and drives PA Off gate U40, VSWR self-test latch U42A, and “RF Drive Switch-over” one-shot U28A.

Q.5.4.2.2 *“Pulse Stretch”: U12A and U12B*

Both U12B and U12A operate in the same way; when a VSWR fault is detected, the logic LOW to HIGH transition at the “B” input triggers the one-shot which generates a 0.5 second logic HIGH pulse at the Q output and a 0.5 second logic LOW pulse at the NOT-Q output. The one-shots are retriggerable, so that if another VSWR fault is detected during the 0.5 second pulse output the output pulse will be “extended” another 0.5 second.

The one-shots are inhibited by the “Supply Fault-L” signal from the Controller during turn-on, when changing voltages could cause false “VSWR” logic signals.

Q.5.4.3 Generating Type 3 Faults (VSWR Logic Circuit Description)

Refer to Figure Q-5, VSWR Logic Simplified Diagram, and to the VSWR Logic circuits on Sheet 2 of the LED Board schematic, 839-7855-184.

Q.5.4.3.1 *Detecting Multiple VSWR “Hits”:*

When an impedance mismatch causes a number of VSWR “hits” to occur in rapid succession, the time between detected VSWR “hits” is less than the length of the logic HIGH pulse at the R-C network to Schmitt Trigger inputs U4-1 and U4-5. (Each time the transmitter PA comes back ON, another VSWR fault will be detected). During the 14 (or 19) millisecond pulse, the capacitor charges, and between pulses it discharges back into the current sink provided by the logic LOW output of U3-4 or U3-8. A series of 20 to 30 “hits” will charge the capacitor above the threshold voltage of the inverting Schmitt Trigger. The inverting Schmitt trigger output goes low and is inverted again to generate a logic HIGH input to the “Status Indicate Latch” circuit.

Q.5.4.3.2 *“Status Indicate Latch” Circuits: U23-6/U24A and U23-3/U24B*

A LOW-to-HIGH transition from the “multiple VSWR” circuit, U4-4 or U4-8, triggers the latch through U23-3 or U23-6, the Q output goes HIGH and the NOT-Q output goes LOW. Refer to the description of “Reset A and Reset B Operation” earlier in this section for a further description of these Latch circuits.

Q.5.4.3.3 *“VSWR Induced Lower” Circuits: U22-3/6, U37-6, U28B*

The following description refers to the Bandpass Filter VSWR circuit (U4-6/8 and U22-6), but operation of the Antenna VSWR circuit is identical (U4-2/4 and U22-3). When multiple (repeated) VSWR “hits” cause the output of U4D to go HIGH, one input to AND gate U22 will go HIGH and additional repeated logic HIGH VSWR pulses will appear at the output of U22-6. The ANTENNA and BPF VSWR pulses are applied to OR gate U37-6. The pulses appear at U37-6 and at the “B” input of one-shot U28B.

When “VSWR-induced lower” one-shot U28 is triggered (via pin 10), it generates a 47 millisecond logic HIGH pulse. Each additional VSWR “hit” will extend the pulse by an additional 47 milliseconds.

The logic HIGH output at pin 5 of U28 is the “VSWR Induced Lower” command to the Power Control Logic on the Controller. This signal will lower transmitter output power until the peak reflected power is below the VSWR detection threshold set on the Output Monitor.

Q.5.4.3.4 *Type 3 Fault Gate: U23-8*

A Type 3 fault occurs when repeated VSWR “hits” lower transmitter power. A remote “Type 3 Fault” status indication is provided at U23-8 and invertor U8-6.

Q.5.4.4 VSWR Status Indication Circuits: U38-3/11, U37-11, U39-2, DS8

The operation of the Bandpass Filter and Antenna VSWR “Status Indicate” circuit is identical (U38-6/8, U37-8, U39-4, and DS16). The Extended (remote) “Status Indicate” logic HIGH signal is present if the Pulse Stretch one-shot “NOT-Q” output goes LOW or if the Repeated VSWR Latch “NOT-Q” output goes LOW. The one-shot and latch outputs are OR’ed by U38-11 then inverted by U38-3 to provide the VSWR-H output. A single VSWR “hit” will send a 0.5 second logic HIGH pulse to the External Interface, and a latched VSWR output will remain HIGH until it is reset.

A GREEN VSWR status indication occurs when there is no VSWR Fault pulse or Latched VSWR fault. The NOT-Q outputs of Pulse Stretcher U12B and Latch U24A are both HIGH (pins 12 and 6 respectively). Both inputs 1 and 2 to gate U38 are HIGH, the output is HIGH, and the GREEN LED is on. If either a VSWR Pulse or Latched output causes an input to U38 to go LOW, U38-3 output goes LOW and the GREEN LED extinguishes.

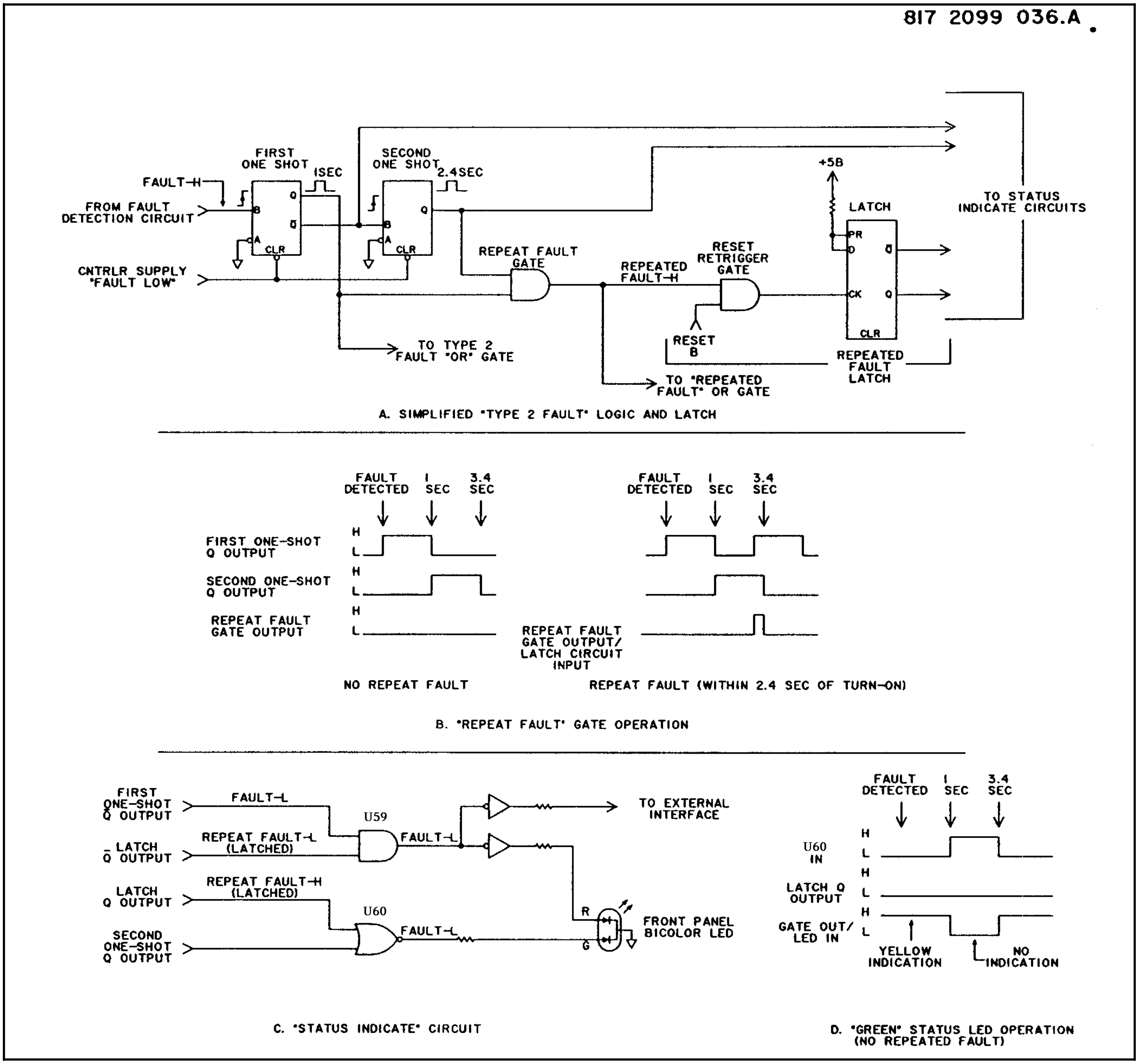

Figure Q-4. Type 2 Fault Logic, Simplified Diagram
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A VSWR condition causes a RED “VSWR Fault” indication by forcing the Q output of the Pulse Stretcher or the Latch HIGH and the output of OR gate U37-11 HIGH.

Q.5.4.5 VSWR Self-Test Circuit

The “VSWR Self-Test” performs a test of VSWR logic AUTOMATICALLY each time AC power is applied to the transmitter. The operator can also perform a VSWR Self-Test MANUALLY at any time. The “Self-test” results are available on a ColorStat™ panel indicator, or as a remote “VSWR Self-Test Pass/Fail” indication.

If all VSWR logic on the Output Monitor and LED Board is working properly when a VSWR Self-Test is performed, BOTH the “Antenna” and “Bandpass” indicators will indicate RED for one-half second and the “VSWR Sensor Status” will flash RED momentarily, then all three indicators will indicate GREEN.

If either the “Antenna” or “Bandpass” indicator remains RED, a VSWR logic fault is indicated. The transmitter should not be operated until the VSWR logic faults are corrected.

Q.5.4.6 VSWR Self-Test, Circuit Description

The following circuit descriptions refer to Figure Q-6, VSWR Self-Test Circuit, Simplified Functional Diagram, or to sheet 2 of the LED Board schematic diagram.

Any time a VSWR self-test is initiated, a 10 millisecond logic LOW pulse is generated by one-shots U29A/B. This logic LOW pulse to the Output Monitor activates a circuit which simulates a VSWR “hit” by applying +5 VDC to both VSWR detector inputs on the Output Monitor.

At the same time, a 0.5 millisecond logic LOW pulse is generated to “reset,” then “clock” latch U42A on the LED Board. Latch U42A is both a VSWR Self-Test “Detector” and Status Indicator latch. If all VSWR logic is operating properly, a “VSWR Fault-H” logic signal will appear at the D input before the Latch “Clock” input occurs. When the latch is “clocked,” the Q output will go HIGH and the NOT-Q output will go LOW. The latch output will then illuminate only the GREEN LED section and there will be NO remote “VSWR Self-Test Indicate” output.

If NO VSWR “Hit” is detected, indicating a logic fault, the D input will be LOW. When the latch is “clocked,” the Q output will go LOW and the NOT-Q output will go HIGH. The ColorStat™ panel LED will indicate RED and a logic HIGH output will be sent to the External Interface to provide a “VSWR Self-Test Indicate” output.

Q.5.4.6.1 Manual VSWR Self-Test Inputs

Depressing the “Manual Test” switch (S2) on the ColorStat™ panel will ground U25-9 and the output (pin 8) will go LOW. The other input to this U25 gate is controlled through the External Interface board. A HIGH-to LOW transition at the A input will trigger One-Shot U29B. The One-Shot will generate two 10 millisecond logic pulses at its outputs, a logic HIGH pulse at its Q output (pin 5) and a logic LOW pulse at its NOT-Q output (pin 12).

Q.5.4.6.2 “Turn-on Induced” VSWR Self-Test Input Circuit

Each time AC power is applied or re-applied to the transmitter, the “Supply Fault-L” signal from the Controller goes from LOW to HIGH after a delay of a few seconds. Buffer/Driver U25-11 and an R-C network delay the transition to allow the CLEAR inputs of one-shots U29A/B in the VSWR logic to go HIGH, then the LOW-to-HIGH transition at the “B” input triggers one-shot U29A. When triggered, one-shot U29A generates 10 millisecond pulses at its Q and NOT-Q outputs (pins 13 and 4).

Q.5.4.6.3 Self-Test Pulse To Output Monitor

Refer to Figure Q-6. A logic LOW pulse from either the turn-on induced self test one-shot U29A or the manual self-test one shot U29B causes U25-6 to go LOW. This is the self-test pulse to the output monitor.

Each time a 10 millisecond logic HIGH pulse goes to the Output Monitor from U29A/B, a 0.5 msec logic LOW pulse is generated by U50-11 and U8-8.

Cond.	1st 1Shot Not-Q	Latch Not-Q Out	AND Gate Out	Invert Out	RED LED	Latch Q Out	2nd 1Shot Q Out	NOR Gate Out	GRN LED	Status Ind. Color
Normal	HIGH	HIGH	HIGH	LOW	OFF	LOW	LOW	HIGH	ON	GREEN
1st.	LOW	HIGH	LOW	HIGH	ON	LOW	LOW	HIGH	ON	YELLOW
2nd.	HIGH	HIGH	HIGH	LOW	OFF	LOW	HIGH	LOW	OFF	OFF
Repeat	LOW	LOW	LOW	HIGH	ON	HIGH	HIGH	LOW	OFF	RED
Latch	HIGH	LOW	LOW	HIGH	ON	HIGH	LOW	LOW	OFF	RED

Conditions are:

Normal: Normal operation (no faults)

1st: Fault starts first one-shot (Cycles transmitter OFF for 4.7 seconds then starts turn-on sequence).

2nd: Second one-shot starts 2-1/2 second time-out.

Repeat: Repeated Fault occurred and Latch changed state.

Latch: Both one-shots have timed out, but Fault Status is still Latched.

Note that when the RED LED is ON an External “Type 2 Fault” status output is also provided (this occurs for both YELLOW and RED status panel indications).

Table Q-2. Type 2 Fault Status

WARNING: Disconnect primary power prior to servicing.

When a VSWR self-test is initiated, U50-11, U26-2, and U8-8 generate a 0.5 millisecond logic LOW pulse at U8-8 output as follows:

a. Initially, the output of U50-11 is LOW, the capacitor at U26-1 is discharged, and the output of inverting Schmitt Trigger U26-2 is HIGH. NAND gate U8-8 has one LOW and one HIGH input, and its output is HIGH.
b. When the self-test pulse causes U50-11 to go HIGH, the 0.5 millisecond delay capacitor begins charging. U26-2 remains HIGH so that pins 9 and 10 of U8 are HIGH and U8-8 goes LOW. The 10 msec self-test pulse then starts the 0.5 msec logic LOW pulse at U8-8.
c. After 0.5 milliseconds, the charging capacitor triggers inverting Schmitt trigger U26 and pin 2 goes LOW. Pin 10 of U8 is now LOW and the output(U8-8) goes HIGH, ending the 0.5 msec logic LOW pulse.

Q.5.4.6.4 *"VSWR Self-Test" Latch U42A*

Refer to the simplified diagram, Figure Q-6, or to Sheet 2 of the LED Board schematic. Latch U42A detects the self-test result and "latches" the self-test status indication. Signals to the latch include a DATA input from the VSWR logic, and CLEAR and CLOCK inputs derived from the pulse generator. The Q and NOT-Q outputs drive status indicator circuits.

When the VSWR self-test pulse goes to the Output Monitor, the latch is also CLEARED. About 0.5 millisecond (500 microseconds) later, the latch CLEAR-L is released. After another 100 nanoseconds the latch is clocked and the data at the latch D input will be stored in the latch.

The Data input to the self-test latch is the output from NOR gate U3-10 in the VSWR logic circuit, through invertor U39-12. When a VSWR "hit" is detected, the Data input will be HIGH, and when no VSWR fault is detected, the Data input will be LOW.

A logic LOW at the "CLEAR" input clears the "self-test" latch, and a LOW-to-HIGH transition at the CLOCK input "Clocks" the latch. The 0.5 millisecond logic LOW pulse from U8-8 clears the latch. When the pulse goes HIGH again the latch can be clocked. A 100 nanosecond delay line, DL1, ensures that the "Clear" input is high before the LOW-to-HIGH transition occurs at the clock input.

When the CLEAR input goes LOW, the Q output goes LOW and the NOT-Q output goes HIGH. This turns the green LED "OFF" and turns the RED LED "ON" for 0.5 milliseconds, until the latch is clocked. The VSWR Sensor "Status" LED will thus flash RED each time a self-test is done.

A RED "VSWR SENSOR" status indication can only be reset by performing a successful VSWR self-test, that is, by correcting the VSWR logic fault and depressing the Manual Test pushbutton again. Until then, the VSWR Sensor Status LED will remain RED.

Q.5.4.6.5 *VSWR Self-Test Passes (VSWR Logic Is Functioning)*

If the simulated VSWR fault generated by the self-test pulse to the Output Monitor is detected, the D input (pin 2) of U42A will be HIGH when the latch is clocked, and outputs and indication circuit conditions will be as follows:

a. Q Output: HIGH. Invertor U26-8 output: LOW. RED LED Section: OFF.
b. NOT-Q Output: LOW. Invertor U39-10 output: HIGH. GREEN LED section: ON.

Q.5.4.6.6 *VSWR Self-Test Fails (VSWR Logic Has Failed)*

If the simulated VSWR fault generated by the self-test pulse to the Output Monitor is NOT detected, the D input (pin 2) of U42A will be LOW when the latch is clocked and outputs and indication circuit conditions will be as follows:

a. Q Output: LOW. Invertor U26-8 output: HIGH. RED LED Section: ON.
b. NOT-Q Output: HIGH. Invertor U39-10 output: LOW. GREEN LED section: OFF.

Q.5.5 Type 4 Fault Circuits

Type 4 Faults generate a PA OFF command which turns the Power Amplifier stage OFF. The PA Power Supply remains energized. Regulated voltage faults on the Analog Input Board and Analog to Digital Converter are Type 4 Faults.

The Type 4 Fault sensing circuit includes a voltage regulator "Fault Alert" output from the Analog Input board or Analog to Digital Converter and voltage comparators on the LED Board.

The five Type 4 Fault circuits are described in the following paragraphs. Figure Q-7 includes simplified diagrams of the supply fault sensing circuit configurations used for Type 4 faults.

Q.5.5.1 "Supply Fault" Comparators On The LED Board

The Type 4 Fault comparators are shown on Sheet 5 of the LED Board schematic, 839-7855-184, in the Drawing Package. The comparators operate from a single +5 VDC supply. When a "fault" is sensed, the comparator output goes to +5 VDC through a pull-up resistor.

The non-inverting input of each comparator is a fixed positive reference voltage, derived from the Controller +5 VDC regulated supply. All "Type 4" comparator reference inputs are tied together and come from a common voltage divider. If a supply fault occurs the inverting input voltage goes below the reference voltage and the comparator output goes HIGH.

Q.5.5.2 Regulator Fault Alert Outputs

For a description of regulator IC operation and faults which cause a "fault alert", refer to SECTION M, "DC Regulator." When there is no fault, the "Fault Alert" output is an open circuit.

When a voltage regulator senses a supply "fault," the internal "Fault Alert" transistor conducts, effectively connecting the Fault Alert output to the regulator internal ground. For POSITIVE supplies, this is the transmitter ground. For NEGATIVE supplies, the internal regulator "ground" goes to the unregulated negative input voltage through a small resistance.

Q.5.5.3 Analog Input Board: +15V Supply

The Analog Input Board +15 VDC supply "Fault Alert" output circuit includes a capacitor and a pullup resistor. If the "Fault Alert" goes LOW, the capacitor will discharge through the fault

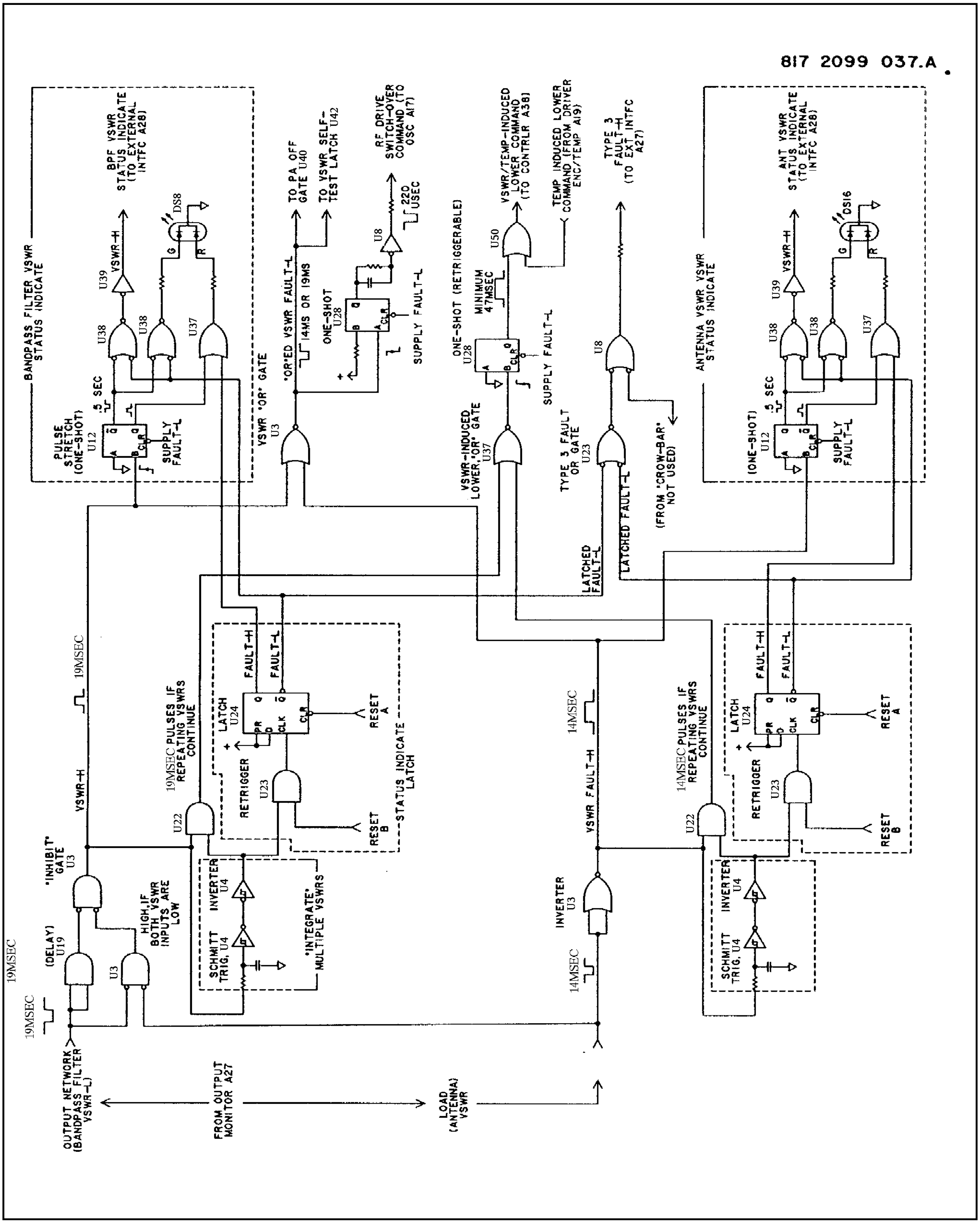

Figure Q-5. VSWR Logic, Simplified Diagram
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alert transistor and J7-11 input will go LOW. A Type 4 Fault will be generated by comparator U67-1.

Q.5.5.4 Analog to Digital Converter: +15V Supply

The Analog to Digital Converter +15 VDC supply "Fault Alert" output enters the LED Board at J9-9. If the "Fault Alert" goes LOW, a Type 4 Fault will be generated by comparator U67-2.

Q.5.5.5 Analog to Digital Converter: +5V Supply

The Analog to Digital Converter +5 VDC supply "Fault Alert" output enters the LED Board at J9-3. If the "Fault Alert" goes LOW, a Type 4 Fault will be generated by comparator U67-13.

Q.5.5.5.1 Analog Input Board: -15V Supply

The Analog Input Board -15 VDC supply "Fault Alert" output enters the LED Board at J7-13. If the "Fault Alert" input goes LOW, a Type 4 Fault will be generated by comparator U68-1.

Q.5.5.5.2 Analog to Digital Converter: -15V Supply

The Analog to Digital Converter -15 VDC supply "Fault Alert" output enters the LED Board at J9-7. If the "Fault Alert" goes LOW, a Type 4 Fault will be generated by comparator U68-2.

Q.5.5.5.3 Type 4 Faults, Status Indicator Circuits

When a comparator's output is LOW (no fault), an invertor provides a logic HIGH signal to illuminate the GREEN section of the LED, and two invertors in series provide a logic LOW ("no fault") signal to the External Interface. When a comparator's output is HIGH ("FAULT"), a logic driver output goes HIGH and illuminates the RED section of the LED and the two invertors in series provide a logic HIGH ("FAULT") signal to the External Interface.

Q.5.6 Type 5 Faults Circuit

There is only one Type 5 Fault, a "Conversion Error." A Conversion Error fault clears all digital audio data latches in the Modulator section, which turns all PA modules OFF. The only Conversion Error circuit located on the LED Board is the status indicator. All other Conversion Error fault circuits are located on the Analog to Digital Converter. Refer to SECTION K, Analog to Digital Converter, for a description of Conversion Error detection and logic circuits.

The Conversion Error status indicator circuit is shown on sheet 5 of the LED Board schematic diagram. The circuit includes AND gate U25-3, Buffer/Driver U56-15, and Invertor/Drivers U41-6/8/10.

Gate U25-3 inhibits "Conversion Error" fault indications unless the transmitter is ON and the PA OFF signal from the turn-on/turn-off logic has been released. An "OVERDRIVE INHIBIT-L" signal from the turn-on/turn-off logic on the Controller inhibits red "Conversion Error Fault" indications when the transmitter is OFF, when the PA is held OFF during the step-start sequence, or when a Fault input to the turn-on/turn-off logic turns the PA "OFF."

There are two inputs to AND gate U25:

a. The "OVERDRIVE INHIBIT-L" at pin 2
b. A "Conversion Error" logic signal, from the Conversion Error circuit on the Analog to Digital Converter, at U25 pin 1.

When the "OVERDRIVE INHIBIT-L" signal is present, the output of the gate will be LOW no matter what the "Conversion Error" logic signal state is and the Conversion Error indicator will be green.

When the "OVERDRIVE INHIBIT-L" signal is released, U25 pin 2 goes HIGH and the output of the gate depends on the Conversion Error logic signal. When a "Conversion Error-H" signal is present, U25-3 goes HIGH.

EXTERNAL INDICATE: When U25-3 is HIGH ("Conversion Error Fault"), invertor U41-10 output goes LOW and invertor U41-8 output goes HIGH, providing a Fault-H output to the External Interface.

Q.5.7 Type 6 Fault Circuit

The Blown Fuse indicator circuit is shown at the bottom of Sheet 4 of the LED Board schematic, 839-7855-184, in the Drawing Package.

A logic HIGH from Blown Fuse Indicator circuits on the Modulation Encoders will bring J2-5 input HIGH and illuminate DS4 on the ColorStat™ panel RED. The transmitter will operate normally, and a power reduction may be noticed, depending on which RF amplifier has failed.

Q.5.8 "RF Sense" Circuits on the LED Board

"RF SENSE" circuits provide GREEN indications for the Oscillator, Buffer, and Predriver status indicators on the ColorStat™ panel when RF output is present. If any section fails (has no RF output), only the FIRST section where RF fails will indicate RED, even though the following sections also have no RF output. Example: If the Oscillator fails, the Buffer and Predriver status indications will remain GREEN even though they also have no RF output.

Because RF failure causes an UNDERDRIVE fault, the RF sense circuits provide only indications to identify the section in which the fault occurred. Figure Q-8 is a simplified diagram of "RF Sense Circuits."

RF sense circuits are shown on sheet 5 of the LED Board schematic diagram. RF sense circuits include diode detectors in the RF section, comparators on the LED Board, and invertors and logic gates to inhibit "fault" indications for following "RF Status" indicators.

Q.5.8.1 "Oscillator Fault" Sensing

With normal output, the Oscillator output is a square wave, switching between zero to +5 VDC. The comparator (U5-14) inverting input is the output of a peak detector and is normally at approximately +5 VDC. The non-inverting input will be approximately 1 Volt or less. The inverting input is more positive than the non-inverting input and the TTL level logic output will be LOW.

If the Oscillator has no RF output, the input to the diodes on the Oscillator will be a positive DC voltage. The comparator's inverting (-) input is pulled toward ground by a resistor and will be LESS positive than the Oscillator DC output. The comparator's non-inverting (+) input is pulled to +5 VDC and will be

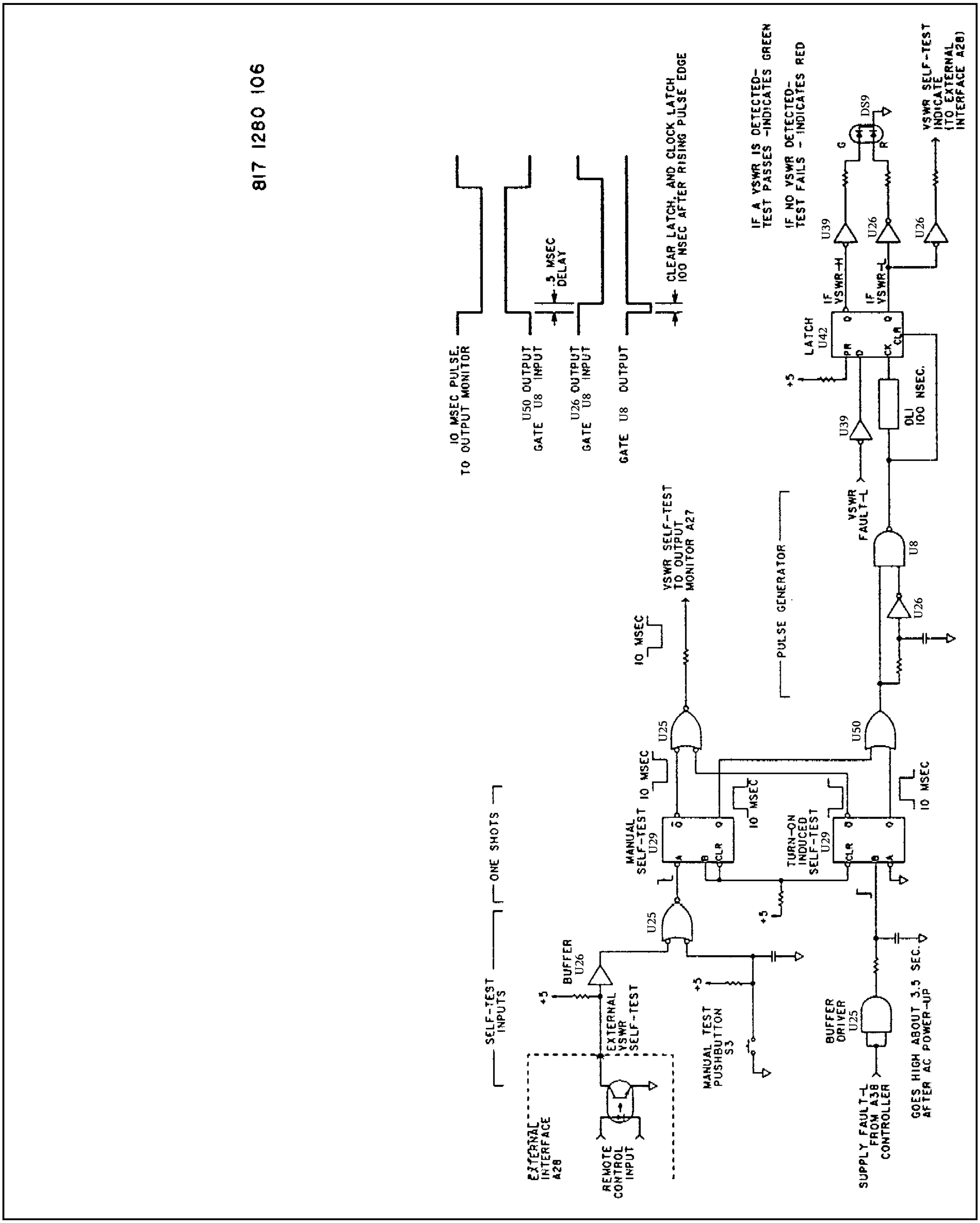

Figure Q-6. VSWR Self-Test Logic, Simplified Diagram
817 1280 106

MORE positive than the Oscillator DC output voltage. When the comparator's non-inverting input is more positive, the comparator output goes logic HIGH. Because the output of the Oscillator is inhibited when the transmitter is OFF, U22-11 inhibits a fault indication until the transmitter is ON.

Q.5.8.2 Buffer and Predriver Fault Sensing

The Buffer Amp sample and Predriver RF sample both come from peak detectors on the Driver Combiner/Motherboard. Both comparators on the LED Board have a positive reference voltage at their non-inverting inputs. When RF is present, the inverting input is positive and the comparator output is LOW; if a fault causes loss of RF, the inverting input voltage goes below the reference voltage and the comparator output goes HIGH.

Q.5.8.3 Status Indicator Circuits

The Status Indicator circuits are the same as those used for "Supply Fault" (Type 4) Status indications. For each status indicator, a logic LOW to the status indicator circuit illuminates the GREEN section of the LED and a "Fault-H" illuminates the RED section of the LED and provides a "Fault" status output to the External Interface Board.

The only RED RF status indication will be for the first section where RF is lost, because indicator "Inhibit" logic, including invertors U7-2 and U7-4, and AND gates U6-3, U6-8, and U6-11, blocks red "fault" indications for following sections.

Q.5.8.3.1 Oscillator Fault

An "Oscillator Fault-H" logic signal always goes to the Oscillator status indicator circuit and causes a RED fault indication. If the invertor output is LOW, the outputs of AND gates U6-3 and U6-8 are forced LOW no matter what the other gate inputs are. The LOW output of gate U6-8 also forces gate U6-11 output LOW. The "Buffer" and "Predriver" status indicator circuit inputs remain LOW and both indicators remain green.

Q.5.8.3.2 Buffer Fault

The Oscillator comparator output is LOW and is inverted to hold pins 2 and 6 of U6. A Buffer Fault causes gate U6-3 output to go HIGH and causes a RED "Buffer" status indication. The LOW inverted Buffer Fault signal at pin 9 of U6 forces output pin 8 LOW, and the LOW input to U6-12 holds its output LOW so the Predriver indicator remains GREEN.

Q.5.8.3.3 Predriver Fault

Both invertor inputs are LOW (no fault) so that both invertor outputs are HIGH and U6-8 output is HIGH. A Predriver Fault causes gate U6-11 output to go HIGH and gives a RED Predriver "Fault" indication. It also causes invertor U7-6 output to go LOW. A PA off signal also is generated by U55-15 through the actions of U39-6, U6, and U40.

Q.5.9 OSC TEST switch S1

The Oscillator is normally held OFF when the PA Power Supply is not energized. A "Turn-On Request" from the Controller will enable the Oscillator. If switch S1 is pressed when the PA Power Supply is OFF, the Oscillator output will be enabled. This is useful for troubleshooting the RF drive chain with the PA Power Supply OFF.

Q.6 Maintenance

Q.6.1 Printed Circuit Board Maintenance

Refer to SECTION IV, Maintenance, for general printed circuit board maintenance procedures.

Q.6.2 Adjustments

Adjustments on the LED Board are identified in the table of "Controls and Indicators." All adjustments are described in SECTION IV, Maintenance.

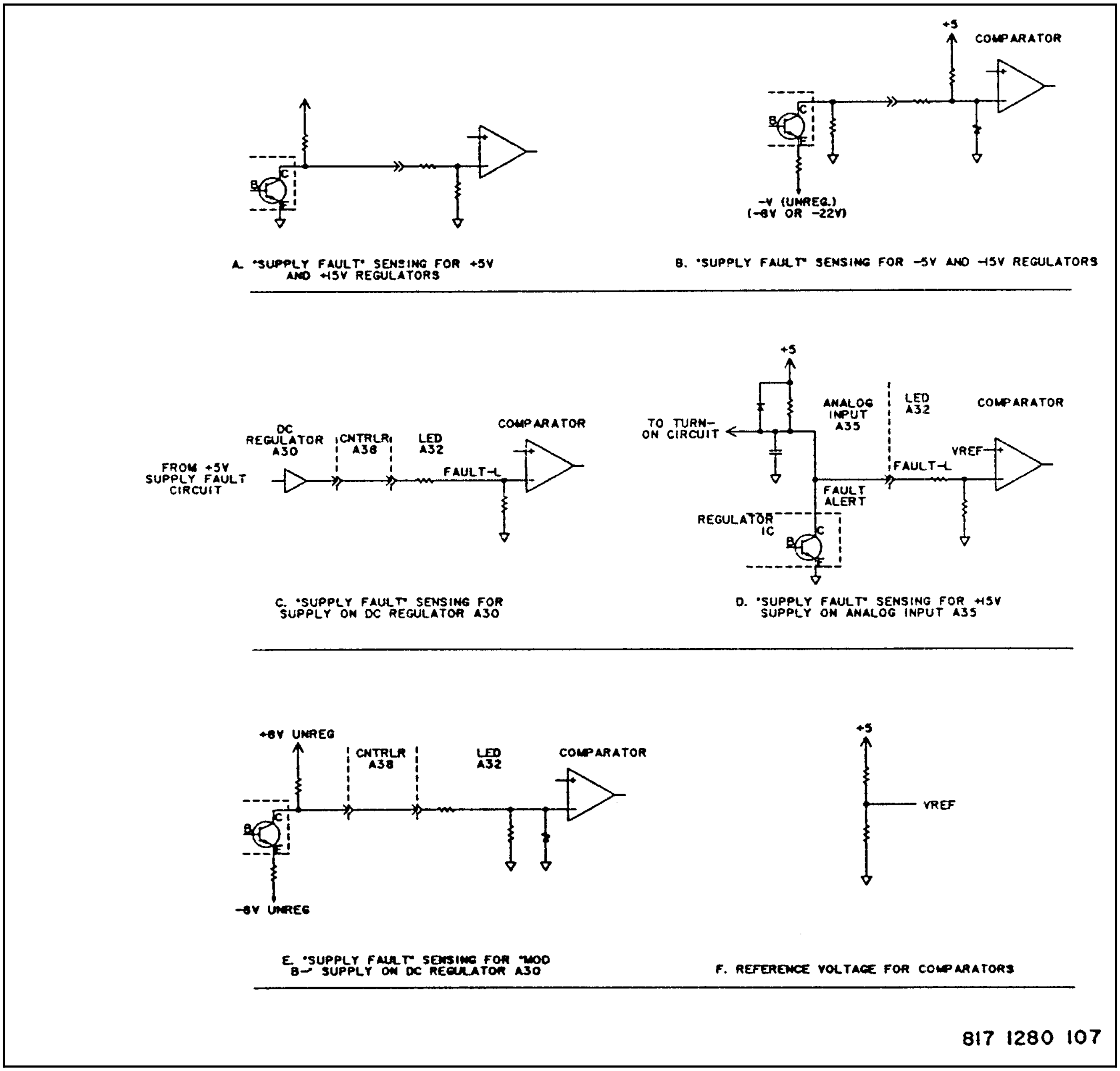

Figure Q-7. "Regulated Supply Fault" Sensing Circuits
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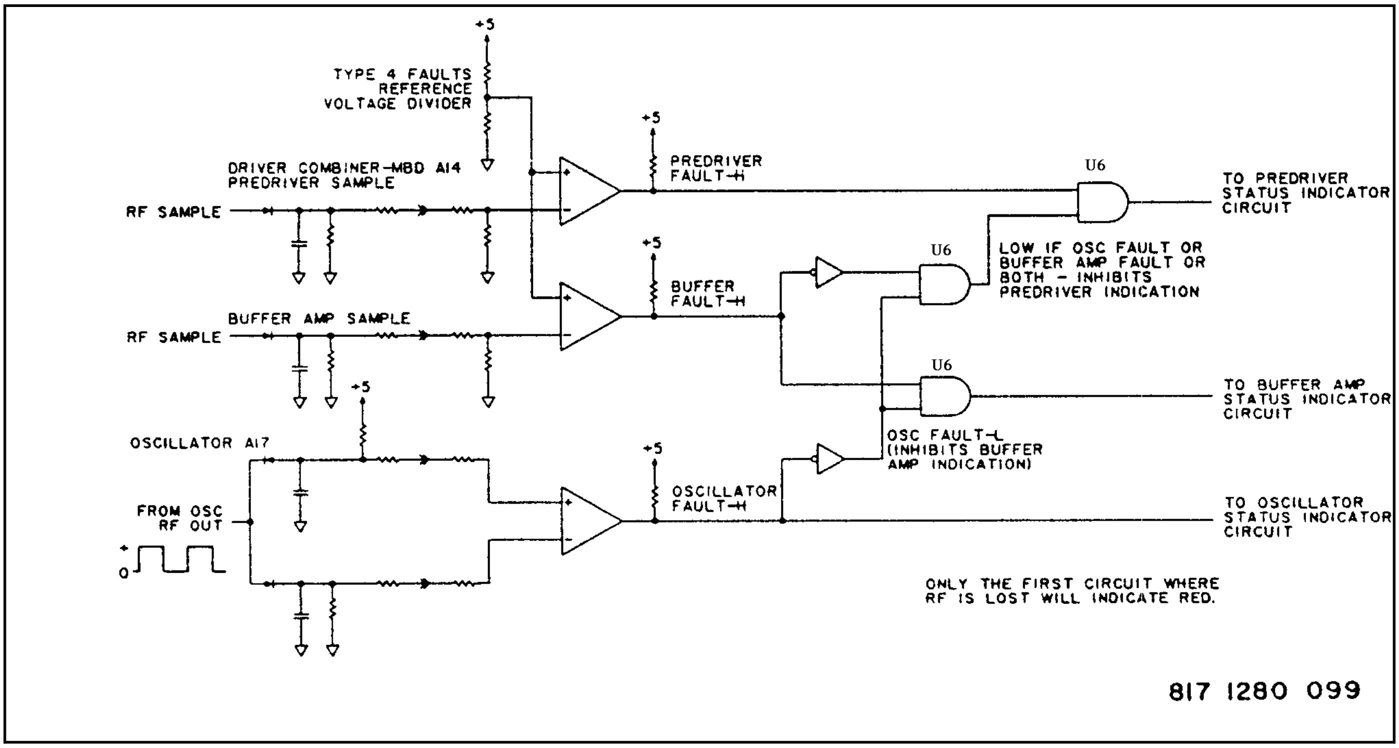

Figure Q-8. "RF Sense" Circuits, Simplified Diagram
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Table Q-3
LED Board Controls and Indicators

COMPONENT	FUNCTION/DESCRIPTION
DS12	Indicates RED when a +5 Volt regulator fault occurs; otherwise indicates green.
DS14	Indicates RED when a -5 Volt regulator fault occurs; otherwise indicates green.
DS17	Indicates RED when a +5 Volt regulator fault occurs; otherwise indicates green.
DS18	Indicates RED when a -5 Volt regulator fault occurs; otherwise indicates green.
DS22	Indicates RED when an AIR interlock fault exists; otherwise indicates green.
DS24	Overvoltage indication. Indicates RED when high voltage is over 260 Volts; otherwise indicates green.
DS26	Indicates RED when a three-phase power supply imbalance exists, either because of primary power phase loss or high voltage supply fault.
DS7	Indicates RED when a Cable Interlock fault exists (a cable between the Modulation encoder is off or faulty, or a PA module is missing), otherwise indicates green.
DS4	Indicates RED when the incoming audio and modulation envelope are not the same; indicates green when they are the same. (Detects modulator section faults or missing RF power amplifier steps).
DS28	Indicates RED when RF drive to the power amplifier is too high; otherwise indicates green.
DS27	Indicates RED when RF drive to the power amplifier is too low; otherwise indicates green.
DS25	Indicates RED when a high voltage power supply overload occurs (either a Peak current overload or an Average supply current overload).
DS23	Indicates RED when a door is open and the door interlock circuit shuts the transmitter OFF; indicates green when door interlocks are closed.
DS21	Indicates RED when the external interlock circuit is open and the external interlock shuts the transmitter OFF; indicates green when the external interlock circuit is complete.
DS8	Indicates RED when an output network fault or mistuning occurs; otherwise, indicates green.
DS16	Indicates RED when a VSWR occurs because of an antenna system (load) fault or mistuning of the transmitter Tee matching network (Tune and Load controls).
DS5	Indicates RED when a +15 Volt regulator fault occurs; otherwise indicates green.
DS6	Indicates RED when a +15 Volt regulator fault occurs; otherwise indicates green.
DS13	Indicates RED when a +5 Volt regulator fault occurs; otherwise indicates green.
DS10	Indicates RED when a -15Vvolt regulator fault occurs; otherwise indicates green.
DS11	Indicates RED when a -15 Volt regulator fault occurs; otherwise indicates green.
DS15	Indicates RED when a Conversion Error is detected on the Analog to Digital Converter board (A34), otherwise indicates green.
DS9	Indicates RED if the VSWR Self-Test does not Pass because of a VSWR detector or logic fault; otherwise, indicates green. (VSWR self-test is done automatically each time primary power is applied or can be done manually at any time).
DS3	Indicates RED if the Predriver loses RF output; indicates green if Predriver RF output is normal.
DS2	Indicates RED if the Buffer Amplifier loses RF output; indicates green if Buffer Amplifier RF output is normal.
DS1	Indicates RED if the Oscillator board loses RF output; indicates green if Oscillator board RF output is normal.
DS20	Indicates that the transmitter is in the LOCAL control mode.
DS19	Indicates that the transmitter is in the REMOTE control mode, and can be controlled either from front panel controls or by remote control.
R86	Sets high voltage power supply protection sensitivity.
R41	Sets PA Overdrive Fault sensing sensitivity.
R67	Sets PA Underdrive Fault sensing sensitivity.
R68	Sets high voltage power supply peak current overload sensitivity.
R42	Sets high voltage power supply average current overload sensitivity.
S4	Selects Local control (remote control disabled) or Remote control (remote control enabled).

Table Q-4. LED Board A32, Test Points
See Figure Q-10

COMPONENT	FUNCTION/DESCRIPTION
TP9	Power Supply Protection Circuit, AC Sample.
TP10	Power Supply Protection Circuit, detected sample (comparator’s non-inverting input).
TP11	Power Supply Protection Circuit, Comparator reference voltage.
TP4	Underdrive fault circuit, Detected rf drive sample.
TP5	Overdrive fault circuit, Comparator reference voltage. (also see TP11)
TP8	Underdrive fault circuit, Comparator reference voltage.
TP7	HV Power Supply Peak Current overload circuit reference voltage (comparator inverting input).
TP6	HV Power Supply Average Current overload circuit reference voltage (comparator inverting input).
TP12	HV Power Supply, Averaged Current sample (Average Current overload comparator’s non-inverting input.
TP13	HV Power Supply Sample (Peak Current overload comparator’s non-inverting input.)
TP3	Underdrive fault circuit, Detected rf drive sample.
TP14	Ground.
TP15	Ground.
TP1	Ground.
TP2	Ground.

R.1 Introduction

The switch board provides manual pushbutton control for transmitter ON/OFF functions, allowing LOW, MED, and HIGH power selection, power raise/lower control, selection controls for the multimeter and the forward/reflected power readings. LED's are provided to indicate the current selections.

The switch board is located on the back of the left Control Compartment door. The printed wiring board itself is a 'breakaway' board, which is split in two pieces which after assembly, are folded in half, and mounted piggy-back. The half containing the switches and LEDs is mounted to the panel such that these components protrude through panel cutouts and are accessible to the operator. The second half is then mounted on the back of the first half, and it contains the control circuitry. This is done so that the height of the components on the second half of the board will not mechanically interfere with the panel since the board must be mounted closely to the panel to allow the switches and LED's to protrude through.

Refer to the Switch/Meter Board Schematic 839-6208-301 for the following discussion.

R.1.1 Power Control

See sheet 1. When any of the power control pushbuttons (OFF, LOW, MED, HIGH, RAISE, or LOWER) are depressed, a +15vdc command signal is provided to the transmitter power control section of the Controller. Refer to section P (Controller) for ON/OFF control logic circuit descriptions.

Indicator LED's are located above each switch (with the exception of the OFF switch) which illuminate when their corresponding switch has been depressed. Each LED is connected to the +15vdc bus through a resistor. The other side of the LED's are connected to an open collector output from the Controller.

R.1.2 Multimeter Circuit (M1)

R.1.2.1 Meter Selection Circuit

See sheet 2. The multimeter selection is done by repeatedly depressing the multimeter selection pushbutton switch until the desired function is reached, indicated by an illuminated LED next to the desired function labeled on the front panel.

Each appropriate metered signal is provided to the board via the ribbon cable connected to the board at J1. Each line is terminated with the appropriate impedance and with a bypass capacitor. Each signal is interfaced via a voltage follower op amp (U2, U4, and U5) and provided to multiplexer U3, which then selects the appropriate line to be fed to the multimeter corresponding to the selection made with the front panel switch.

The corresponding LED is illuminated similarly by demultiplexer U8, which selects the appropriate LED to illuminate corresponding to the selection made with the front panel switch. The LED's are connected to the +15vdc bus via resistors, then through driver IC U1, through the demultiplexer, to ground.

Both multiplexer U3 and the demultiplexer U8 are addressed via a counter IC U6, which is incremented by each closure of the selection switch. At power up, the address is set to 000, which selects the first multimeter position automatically.

R.1.2.2 Metering Circuits

The 100ua movement meter used as the multimeter is driven by a final op amp (U9A) and has an RF bypass cap (C41) and a filtering cap (C1). The filtering cap helps remove any transients from the power supply, and removes any ripple from the -15vdc converter regulator IC, U14.

Each meter signal is provided from the metering circuits described following.

a. PA +VDC (+230vdc supply): Multiplier resistors are located on Fuse board A24, and buffering is provided on the Controller board.
b. ANTENNA NULL and FILTER NULL: These are detector null indications for the VSWR detector circuits on the Output Monitor. Buffering of these signals is provided by op amps on the Controller board.
c. RF DRIVE: The Relative RF Drive signal is taken from RF drive sample circuit located on the LED board. The 'RF drive estimate' output is routed through the Controller to the switch board.
d. +/- 22vdc, +/-8vdc: These positions indicate unregulated output voltages from the Low Voltage power supply. The multiplier resistors for these voltage scales are located on the Controller.

R.1.3 Supply Current Meter Circuit (M2)

The power supply current sample is taken from a shunt resistor in the negative output of the 230 volt power supply. The voltage developed across the meter shunt is proportional to the supply current (and is 50 millivolts when supply current is 100 amperes). This voltage is brought to J1-36 and J1-37 on the Switch Board/Meter Panel printed circuit board, and is routed through Controller Board A38 to Overcurrent fault and overload circuits on LED Board A32. See sheet 2.

R.1.4 Power Meter Circuit (M3)

Buffering of the forward and reflected power samples is provided by two sections of op amp U5. The U5 output signals are routed through multiplexer U10, op amp U9, then to the power meter.

Selection of forward or reflected power is accomplished by multiplexer U10, which is driven by flip flop U11. Switch S8 toggles flip flop U11. Display of the selected metering function is provided by leds DS8 and DS9.

Upon application of dc power, the forward/reflected meter should be in forward power position, as determined by the Set input to flip flop U11.

R.1.4.1 Minus 15 Volt Power Source

IC U14 provides the negative power supply voltage that is needed by the various op amps. See sheet 2.

R.2 Maintenance

R.2.1 Adjustments

There are two adjustments on the Switch Board/Meter Panel: Forward Power Calibrate control A31R14, and Reflected Power Calibrate control A31R13. These adjustments are made at the factory by measuring transmitter power output in a calorimetric dummy load. These calibration adjustments should not be changed unless some means of accurately measuring transmitter output power is available. Refer to the Tuning/Frequency Change Procedure for information on calibrating the reflected power meter.

R.3 Troubleshooting

R.3.1 Symptom: Incorrect Meter Indications

R.3.1.1 Possible Causes:

a. Metered Parameter (Voltage, Current, or Power) Has Changed. If possible, check the parameter with another meter which is known to be accurate. Most parameters can be checked on other circuit boards in the non-interlocked compartment. The paragraphs on "Principles of Operation" above include circuit boards on which various metering circuits are located.

b. Metering Circuit Fault. Again, refer to the paragraphs on "Principles of Operation", above, for location of metering circuits. Possible faults include:

   1. Operational Amplifier (IC) failure (for PA SUPPLY VDC, DET NULL, RELATIVE RF DRIVE, REFLD PWR, and FWD PWR indications). Operational amplifier failure could cause either no indication or a full scale indication. Voltage followers used as buffer-drivers should have a gain of 1, that is, input and output voltage should be the same. b. Multiplier resistor changed value. Most multiplier resistors can be checked in-circuit, if the multimeter is switched to some other position to eliminate parallel resistance paths.
   2. Faulty Meter Movement. Occasionally, meter movements can change calibration. One way to check a meter movement is to put the meter in series with a low-current source and a microammeter of known accuracy. Multimeter M1 and power meter M3 have 640 ohm, 100 microampere movements. Supply current meter M2 has a 10 ohm, 5 milliampere movement.

Prior to starting a troubleshooting procedure check all switches, power cord connections, connecting cables, and power fuses.

Section S
Driver Encoder/Temp Sense Board (A19)

S.1 General Description

The Driver Encoder/Temp Sense Board is located in the Driver Control Compartment and provides the following functions:

a. Provides "turn-on" control signals to the 15 RF amplifiers used in the Driver stage. "Turn-on" control signals are fed to the driver amplifiers when a transmitter TURN ON REQUEST signal is generated by depressing one of the transmitter LOW, MEDIUM, or HIGH buttons. The "Turn-on" control signals are removed when the "OFF" push-button is depressed.

b. Provides a status output signal to the Modulation Encoder cable interlock circuitry. If an RF amplifier module is removed from the Driver Combiner Motherboard or if a cable between this board and the Driver Combiner Motherboard is not connected, DRIVER CABLE INTERLOCK LED DS8 will illuminate. This will generate a "CABLE INTERLOCK" fault to the LED Board and the transmitter will turn OFF.

c. Monitors the temperature of RF amplifier modules RF33 and RF34. A voltage proportional to the temperature is provided to the External Interface for remote monitoring. If the module temperature rises above a preset reference level, the transmitter power output will automatically reduce (foldback) in a three-step sequence:

   1. If the temperature approaches the foldback set point TEMPERATURE CAUTION LED DS3 will illuminate.
   2. If temperature further increases, power output will gradually reduce until a safe operating point is reached. The OVER TEMP LED DS2 will flash, indicating foldback is in process.
   3. If temperature continues to increase during the gradual foldback sequence, power will rapidly reduce and the OVER TEMP LED DS2 will latch ON.

d. Monitors air flow for normal, reduced and fault conditions.

   1. If the air flow is reduced because of restricted filters or failure of one of the four cooling fans, the AIR FLOW REDUCED LED DS7 will illuminate. The AIR LED on the ColorStat™ panel will change from GREEN to AMBER.
   2. If the air flow is further reduced because of restricted filters or the failure of two of the four cooling fans, the AIR LED on the ColorStat™ panel will change from AMBER to RED and the transmitter will shut OFF.

S.2 Theory Of Operation

Refer to the Driver Encoder/Temp Sense schematic, 839-7855-175, in the Drawing Package.

The Driver Encoder/Temp Sense Board can be divided into five basic circuits:

- Driver Turn-On Control
- Temperature Sensor/Power Foldback
- Air Flow Detection
- Cable Interlock Monitor
- Power Supplies

S.2.1 Driver Turn-On Control

When the LOW, MEDIUM, or HIGH button is pressed, a "TURN-ON REQUEST" active LOW signal is received from the LED Board. This signal is applied to the input of inverter U8. The output of U8-11 provides a logic HIGH to the inputs of line drivers U1 and U2 and provides the pull-up voltage for comparator U3-14. The outputs of U1 and U2 drive transistor pairs Q1-Q7, Q2-Q8, Q3-Q9, Q4-Q10, Q5-Q11, and Q6-Q12.

When the input to the line drivers is HIGH, the outputs are LOW. This will turn on the PNP transistors in the Driver Turn-On Control circuit and provide -5 VDC to the control transistors on the Driver Amplifier modules. This will turn the modules ON.

When the inputs to the line drivers are LOW, the outputs are HIGH. This will turn on the NPN transistors in the Driver Turn-On Control circuit and provide +5 VDC to the control transistors on the Driver Amplifier modules. This will turn the modules OFF.

Line drivers U1-3, U1-6, U1-8, and U2-3 control 13 of the 15 Driver Amplifiers.

Table S-1. Integrated Circuit Functions

U1,U2	MC1488	QUAD MDTL LINE DRIVER
U3,U7,U11	CA339E	QUAD COMPARATOR
U4	MC74HC74	DUAL D FLIP-FLOP
U8	MC74HC00	QUAD 2 INPUT NAND
U9,U10	LM324N	QUAD OP AMP
U12	MC74HC423AN	MULTIVIBRATOR
U13	UA7815UC	+15V REGULATOR
U14	LM340T5	+5V REGULATOR
U15	MC7905CT	-5V REGULATOR

Driver Amplifier modules D5, D9 and D10 can be selected during factory test to be ON or OFF by JP1, JP2 and JP3. Some frequencies do not require all 13 Driver Amplifier modules.

Line driver U1-11 controls the SPARE DRIVER D6 and line driver U2-6 controls the AUTO DRIVER D7. The SPARE DRIVER switch S1 is normally in the OFF position. The AUTO DRIVER switch S2 is normally in the ON position.

S.2.1.1 Auto Spare Control Circuitry

The RF drive level to the 64 PA amplifiers is sampled and converted into a “Control +VDC” signal. The “Control +VDC” signal is used as the RF drive reference for the Driver Supply Regulator and for the Auto Spare Control circuitry. The Control +VDC voltage can be monitored on the RF MULTIMETER on the inside of the Driver Compartment door.

The AUTO DRIVER D7 is used as a “coarse” drive adjustment. If the RF drive level to the PA amplifiers decreases, due to the failure of a Driver Amplifier or a decrease in AC line voltage, the Control +VDC signal will decrease. The Driver Supply Regulator will increase the drive by raising the B+ voltage to D8A and then to D8B. If the Driver Supply Regulator increases the B+ voltage to both D8A and D8B to maximum (+115 VDC), and the RF drive is still not at the proper level, the Auto Spare Control circuit will turn D7 ON.

When D7 turns ON, the Driver Supply Regulator will reduce the B+ voltage to D8A and D8B to keep the RF drive within the correct range. The Driver Supply Regulator will then continue to regulate the RF drive level by adjusting the voltage to D8. The D8A and D8B voltage can be monitored on the RF MULTIMETER on the inside of the Driver Compartment door.

Comparators U3-8 and U3-10 form a threshold window to determine when D7 is ON or OFF. Driver Threshold adjustment R19 sets the ON threshold and Driver Threshold Reset R17 sets the OFF threshold. When the Q output of U4 is HIGH, “set”, D7 is ON. When the Q output of U4 is LOW, “reset”, D7 is OFF. The AUTO DRIVER LED DS1 will illuminate then the Auto Driver is operating.

During normal operation, the “Control +VDC” signal is above the Driver Threshold ON level at TP-2 and below the Driver Threshold Reset (OFF) signal at TP-1. Therefore, U3-13 is LOW, U3-14 is HIGH, and U8-6 is LOW. This will “reset” U4-5 Q output (LOW) and cause U2-6 to go HIGH. This will turn D7 OFF.

If the “Control +VDC” signal falls below the Driver Threshold ON reference at TP-2, U3-13 goes HIGH and U8-6 goes HIGH. This will “set” U4-5 Q output HIGH and cause U2-6 to go LOW. This will turn D7 ON.

If the “Control +VDC” signal rises above the Driver Threshold Reset (OFF) reference at TP-1, U3-14 goes LOW and U8-6 goes LOW. This will “reset” U4-5 Q output LOW and cause U2-6 to go HIGH. This will turn D7 OFF.

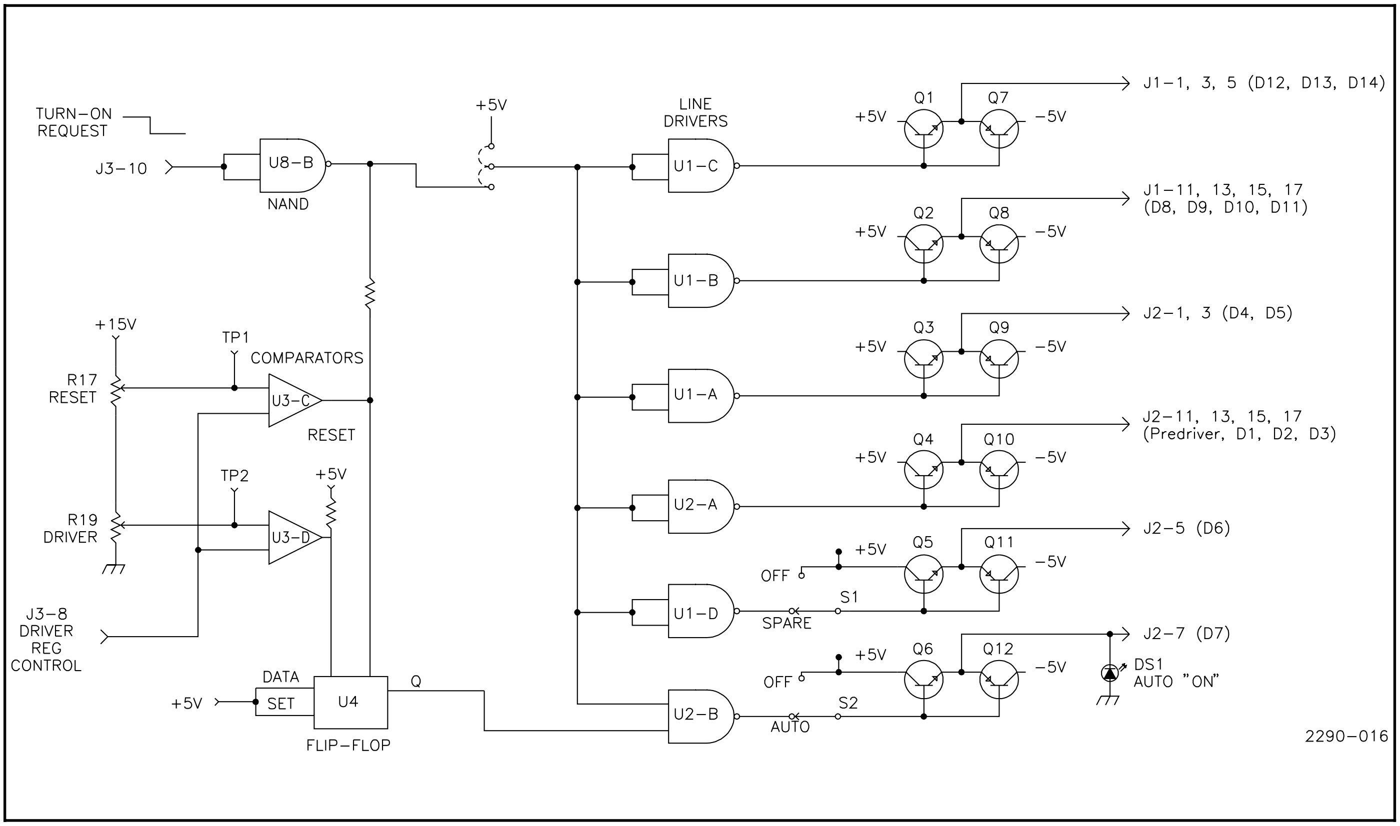

Figure S-1. Driver Encoder Block Diagram
Buffer Amplifier Control Functions

When S2 is in the OFF position, the AUTO DRIVER D7 is disabled. This position is used only during factory test of the transmitter.

With J5 in the "TEST" position, operation is the same as described above except that drive "ON" signals can be applied to all Driver Modules except the "AUTO" driver without turning the transmitter ON. This feature is provided as an aid to troubleshooting.

S.2.2 Temperature Sensor/Power Foldback

Refer to Figure S-2 for the following discussion.

The PA RF amplifier temperature is monitored by two precision temperature sensors mounted on the heat sinks of PA Modules RF33 and RF34 (steps 1 and 2). The voltages from the sensors are calibrated by AMB1 potentiometer R50 and AMB2 potentiometer R51, buffered by operational amplifier U9, and ampli-

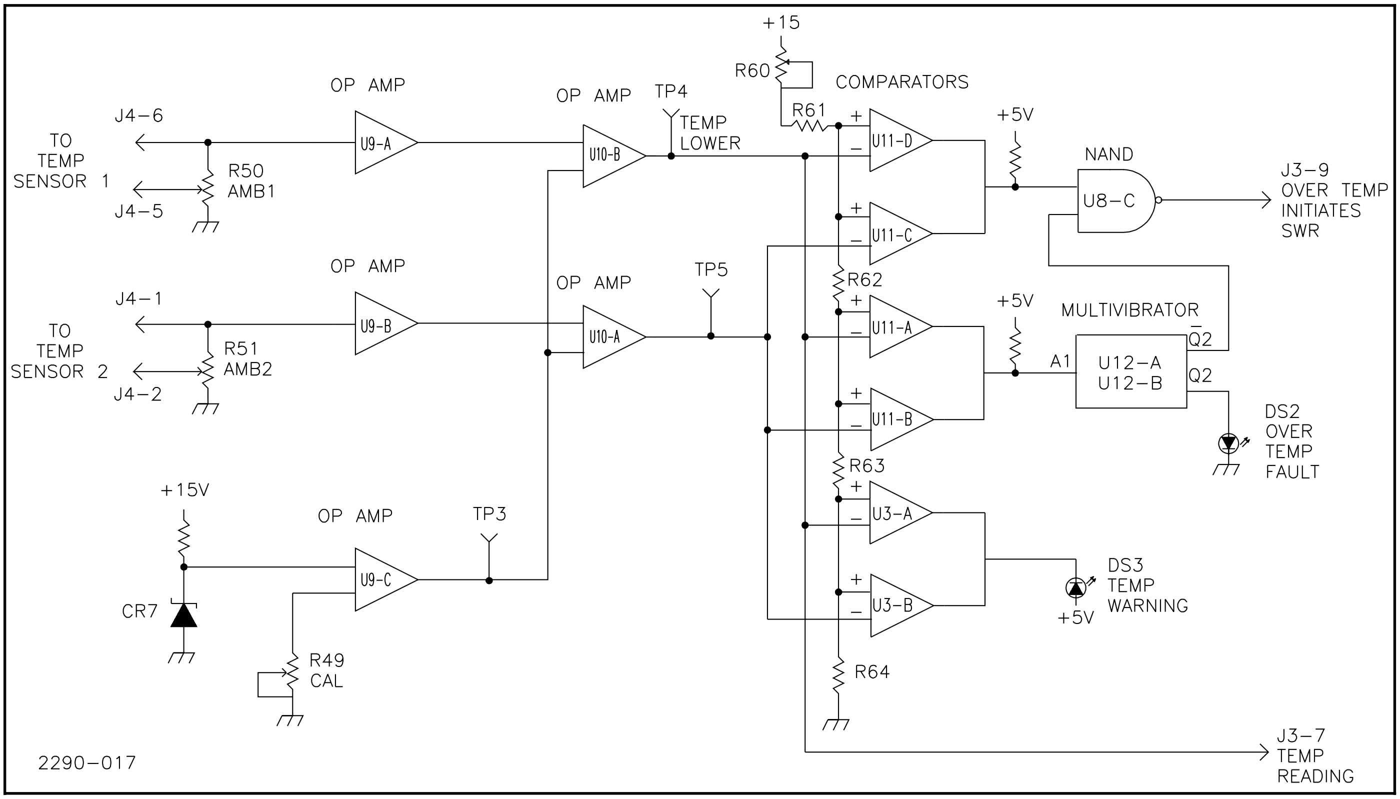

Figure S-2. Driver Encoder Block Diagram
Temperature Sensor/Power Foldback Function

Table S-2. Adjustments and Indicators
(See Figure S-4)

LOCATION	COMPONENT	FUNCTION/DESCRIPTION
D5	DS1	DRVR, illuminates when D7 is turned on
D6	DS2	OVER TEMP, illuminates when power reduction signal is high
D5	DS3	TEMP CAUTION illuminates when U3 comparators activate
E5	J5	Jumper plug to set Control Functions to Auto or ON
B2	R17	Adjusts the OFF threshold for D7
B2	R19	Adjusts the ON threshold for D7
A2	R49	Adjusts reference voltage output of U9-C, "CAL"
B2	R50	Adjusts calibration of sensor AMP 2
A2	R51	Adjusts calibration of sensor AMP 1
A5	R60	Adjusts TEMP LOWER threshold for U11
D4	S1	Selects D6 control function
E4	S2	Selects D7 control function

fied by U10. A DC offset voltage for U10 is provided by U9. The reference for U9 is obtained from zener diode CR7 and is adjusted for 2.73 Volts at TP3 with CALIBRATE potentiometer R49.

Voltage divider R60, R61, R62, R63, and R64 provides the reference voltage for the non-inverting inputs of comparators U11 and U3. A voltage proportional to the temperature of RF33 is supplied from the output of U10-1 to the inverting input of comparators U11-4, U11-10 and U3-4. The temperature of RF33 can also be monitored externally.

A voltage proportional to the temperature of RF34 is supplied from the output of U10-7 to the inverting input of comparators U11-6, U11-8 and U3-6.

Since the operation of both circuits is identical, only RF AMP TEMP SENSOR 1 operation will be discussed.

If the RF33 temperature increases, the voltage to the inverting inputs of U11 and U3 will increase. Due to the reference voltage divider action, the output of U3-2 will go LOW while the outputs of U11-2 and U11-13 will remain HIGH. When the output of U3-2 goes LOW, TEMP CAUTION LED DS3 will illuminate.

If the RF33 temperature continues to increase, the output of U11-2 will go LOW. This will enable multivibrator U12 and cause U12-12 to toggle between HIGH and LOW. Each time U12-5 goes high, U4 completes one clock cycle and TEMP INDUCED LOWER LED DS2 will illuminate, indicating power reduction is in process.

At this point NAND gate U8-9 is held HIGH by U11-13 while U8-10 toggles from HIGH to LOW. Each time U12-12 goes LOW, output U8-8 will go HIGH. This HIGH (pulse) to the Controller will slowly lower the transmitter power until the proper operating temperature is reached.

If RF33 temperature continues to rise while gradual power fold-back is taking place, U11-13 will go LOW. This will cause the output of U8-8 to go HIGH. The constant HIGH signal to the Controller will cause the transmitter to reduce power rapidly. As the temperature lowers, the signal at J3-9 will change from a continuous HIGH, to a pulsing HIGH-LOW, to a continuous LOW. When the temperature falls below the TEMP INDUCED LOWER set point, the continuous foldback will stop.

The OVER TEMP LED DS2 will remain ON until the FAULT IND RESET switch S3 is depressed.

S.2.3 Air Flow Detection

The air flow detection consists of an air flow monitor and a two-stage fault detection circuit.

S.2.3.1 Air Flow Monitor

The Air Flow Monitor consists of an ambient temperature sensor, a heated temperature sensor, and a differential amplifier. Both sensors are mounted at the lower edge of the board in the airstream from the PA Power Supply section of the Driver Compartment.

The output of ambient temperature sensor U16-2 is connected to the inverting input of differential amplifier U18-2. The heated temperature sensor U17 is thermally connected to R91, a 30

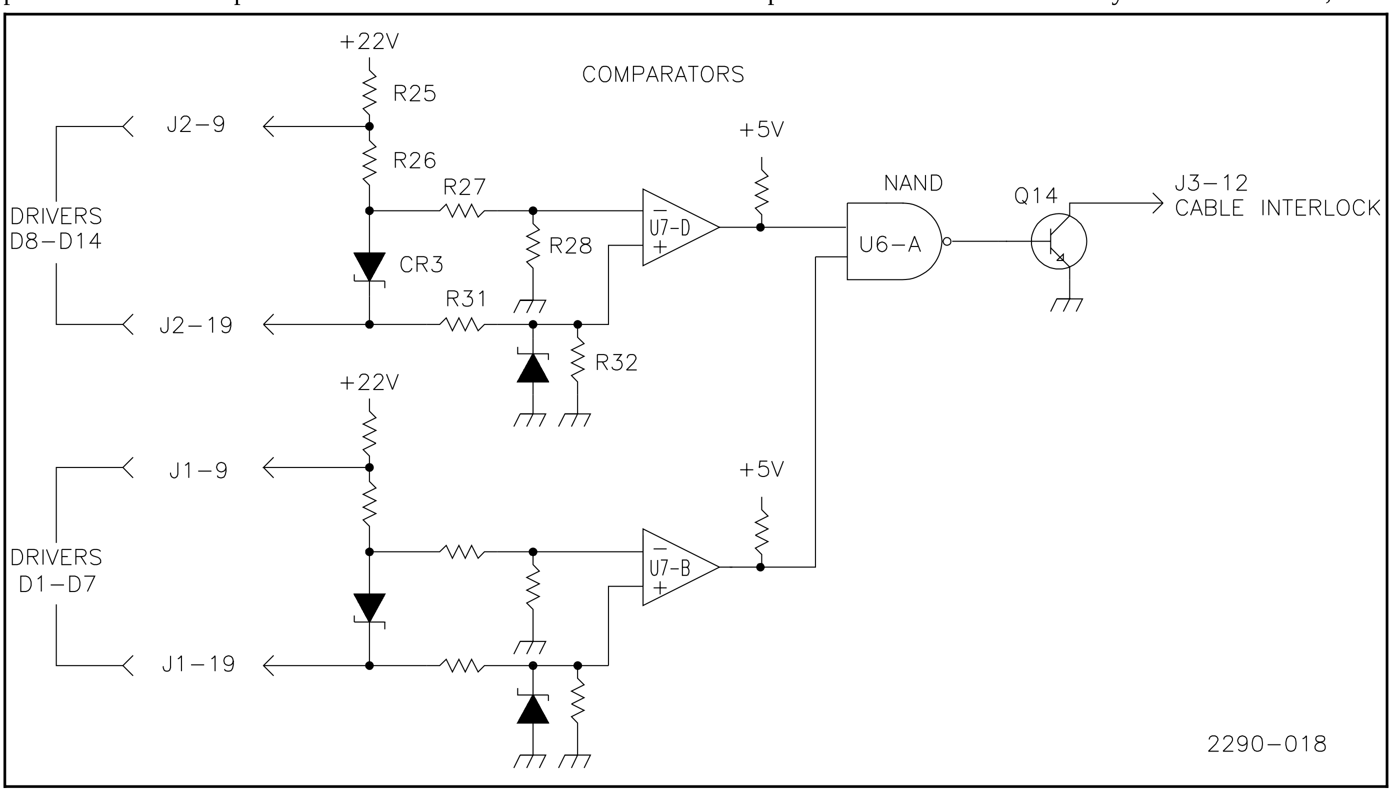

Figure S-3. Driver Encoder Block Diagram
Driver Interlock Function

Ohm, 20W resistor, by an angle bracket. The output of U17-2 is connected to the non-inverting input of differential amplifier U18-3. Differential amplifier U18 will only amplify the difference between these two inputs.

A TURN ON REQUEST switches Q15 ON and applies +5 VDC to R91. The output voltage of U17-2 will increase as the R91 heats up. The voltage will then stabilize as air flow passes over both components.

Normal air flow in the transmitter will cause the voltage at U18-1 to stabilize. If the air flow decreases, the temperature of R91 will increase and U18-1 output will increase due to the greater differential between inputs U18-3 and U18-2.

The difference between the Ambient temperature sensor and the output of the heated sensor is buffered and amplified by U18. The AIR FLOW CAL is adjusted by R98.

S.2.3.2 Air Flow Fault Detectors

A two level fault comparator circuit is formed by U19. A resistive voltage divider establishes voltages at the inverting inputs of the comparators: +2.76 VDC at U19-4 and +2.90 VDC at U19-5. The non-inverting inputs U19-5 and U19-7 are connected together.

The failure of one of the four fans or restricted air intakes will cause the air flow voltage at TP11 to increase above the reference at U19-4 (2.76 VDC) and cause output U19-2 to go HIGH. This will cause U19-13 to go from HIGH to LOW and illuminate AIR FLOW REDUCED LED DS7. This logic HIGH is also sent to the LED Board and will cause the AIR LED on the ColorStat™ panel to change from GREEN (normal) to AMBER (air flow reduced).

If the air flow voltage continues to rise, the air flow voltage will increase above the fault reference U19-5. The output U19-1 will go HIGH and trigger the AIR FAULT on the LED Board. The AIR LED on the ColorStat™ panel will turn from AMBER to RED (fault).

S.2.4 Cable Interlock Monitor

Refer to Figure S-3 for the following discussion.

The CABLE INTERLOCK MONITOR function is provided by two series connections. When all the Driver Modules and Driver Encoder cables are properly installed, a circuit is established between J1-9 and J1-19 from Driver Modules D8 through D14 and between J2-9 and J2-19 from Driver Modules D1 through D7. Both interlock circuits are identical. Therefore, only the interlocks involving J2-9 to J2-19 will be discussed.

Due to the voltage divider action of R25, R26, R27, R28, and R25, R31, R32 (through the interlock circuit), the voltage at non-inverting input U7-11 will be greater than the voltage at inverting input U7-10. Under these conditions, output U7-13 will be HIGH.

If the interlock J1-9 to J1-19 is not broken, U8-1 and U8-2 inputs will both be HIGH. With both inputs to NAND gate U8 HIGH, the output U8-3 will be LOW and Q14 will be turned OFF. The collector of Q14 will be HIGH due to a pull-up resistor on the Modulation Encoder.

If the circuit between J2-9 and J2-19 is broken (by removing the encoder cable or unplugging a Driver Module), the voltage at non-inverting input U7-11 will be lower than the voltage at the inverting input U7-18 due to the additional voltage drop provided by CR3. Under these conditions, U7-13 will go LOW. With a LOW on either or both inputs of U8, output U8-3 will go HIGH and turn on Q14. This will light the DRIVER CABLE INTERLOCK LED DS8 and give a CABLE INTERLOCK fault to the LED Board through the Modulation Encoder. The CABLE INTERLOCK LED will illuminate on the ColorStat™ panel and the transmitter will turn OFF.

S.2.5 Power Supplies

Regulator U13 provides +15 VDC from the unregulated +22 VDC supply. When the +15 VDC is present, DS4 will illuminate. The +15 VDC supply is fused by F01 and can be monitored at TP7.

Regulator U14 provides +5 VDC from the unregulated +8 VDC supply. When the +5 VDC is present, DS5 will illuminate. The +5 VDC supply is fused by F02 and can be monitored at TP8.

Regulator U15 provides -5 VDC from the unregulated -8 VDC supply. When the -5 VDC is present, DS6 will illuminate. The -5 VDC supply is fused by F03 and can be monitored at TP9.

S.3 Maintenance

Refer to Section V of this manual for general printed circuit board maintenance procedure.

S.4 Adjustment

Refer to Tuning and Setup Procedures in SECTION V, Maintenance.

Appendix A
Lightning Protection Recommendation

a.1. Introduction

What do you do with a 2 million volt pulse pushing 220,000 amps of current into your transmitting plant? Like the 500 pound gorilla you let it do what ever it wants to. There is not much that can be done to protect against a major direct lightning strike. This is called a significant impulse lightning stroke. It usually lasts less than 100 microseconds and is most destructive to electronic equipment because it contains huge amounts of high frequency energy.

Here are some examples of this damage:

- Melted ball and horn gaps.
- Ground straps burned loose.
- H.V. rectifier stacks shorted.
- Massive arc marks in the output circuit of AM transmitters.
- Ball lightning traveling into building on outer conductor of transmission line.

Figure A-1 is a map of the United States that shows the number of lightning days you can expect in any year. You fellas in Colorado, New Mexico, and Florida need lightning rods on your hats.

Figure A-2 shows the incidents to tall structures. A triggered event is one that happens because the tower was present. Without the tower the strike would not have occurred.

a.2. Enviornmental Hazards

There are devices and procedures that do offer protection from lessor environmental hazards than lightning. Some of these anomalies are listed and defined:

a. Over voltage/under voltage (brownout). Where the lines voltage differs from the nominal RMS for longer than one cycle.
   - Remedy - Automatic voltage regulators, preferably individual regulators on each phase. This can only be accomplished when the power feed line is delta or 4/wire wye connected. (See Figure A-3.)

b. Single phasing. This is where one leg of the three phase service is open.
   - Remedy - Protection afforded by a loss of phase detector. Without protection power transformers and 3 phase motors over heat.

c. Radio frequency interference (RFI). This is something we must design into all of our transmitters, however, you may purchase equipment that is susceptible, is not protected, and develop problems.
   - Remedy - RFI filters on the ac lines and control lines are sometimes effective. Sometimes the entire device must be enclosed in an RF free space.

d. Electromagnetic pulse (EMP). This is a interfering signal pulse that enters the system by magnetic coupling (transformer). Generally caused by lightning.
   - Lightning from cloud to cloud produces horizontally polarized waves while lightning from cloud to earth produce vertically polarized waves. The waves couple into the power lines and transmission lines causing large induced voltage that destroy high voltage rectifier stacks and output circuit faults. High frequency energy is coupled back into the transmitter causing VSWR overloads. (See Figures A-4 & A-5.)
   - Remedy - Ball or horn gaps at the base of the antenna prevent the voltage from exceeding some high potential. Transient suppressor devices on the input power lines remove excessive voltage spikes. Buried power and transmission lines will reduce the amount of coupled energy to a great extent. This does not totally eliminate the problem because there are currents traveling in the earth when lightning strikes close to the station which prefer to travel on the metal conductors.

e. Surge. A rapid increase in voltage on the power lines usually caused by lightning. The duration is less than 1/2 cycle and can be very destructive.
   - Remedy - Transient protectors are very effective in preventing damage to the equipment when properly designed and installed. (See Figure A-7.)

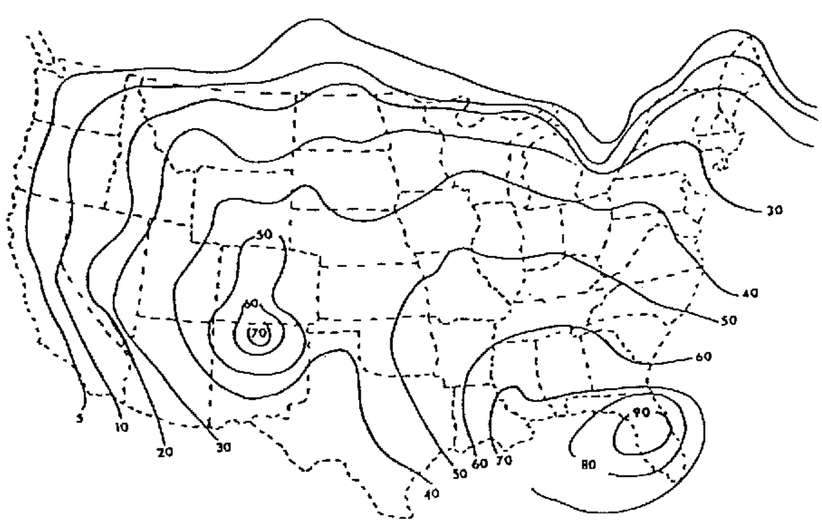

Figure a-1. Isokeraunic Map of the United States Showing Lightning Days Per Year

Significant Lightning Stroke Characteristics	
Charge Range	2 to 200 coulombs
Peak Currents	2,000 to 400,000 Amperes
Rise Time to 90%	300 Nanoseconds to 10 Microseconds
Duration to 50%	100 Microseconds to 10 Milliseconds
Potential Energy at 99%	1010 Joules*
* Only a small portion is manifested in a surge, usually less than 10,000 Joules.	

a.3. What Can Be Done?

Installation of the transmitter building, antenna tuning unit if applicable, and antenna should be done so that the risk of destruction due to lightning is minimal and the efficiency of the over all system is maximized. To do this, separate ground systems should be installed for the building and antenna. This forces all of the RF return currents to flow in the transmission line shield. The coax can be buried below the antenna ground plane to still further reduce the RF current coupled to it.

In medium and short wave installations the antenna ground plane is very important as it is ½ of the radiating element. RF current leaving the antenna must return via the ground path (ground wave). For this reason the “antenna coupling unit” must be close to the base of the tower and securely connected to the ground plane.

Figure A-6 shows the basic elements of a properly designed antenna system.

- Good ground plane.
- Ball gap on tower.
- Series inductor in tower feeder.
- Antenna coupling unit connected to antenna ground.
- The π circuit is equivalent to the normal Tee used by Harris.
- Underground coax.
- Guy wire length broken by insulators and grounded at the bottom end.

The transmitter building must be given extra protection to insure reliable equipment operation. A low impedance safety ground system must be installed using 3 inch wide copper strap hard soldered at all joints and connected to multiple ground rods located at the perimeter of the building. The ground rods should be wet to make good connection to the earth water table. All equipment cabinets within the building must be connected to the ground straps for safety reasons.

a.4. AC Service Protection

See Figure A-7. All incoming ac lines should have a choke connected in series to limit the high frequency surges on the lines followed by a surge protector. The surge protector must be connected to the building ground system by short direct connections.

A surge protector is a solid state device that is a high impedance until the voltage across it reaches its rated clamping voltage at which time the impedance suddenly decreases. The protector will then conduct hundreds to thousands of amperes to ground. All protectors are rated for maximum voltage and maximum surge energy. If the surge energy exceeds rating of the device it will normally short and for this reason must be fused so it will disconnect itself from the line being protected. When this happens all protection is lost so some warning system must be used to tell the operators that a new protector should be installed.

Speed is essential to protect equipment from current surges with rates of rise exceeding 10,000 amps per microsecond and pulses that last no longer than 100 microseconds. Very short, low inductance ground straps are required to pass surges of this type.

The surge protectors must be selected for the line to ground voltage and the maximum energy to be diverted. Bigger is always better in this case. There are several manufacturers of surge protectors:

- Lightning Elimination Assoc., Inc.
- Current Technology
- Control Concept

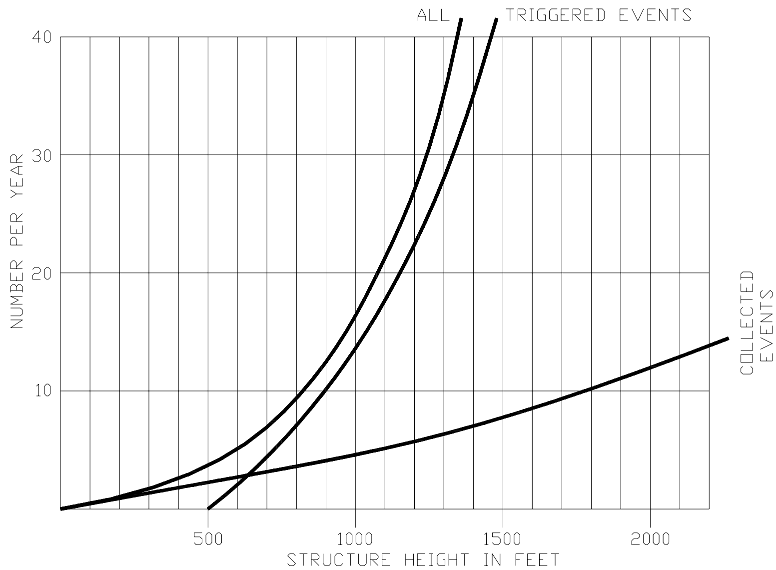

Figure a-2. Lightning Incidents to Tall Structures

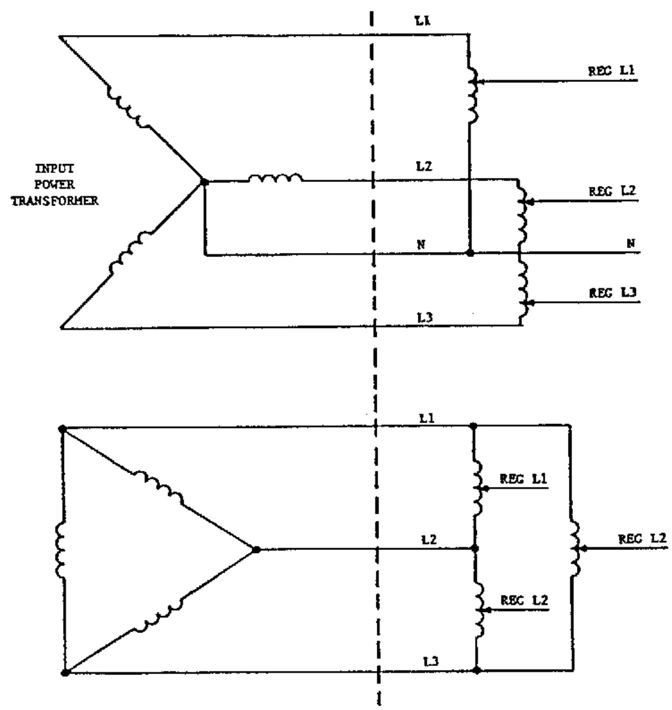

Figure a-3. Regulators in Delta and 4/Wire WYE Systems

- MCG Electronics, Inc.
- EFI Corp.
- General Electric

All of these vendors provide parts and systems to protect broadcast transmitters.

All audio and control lines should be protected the same as described for ac lines with components sized accordingly.

All coaxial lines should have the shield connected to the system ground at the point of entrance and in addition have a ferrite choke around it located between the entrance point and the equipment rack. This will provide a high impedance for current flowing in the shield but does not affect the signal currents.

a.5. Conclusion

The 1% chance of a major lightning strike probably can not be protected against but the other 99% can be controlled and damage prevented. Install surge protection on all incoming and outgoing lines at the wall of the building connected to a well designed ground system. Properly install the antenna ground system with spark gap adjusted correctly and maintained. With this done you can sleep peacefully at night if your bed isn't under the feed line.

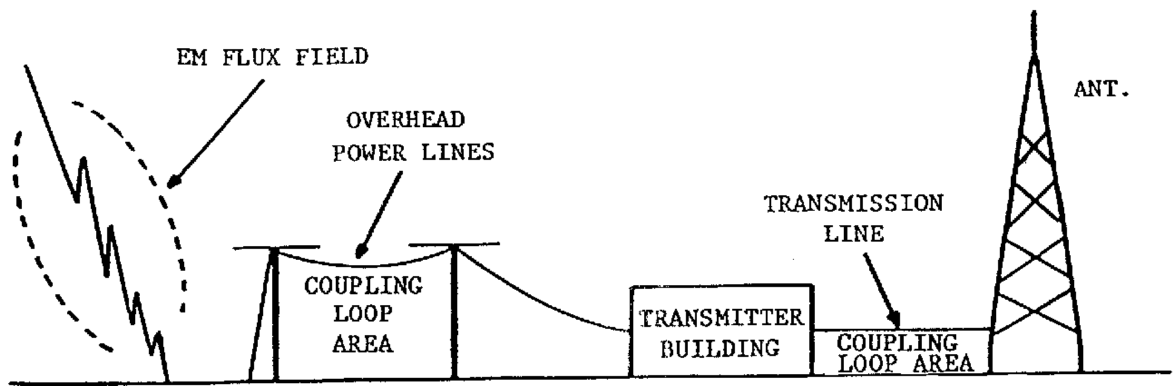

Figure a-4. EM Flux Field

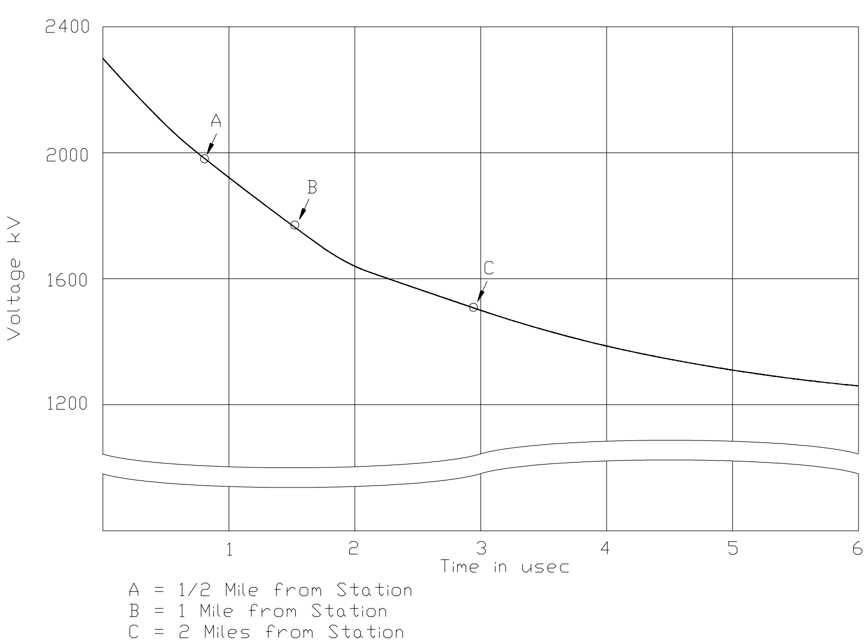

Figure a-5. Sample Surge Voltage as a Function of Distance from Stroke to Line

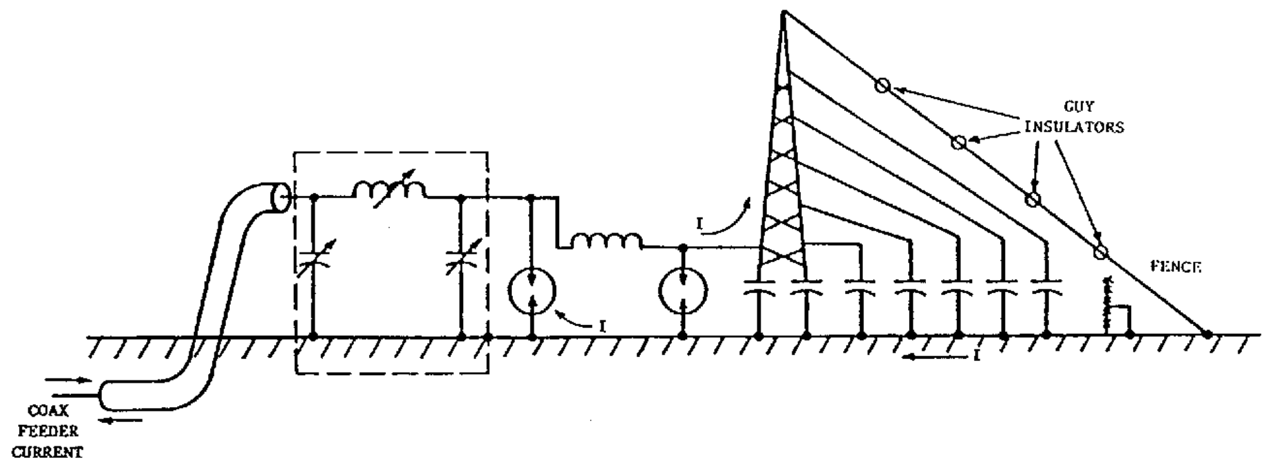

Figure a-6. Basic Elements of a Properly Designed Antenna System

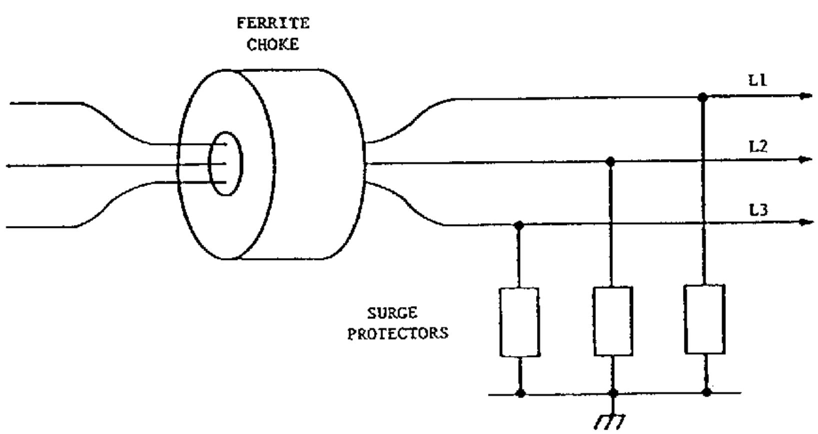

Figure a-7. Surge Protectors and Ferrite Choke

WARNING: Disconnect primary power prior to servicing.