Model AMM-3A
AM Modulation Monitor

Guide to Operations

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WARRANTY AND ASSISTANCE

All Belar products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, FOB factory or, in the case of certain major components listed in the instruction manual, for the specified period. Belar will repair or replace products which prove to be defective during the warranty period provided that they are returned to Belar prepaid. No other warranty is expressed or implied. Belar is not liable for consequential damages.

For any assistance, contact your Belar Sales Representative or Customer Engineering Service at the Belar factory.

1 General Information

1-1 General Description

The Belar AMM-3A AM Modulation Monitor is an all solid-state precision AM demodulator which exceeds the US Federal Communications Commission standards for measuring the total modulation characteristics of medium-frequency AM broadcast transmitters. The detector circuitry of the AMM-3A is non-frequency discriminating, so the unit is also suitable for use with shortwave transmitters. The AMM-3A employs a unique analog divider circuit which maintains the accuracy of all indications despite changes in carrier level. Simultaneous indications of negative and positive modulation appear on two semi-peak reading meters. Negative and positive modulation peaks are simultaneously indicated on two thumbwheel-programmable peak indicators, as well as individual fixed negative 100% and positive 125% modulation peak indicators. Front panel pushbuttons select meter indications of relative carrier level and AM noise. The AMM-3A incorporates a carrier level alarm which indicates when the carrier level falls outside the range required for accurate indications. Also included are an adjustable modulation level alarm, and a calibration reference to check the accuracy of the readings at any time. An internal jumper can be set to apply the USA NRSC de-emphasis characteristic to the audio outputs.

1-2 Physical Description

The AMM-3A is constructed on a standard EIA 5¼ × 19 inch rack mount chassis. The AC power input, RF input, and monitor outputs are located at the rear of the AMM-3A chassis on individual connectors and the rear panel card-edge connector. Calibration adjustments are located within the unit. The modulation alarm adjustment is accessible at the rear.

The AMM-3A is completely solid-state, utilizing all silicon transistors and integrated circuits for long, trouble free service. LED's (light-emitting diodes) are used for the indicators to eliminate lamp burnout. The individual circuits are constructed on a military grade glass-epoxy, plated and masked printed circuit board. High reliability industrial grade components are used throughout.

1-3 Electrical Description

The AMM-3A is a solid-state, low sensitivity, precision AM demodulator incorporating a highly linear biased-diode detector. The detector circuit will accurately demodulate envelopes of AM carriers from 260 kHz to 50 MHZ. Various metering and testing provisions are contained within the monitor to measure transmitter output characteristics. These provisions include a semi-peak reading negative modulation meter that may be switched to read relative carrier level; a semi-peak reading positive modulation meter that may be switched to read AM noise; a negative peak modulation light, adjustable from 1% to 99% peak modulation; a positive peak modulation light, adjustable from 1% to 199% peak modulation; a peak modulation light that responds when the negative modulation exceeds 99%; a peak modulation light that responds when the positive modulation exceeds 125%; a calibrator to check the accuracy of the modulation readings; and a carrier limit alarm light that responds when the carrier is less than 50% or greater than 133% of nominal value.

Outputs provided by the monitor include an active-balanced audio output, a high level output for aural monitoring, and a test output with a BNC connector for connecting a distortion meter or other test equipment. An internal jumper permits easy application of the NRSC de-emphasis characteristic to all three audio outputs. A modulation alarm, with an adjustable modulation threshold and a fixed time-out of approximately 15 seconds, is also provided. The alarm output, in the form of a set of single-pole, double-throw (SPDT) relay contacts, is accessible at the rear panel card-edge connector. The same card-edge connector provides access to the SPDT relay contacts for the carrier level alarm, as well as open-collector transistor outputs for remote connections of the carrier level alarm and each of the four peak LED's. The output of the chassis +5 VDC power supply also appears on the card-edge connector. This is provided for driving external indicating devices connected to the monitor. The AMM-3A also drives remote negative and positive modulation meters via the rear card-edge connections.

The AMM-3A incorporates an analog divider to provide a true *ratio* measurement of the modulation envelope relative to the carrier level. The analog divider continuously references the demodulated output to the carrier level so that the modulation percentage readings are independent of carrier level. For special applications, a rear panel switch disables the divider so the AMM-3A indications are proportional to the applied RF carrier level.

1-4 Electrical Specifications

RF Frequency Range	260 kHz to 50 MHZ
RF Sensitivity	5 Vrms to 10 Vrms
RF Input Impedance	1000 Ω standard, 50 Ω optional
RF Input	Rear panel BNC connector
Negative Modulation Meter Range	0% to 100%
Positive Modulation Meter Range	0% to 133%
Carrier Level Meter Range	0% to 133%
Modulation Meter Accuracy*	±2%
100% Negative Indicator*	Internally adjustable
125% Positive Indicator*	Internally adjustable
Carrier Level Alarm	Fixed to alarm below 50% and above 133% nominal carrier level
Audio Frequency Response	+0.0 dB, -0.5 dB from 20 Hz to 15 kHz (detector response -3 dB at 50 kHz)
Envelope Pulse Response	Overshoot less than 1%
Harmonic Distortion	0.25% maximum at 99% modulation
Signal-to-Noise Ratio	≥ 80 dB (de-emphasis out)
Remote Modulation Metering	Meters may be used with lines of up to 8 kΩ total loop resistance
Audio Monitoring Output	+16 dBu (4.9 Vrms), 600 Ω, active balanced
Audio Test Output (proof-of-performance)	Bandlimited, 2.45 Vrms, rear panel BNC connector
Auxiliary Detector Output	2.45 Vrms, rear panel card-edge connector
Carrier Reference Output	+5 VDC for 100% carrier level
Power Consumption	8 watts, 100–240 VAC, 50–60 Hz, IEC-320 AC line inlet
Operating Temperature	0°C to +50°C.

*The modulation meter and peak flasher indications are based on true ratios and remain accurate across the range of 50% to 133% relative carrier input level.

1-5 Mechanical Specifications

Dimensions	5¼" H × 19" W × 8.5" D (133mm × 483mm × 216mm) (EIA rack mount) Allow 10.5" (27 cm.) depth behind panel for connections.
Net Weight	5½ pounds (2.5 kg)
Shipping Weight	11 pounds (5 kg)

The AMM-3A is shipped with one Belden #17250 molded AC line cable, one double-readout 36 contact printed circuit card-edge connector (Cinch 50-36SN-9 or equivalent), four beige rack mounting screws, and an operating manual.

1-6 Instrument Identification

The instrument is identified by the model number and a six digit serial number. The model number and serial number appear on the rear panel of the monitor. This model number and the complete serial number should be referenced in all communications with your Belar representative or with the Belar factory.

1-7 Accessories

The Belar AMM-3A Modulation Monitor permits remote monitoring of an AM transmitter when used in conjunction with the Belar MP-7A Remote Meter Panel, or the Belar RFA-2 AM RF amplifier.

The Belar MP-7A Remote Meter Panel replicates the front panel display of the AMM-3A AM Modulation Monitor. The MP-7A Remote Meter panel contains negative and positive modulation meters, four peak indicators (LED's), and a carrier alarm LED. The MP-7A requires a ten-conductor cable for connection to the AMM-3A. The MP-7A accepts a 115 or 230 VAC line connection to power the miniature lamps which backlight the two meters.

In cases where full duplication of the AMM-3A front panel indications is not required, or where interconnection wiring precludes the use of the MP-7A Remote Meter Panel, individual remote modulation meters may be used. For this purpose, unmounted modulation meters identical to the meters used in the monitor may be ordered from Belar. The modulation meter requires only a resistive build-out network and a single pair of wires to connect to the AMM-3A and may provide adequate remote monitoring capability in lieu of the MP-7A.

When the AMM-3A is located where an RF sample cannot be obtained directly from the transmitter, the Belar RFA-2 AM RF Amplifier may be used to provide the necessary RF signal. The RFA-2 takes the low level AM signal from an appropriate receiving antenna and provides the necessary selectivity and amplification for *off-air* monitoring with the AMM-3A. *NOTE: When the RFA-2 is used as the RF signal source for the AMM-3A, the input impedance of the AMM-3A must be set to 1000 Ω to prevent damaging the RF amplifier.*

2 Installation

2-1 Initial Inspection

Check the shipping carton for external damage. If the carton exhibits evidence of abuse in handling (holes, broken corners, etc.) ask the carrier's agent to observe unpacking of the unit. Carefully unpack the AMM-3A to avoid damaging the unit. Inspect all of the equipment for physical damage immediately after unpacking. Bent or broken parts, dents, and scratches should be noted. If damage is found, refer to paragraph 2-2 (below) for the recommended claim procedure. Keep all packing material for proof of damage claims, or, if no damage is evident, for possible future shipment of the instrument.

The AMM-3A is shipped with an instruction book, a three-conductor line cord, a 36 contact mating card-edge connector, and four beige rack mounting screws.

2-2 Claims

If the unit has been damaged, notify the carrier immediately. File a claim with the carrier or transportation company and advise Belar of such action. This will allow Belar to arrange for the repair or replacement of the unit without waiting for a claim to be settled with the carrier.

2-3 Repacking for Shipment

A return authorization number must be obtained from Belar before returning the unit to the factory for repair or recalibration. Authorization may be obtained by calling Belar at 610-687-5550 between 8 AM and 5 PM US Eastern Time. Before packing the unit for return, attach a tag to it showing the name and address of the owner. A description of the service required should be included on the tag. The original shipping carton and packaging materials should be used for return shipment. If they are not available, or are not reusable, a shipping carton may be obtained from Belar. Otherwise, the unit should be repackaged in the following manner:

a. Use a double-walled carton with a minimum bursting strength of 275 pounds per square inch (190 newtons per square centimeter).
b. Use heavy paper or sheets of cardboard to protect all surfaces.
c. Use at least 4 inches (10 cm) of tightly packed, industry approved shock absorbing material, such as extra firm polyurethane foam or rubberized hair, to line all six sides of the shipping carton. **Newspaper is not sufficient for cushioning material!**
d. Use heavy duty shipping tape to secure the outside of the carton.
e. Use large **FRAGILE** labels on each surface.
f. Return the unit, freight prepaid. Be sure to insure the unit for full original purchase price.

2-4 Preparation for Use

Environment, AC Line Power, & RF Input Level

The AMM-3A AM Modulation Monitor is designed to be mounted in a standard 19 inch electronic equipment rack with EIA standard spacing. When mounted in a rack, some air space should be provided above and below the unit for cooling. When the monitor is mounted above equipment generating large amounts of heat, such as power supplies and amplifiers, provisions must be made to insure the free movement of cool air around the AMM-3A. In no instance should the ambient chassis temperature be allowed to rise above 50°C (122°F). Mount the AMM-3A to the rack using the four beige 10-32 rack mounting screws provided.

The AMM-3A uses a switching power supply that accepts line voltages in the range of 100–240 VAC, 50–60 Hz. No adjustment is necessary as long as the line voltage falls within these ranges. The fuse in the rear panel AC input module should be only a type 3A−250V (UL/CSA) fuse or a type T3.15A−250V (IEC) fuse. A spare fuse is stored in the removable fuse compartment in the module.
The rear panel AC power entry module conforms to the IEC-320 standard and accepts a PH-386 grounded AC connector. The AMM-3A is supplied with a three-conductor power cord with a PH-386 connector on one end and a type 290B connector on the other end. When the power cord is plugged into an appropriate AC outlet, the unit is grounded. (The offset pin on the power cable's three-prong connector is the ground contact.) To preserve the grounding feature when operating the unit from a two-contact outlet, use a three-prong-to-two-prong adaptor and connect the green pigtail on the adaptor to a good electrical ground.

The AMM-3A does not have an internal power switch. When the power cord is attached, the unit is operating. Position the supplied power cable but leave one end disconnected.

BEFORE APPLYING ANY RF INPUT, TURN THE CARRIER LEVEL CONTROL MAXIMUM COUNTERCLOCKWISE!

CAUTION: DO NOT APPLY MORE THAN 15 VOLTS RF TO THE MONITOR OR THE RF INPUT MAY BE DAMAGED!

Damage as a result of excessive RF input is **not** covered under the warranty.

Verify by some independent means (such as a wideband oscilloscope or RF voltmeter) that the voltage of the RF sample falls in the range between 5 and 10 Vrms (between 14 V peak-to-peak and 28 V p-p for an ***unmodulated*** AM carrier). If necessary, adjust the RF sample voltage to fall within this range.

The AMM-3A is normally shipped with the RF input configured for 1000 Ω input impedance. If a 50 Ω input impedance is required, remove the unit cover and solder the free lead of the 56 Ω resistor mounted on the rear panel to the center pin of the RF INPUT BNC connector (J2).

NOTE: When the RFA-2 is used as the RF signal source for the AMM-3A, the input impedance of the AMM-3A must be set to 1000 Ω to prevent damaging the RF amplifier.

Check that the locking rear panel CARRIER SET potentiometer is at its extreme counterclockwise (minimum) position. With the RF input voltage in the proper range and the CARRIER SET potentiometer at its minimum, connect a coaxial cable between the monitoring probe on the transmitter (or RF amplifier) and the BNC RF input connector (J2) on the rear panel of the AMM-3A.

To apply power and begin operating the AMM-3A, skip forward to *Section 3-1, Initial Operation.*

The following subsections present important information regarding other external connections to the AMM-3A, as well as suggestions for obtaining full benefit of the capabilities of the AMM-3A.

Card-Edge Connector / Connector Designations

Many of the external electrical connections to the AMM-3A are made via P1, an array of plated, printed circuit board card-edge contacts that project out from the rear of the unit. A 36 pin mating connector with solder eyelet terminals (Cinch model 50-36SN-9, or equivalent) is supplied with the AMM-3A to facilitate interconnection with external circuitry. Permanent remote connections are soldered to the mating connector, allowing the AMM-3A to be removed from its rack mounting by simply pulling the connector from the A1 printed circuit card edge projecting from the rear of the unit. The audio output, remote metering, peak flasher, and relay contacts listed below appear at the P1 card-edge connector. The wiring to each of these circuits is soldered to the supplied connector, which is then pushed onto the projection of the A1 card at the rear of the monitor. (The part number of the push-on connector is printed in the parts list in *Section 7* of this manual.) Note that any of the lower row of alphabetically designated contacts may be used for connection to the AMM-3A chassis ground (by soldering to the appropriate eyelets on the mating connector).

P1-1 Remote POSITIVE MODULATION meter
P1-2 Remote NEGATIVE MODULATION meter
P1-3 +5 VDC supply
P1-4 Remote - 100% peak indicator open collector
P1-5 Remote adjustable negative indicator open collector
P1-6 Remote Carrier Level Alarm open collector

P1-7	Remote adjustable positive indicator open collector
P1-8	Remote +125% peak indicator open collector
P1-9	Modulation Level Alarm contact (normally closed—shorted to the relay common in the alarm condition)
P1-10	Modulation Level Alarm contact (normally open—shorted to the relay common with the alarm off)
P1-11	Modulation Level Alarm relay contact common
P1-12	Carrier Level Alarm contact (normally closed—shorted to the relay common in the alarm condition)
P1-13	Carrier Level Alarm contact (normally open—shorted to the relay common with the alarm off)
P1-14	Carrier Level Alarm relay contact common
P1-15	DC carrier level reference output
P1-16	Balanced Aural Monitor Output, + polarity output (positive voltage excursions correspond to positive modulation swings)
P1-17	Balanced Aural Monitor Output, - polarity output
P1-18	Auxiliary Detector Output

P1-A through P1-V (bottom side of A1 board) are chassis ground

NRSC De-emphasis

The AMM-3A includes provisions for de-emphasizing the audio signals which appear at the AUDIO TEST output (rear panel BNC jack J3), and the Aural Monitoring and the Auxiliary Detector outputs (both of which appear on rear panel card-edge connector P1). The de-emphasis curve conforms to the standard set by the National Radio Systems Committee (NRSC) in the USA, a joint group of the Electronic Industries Association and the National Association of Broadcasters (EIA/NAB). It consists of a 75 microsecond de-emphasis with a zero placed at 8700 Hz to complement the breakpoint in the transmission pre-emphasis network. Transmission using NRSC pre-emphasis in the main channel (L+R) is mandatory for stations broadcasting AM Stereo in the United States, and elective for monaural stations in the US. (Note that use of the de-emphasis network in the AMM-3A does not affect the AMM-3A modulation readings in any way. The de-emphasis network is provided for the characterization of the transmission pre-emphasis curve, as well as the subjective evaluation of audio that would be recovered by an NRSC standard receiver.)

Insertion and removal of the de-emphasis is made by changing the position of the blue circuit board jumper P2 (designated as "NRSC DE-EMPHASIS" on the schematic) on the AMM-3A A1 board. The procedure requires removal of the unit's top cover. (The AMM-3A is shipped with the de-emphasis disabled.) To place the NRSC de-emphasis network in the circuit, remove the top cover of the AMM-3A by removing the 6 Philips screws. Jumper P2 is located near the center of the A1 board, towards the rear of the unit, between resistors R14 and R16. Pull the blue jumper off the left and center pins (labeled "FLAT" on the board) and replace it in the right-most position (labeled "NRSC"), connecting the center and right pins of the P2 assembly. Replace the cover.

Audio Output Connections

Three audio outputs are provided. All appear at the rear of the unit. Both the Auxiliary Detector Output and the Audio Test Output provide nominally 2.5 Vrms at 100% modulation into high impedance loads. The Audio Test Output appears at BNC connector J3 and is intended primarily for driving test equipment. The Auxiliary Detector Output appears at card-edge contacts P1-18 and P1-V (ground). This is intended for permanently connecting low sensitivity equipment such as distribution or power am plifiers. The Aural Monitor Output provides an active balanced output for driving 600 Ω loads and long audio cables at +16 dBu (4.9 Vrms) at 100% modulation. The positive (+) output appears at P1-16, and the negative (−) at P1-17. (The output sense of P1-16 and the other two audio outputs is the same—the crest of a positive peak of AM modulation produces a positive voltage at the outputs.) Either P1-16 or P1-17 may be used to drive unbalanced 600 Ω loads at 4.9 Vrms. When driving unbalanced loads, the alternate output of the active balanced pair should be grounded at the card-edge connector. (Note that while the two outputs of the active balanced pair may be used to drive separate unbalanced loads, the line balancing mechanism of the circuit results in interaction between the two outputs due to circuit loading. Therefore, this arrangement is strongly discouraged.)

Connection of Remote Meters

Remote modulation meters for both positive and negative modulation indications may be connected to the AMM-3A via contacts on the card-edge connector P1 at the rear of the monitor. (A mating connector is supplied with the AMM-3A to facilitate the wiring.) The remote modulation metering circuits are activated when the REMote button is depressed. Note that carrier level and noise readings are not available remotely.

For proper operation of the remote meters, the effective series resistances of the external metering circuits must be set to a prescribed value. When remoting meters via DC telephone pairs or long exterior cable runs, it is advisable to split any added resistance equally between the two legs of the external loop and to place the added resistances at the monitor end. This helps balance the line and provides additional protection for the monitor from line transients, such as lightning.

For proper ballistics, both remote modulation meters should see a *source resistance* of approximately 5.1 kΩ. Since the AMM-3A provides a low source resistance (200 Ω) for the remote modulation meters, the external modulation meter circuits must be built out to provide the proper source resistance. First, both remote modulation meters must be shunted by a resistance between 13 kΩ and 15 kΩ at their terminals. Second, *the total series resistance of the conductors* connecting the shunted meter to contacts P1-2 ("+") and P1-B ("−", or ground) for the negative remote modulation meter, or P1-1 and P1-A for the positive remote modulation meter, should be approximately 8 kΩ. If the total conductor resistance is less than 8 kΩ, sufficient resistance should be added to bring the total series resistance of the two built-out conductors to 8 kΩ. The 8 kΩ is measured by shorting together the two remote ends of the wire pair and using an ohmmeter to measure the resistance between the two wires of the pair at the local end. (See the above discussion concerning the location and the splitting of the added resistance in the remote carrier meter circuit.)

Connection of a standalone remote negative modulation meter will be described. Connection of a remote positive meter follows in the same fashion, with the exception of the change in the P1 terminals. (Connections for using the MP-7A remote meter panel are discussed below.) Shunt the terminals of the remote meter (Belar part number 1120-0012) with a resistor of between 13 kΩ and 15 kΩ. In the manner described above, build out the pair of wires running from P1 to the remote meter so their total series resistance is approximately 8 kΩ. The conductor connected to the "+" terminal of the remote negative modulation meter should then be connected to contact P1-2 of the card-edge connector; the conductor to the meter's "−" terminal goes to P1-B (ground). Note: Remote modulation meters should be obtained from Belar to guarantee proper ballistics.

Once any remote meters are connected, their calibration may be checked as follows. Operate the monitor in NEGative. Modulate the transmitter with a steady tone at high modulation, or operate the AMM-3A in the CALibrate mode. Compare the readings of the internal and remote meters. (Only minor adjustment of the series line resistance should ever be necessary to bring the remote modulation meters into agreement with the internal meters.)

The Belar MP-7A Remote Meter Panel greatly simplifies setting up a remote display. Two remote modulation meters, 5 LED's, and interconnection facilities are provided. The required meter build-out networks are provided, along with a series potentiometer for each meter to facilitate adjustment. Interconnection instructions are provided with the meter panel.

Connection of Remote Peak and Alarm Indicators

Remote indicators duplicating the four AMM-3A front panel peak flasher LED's and the CARRIER ALARM LED are brought out to contacts of the card-edge connector P1 at the rear of the chassis. The outputs at P1 are transistor open-collectors that sink current to ground when the respective front panel LED's are lit. Terminal P1-3 provides a +5 VDC source to power the external indicators. If LED's are used as external indicators, a series resistor for each LED must be used to limit current to an appropriate value. As an example, a remote −100% peak modulation *lamp* (operating at 5 volts and drawing less than 100 milliamps) would be connected between P1-3 and P1-4. If an *LED* were used as the remote indicator, a series resistance of approximately 200 Ω would be connected between P1-3 and the anode of the diode. The cathode of the LED would be connected to P1-4.

Sensitive relays (relays with low actuating current—less than 20 milliamps coil current) may be used to isolate other heavy loads from the monitor's remote indicator circuits. Reverse-biased shunt diodes must be paralleled across any relay coils to protect the transistor collectors from the back-EMF generated by the collapsing field of the coils when the relays are de-energized.

The Carrier Alarm and Modulation Level Alarm each provide a single-pole, double-throw relay (SPDT, form C contacts) within the chassis to control external alarm devices. The contacts are rated at maximums of 0.5 amp, 28 VDC, and 3 watts. The relays are operated in a fail-safe mode—the coils are de-energized in the alarm condition. (The schematic for the A1 board shows the relays de-energized.) Card-edge contact P1-14 is shorted to P1-12 during carrier level alarms, and P1-11 is shorted to P1-9 during modulation level alarms.

3 Operation

3-1 Initial Operation

1. Verify that the physical installation, the AC line voltage, and the voltage of the RF sample conform to the requirements of *Section 2-4* of this manual. Leave the AC line cord disconnected.

2. Turn the locking rear panel CARRIER SET potentiometer (chassis R1) maximum counterclockwise. Release the REMote pushbutton.

3. Note the readings of the two chassis modulation meters. If either meter does not read zero, perform the following zeroing procedure. Use a small screwdriver to turn the zero adjustment of the appropriate meter counterclockwise so the meter indicates slightly downscale from zero. Then turn the adjustment screw clockwise to bring the pointer just to zero. Finally, turn the zero-set a few degrees counterclockwise to take pressure off the meter's internal adjustment fork. If necessary, zero the other modulation meter following the same procedure.

4. Attach the power cable between the AMM-3A and the power line receptacle. This turns the unit on. Press the CARrier pushbutton and note that the NEGATIVE/CARRIER (left-hand) meter indicates zero and that the CARRIER ALARM LED is lit. Turn the CARRIER SET potentiometer clockwise to verify that setting the potentiometer in the top third of its range brings the carrier level to a 100% reading. NOTE: if the

CARRIER indication comes up to 100% when the CARRIER SET potentiometer is at ¼ **or less** of its full rotation, immediately remove the coaxial cable carrying the RF sample to the CARRIER RF input jack (J2) and reduce the voltage of the RF sample at its source. Otherwise, damage to the AMM-3A may result. Once the proper level of the RF sample is confirmed, adjust the CARRIER SET potentiometer to obtain a CARRIER indication of 100%.

5. After allowing a few minutes for the AMM-3A to warm up, rotate the CARRIER SET potentiometer fully counterclockwise. The CARRIER LEVEL LED will be lit. Depress the NEGative and the ZERO pushbuttons and note that both the NEGATIVE MODULATION (left-hand) meter and the POSITIVE MODULATION (right-hand) meter read 0.0%, ±0.5%.

6. Depress the CARrier button and rotate the CARRIER SET potentiometer clockwise to raise the carrier level so it reads 100% on the NEGATIVE/CARRIER level meter. This is the normal set point for the carrier level. The CARRIER ALARM LED will extinguish when the carrier level is between approximately 50% and 133% relative level. With a low noise, unmodulated transmitter, both MODULATION meters should read less than 1%.

7. Depress the CALibrate pushbutton. With the CARrier button depressed, the NEGATIVE/CARRIER level should read 100%. With the NEGative button depressed, both MODULATION meters should read 100%, verifying the accuracy of the AMM-3A's calibration. The adjustable NEGative LED, the -100% LED, and the +125% LED should all be on. The adjustable POSitive LED should be on when the right-hand thumbwheel is set to 100%, but should extinguish when the thumbwheel is set to 101%. Note that the negative thumbwheel does not have a 100% setting. However, CALibrate operation overrides the thumbwheel setting and sets the NEGative LED threshold to -100% modulation.

8. Depress the OPERate switch. The monitor is now operating with the right-hand meter indicating positive modulation. Note that the left-hand meter indicates negative modulation when the NEGative button is depressed, but indicates relative carrier level with the CARrier button depressed.

9. With the NEGative and the OPERate buttons depressed, the AMM-3A is ready for normal operation.

3-2 Normal Operation

For normal operation of the AMM-3A, depress both the NEGative and the OPERate pushbuttons. The two meters now indicate POSITIVE and NEGATIVE AM modulation simultaneously. With the rear panel REFerence switch in the AGC position, variations of the RF carrier level from 50% to +133% will not affect the accuracy of either the modulation meters or the peak LED's. The CARRIER ALARM LED will light (and the alarm will be activated) when the carrier level falls below 50% or exceeds 133%, indicating the RF level is outside the proper range for the AMM-3A.

The POSitive thumbwheel switch is usually set to a level slightly lower than +125%, typically around +120%. The NEGative thumbwheel switch is usually set to a level slightly lower than 100%, typically around 95%. Then the transmitter modulation may be easily set for frequently recurring peaks of -95%. Note that an audio limiter providing independent control of negative and positive peaks is required to allow maximum benefit from this type of operation. The separate -100% and +125% peak lights permit the maximum level of modulation without exceeding FCC limits.

When the CARrier switch is depressed, the percentage of carrier shift can be determined from the left-hand NEGATIVE/CARRIER meter. The unmodulated transmitter carrier level is first set to indicate 100%. Shift in the transmitter carrier level due to modulation of the carrier is indicated by the change in readings of the CARRIER meter.

3-3 Transmitter Measurements

Transmitter proof-of-performance measurements may be made with the AMM-3A. Modulation percentages are read directly from the two modulation meters, and the percentage of carrier shift is read from the left-hand meter in CARrier mode. Accurate readings of system distortion and noise may be made at the rear panel AUDIO TEST jack J3 using external measuring equipment. The audio passband of the J3 output is bandlimited to approximately 23 kHz so signal components outside the range of hearing are suppressed. The audio output level at J3 is 2.45 Vrms at 100% modulation, so most distortion and noise analyzers may be used. The most accurate audio frequency response readings are obtained from either the AUXILIARY DETECTOR OUTPUT (P1-18) or the AURAL MONITOR OUTPUT (P1-16 & P1-17).

NOTE: In addition to bandlimiting of the J3 output, the frequency response characteristic of all three audio outputs is controlled by the setting of A1-P2, the internal NRSC de-emphasis jumper. Meaningful distortion and noise measurements require an audio passband with flat frequency response. If P2 has been set to the "NRSC" position, it will be necessary to move it to the "FLAT" position before making transmitter measurements. See the two paragraphs under *NRSC De-emphasis* in *Section 2-4, Preparation for Use.*

3-4 Modulation Level Alarm

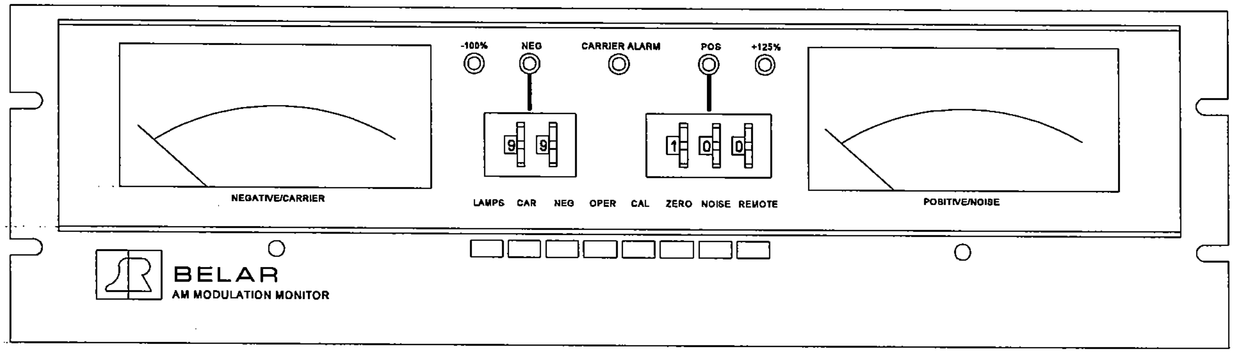
The Modulation Level Alarm is activated when the negative program modulation of the transmitter remains below the user set threshold for approximately 15 seconds. The modulation threshold for the alarm is adjusted by R114, a multiturn potentiometer accessible at the rear of the AMM-3A through a cutout in the cover. The adjustment range is from approximately 30% to 100% negative modulation.

The alarm is driven by the output of the negative modulation metering rectifier. Therefore, the alarm senses modulation as displayed by the negative MODULATION meter and the adjustable NEGative peak modulation LED. Note, that like the indications of the peak flashers and modulation meters, when the rear panel REFerence switch is in the AGC position, the Modulation Level Alarm operates at the user set modulation threshold, despite variations in carrier level from 50% to 133% of its nominal input value.

Following is a suggested adjustment procedure for the Modulation Level Alarm:

With the NEGative and OPERate buttons of the AMM-3A depressed and the REFerence switch in the "AGC" position, check that program modulation is in its normal range. Locate the MODULATION ALARM THRESHOLD potentiometer, A1-R114, in the AMM-3A cover cutout, to the left and just above the REFerence slide switch. Using an adjustment screwdriver, turn A1-R114 clockwise until the modulation alarm is activated. (The status of the alarm, of course, must be monitored using an external indication device connected to the alarm relay RL2 via card-edge connector contacts P1-9–P1-11.) Now, *slowly* turn R114 counterclockwise until the Modulation Alarm turns off. At this point, a modulation peak just exceeded the threshold set by R114. It is suggested that the pot be turned one or two additional turns counterclockwise so the alarm does not fire inadvertently. (The potentiometer changes the alarm threshold by slightly more than 4% modulation for each turn of the adjustment screw.)

4 AMM-3A Front Panel



4-1 Front Panel Controls

Below are short functional descriptions for each of the AMM-3A front panel controls. The controls are illustrated in the front view drawing of the AMM-3A above. The pushbuttons are described first. The LAMPS button is a *push-push* type acting independently of the others. The CARrier and NEGative pushbuttons are mechanically interlocked to select the parameter displayed by the left-hand meter. The OPERate, CALibrate, ZERO, and NOISE pushbuttons are mechanically interlocked so only one mode of operation may be selected at a time. The REMote button is also *push-push*, and operates independently of the others. The descriptions for the buttons follow as they appear on the front panel, from left to right.

LAMPS This is a multifunction *push-push* type push-button switch. As set at the factory, depressing this button increases the intensity of the backlighting of the two front panel meters. Releasing the button dims the meter backlighting. By moving the internal wire (white with blue tracer) from contact 2 to contact 1 on the S2 switch assembly, the LAMPS button allows selection between dim backlighting (button released) and backlighting off (button depressed).

CARrier: This button selects the carrier level applied to the AMM-3A A1 card for display on the "NEGATIVE/CARRIER" (left-hand) meter. The level is adjusted by the rear panel RF SET potentiometer R1. Normal operating level for the monitor corresponds to a CARRIER reading of 100%. Note, however, that when CALibrate is selected the CARRIER meter indicates the level of the internally generated calibration signal, not the applied RF carrier.

NEGative: When depressed, the NEGATIVE/CARRIER meter reads the percentage of negative AM modulation. Under normal operating conditions, this button remains depressed.

Note: Negative AM modulation is defined as the instantaneous *decrease* in amplitude of the carrier envelope measured from, and relative to, the average amplitude (or the unmodulated amplitude) of the carrier envelope. Shutoff of the AM carrier represents 100% negative modulation. (This is usually referred to as "-100%" modulation.)

OPERate: The detected AM signal is fed through the metering and indicating circuits of the monitor. This is the normal operating mode for the AMM-3A. In this mode the right-hand meter reads positive modulation.

CALibrate: This button activates a precision test signal in the AMM-3A which is applied to the measurement circuitry to verify whether any change in calibration has occurred. When both CALibrate and CARrier are depressed, the left meter indicates the DC amplitude of the test signal. The reading should be 100%. With NEGative depressed, the left and right-hand meters display the negative and positive components of the calibrate signal, respectively. Both readings should be 100%. The adjustable NEGative flasher is set to indicate the -100% level in CALibrate, overriding the left thumbwheel setting. The fixed –100% and the adjustable POSitive flashers indicate normally, so both should be lit when the POSitive (right-hand) thumbwheel is set to 100%. In CALibrate, the test signal to the +125% flasher is scaled so the +125% flasher just lights.

ZERO: The ZERO mode grounds the input to the metering circuitry of the monitor. When both ZERO and NEGative are depressed, both MODULATION meters should read zero and all peak LED's should be extinguished. This provides a check of DC offsets in the measurement circuits.

NOISE: Depressing this button converts the POSITIVE/NOISE (right-hand) meter to indicate the RMS amplitude of the detected AM noise on the RF carrier. A gain of 40 dB is inserted following the detector, so that an indication on the NOISE meter of "0 dB" corresponds to an AM noise reading of –40 decibels relative to 100% sine wave modulation. This button should not be depressed when there is modulation present on the RF input.

REMote: When depressed, remote modulation meters attached to contacts P1-1 and P1-2 at the rear of the monitor are activated. (See *Section 2-4, Preparation for Use* for information about the connection of remote meters.) When released, the internal circuitry of the AMM-3A is isolated from voltage surges which may occur on circuits connecting remote meters to the monitor. Therefore, it is best to release the REMote button when the remote meters are not in use, or when electrical storms present a threat.

NEGative Thumbwheel: This two digit thumbwheel is located directly below the adjustable NEGative peak LED. It sets the indicating threshold for the NEGative peak LED. Any negative modulation peak at or exceeding the thumbwheel setting lights the LED. The range of indication possible is from 0% to 99% negative peak modulation. The two wheels of the switch allow repeatable setting of the indication threshold in units of tens and ones.

POSitive Thumbwheel: This three digit thumbwheel is located directly below the adjustable POSitive peak LED. It sets the indicating threshold for the POSitive peak LED. Any positive modulation peak at or exceeding the thumbwheel setting lights the LED. The range of indication possible is from 0% to 199% positive peak modulation. The three wheels of the switch allow repeatable setting of the indication threshold in units of hundreds, tens, and ones.

Note: Positive AM modulation is defined as the instantaneous *increase* in amplitude of the carrier envelope measured from, and relative to, the average amplitude (or unmodulated amplitude) of the carrier envelope. Positive modulation of 100% corresponds to an instantaneous envelope amplitude equal to twice the average amplitude (or unmodulated amplitude) of the carrier envelope. (This is usually referred to as +100% modulation.)

4-2 Front Panel Indicators

NEGATIVE/CARRIER Meter: With the CARrier button depressed, this meter indicates the relative input level of the transmitter's or RF amplifier's RF carrier signal applied to the AMM-3A circuitry. (The nominal operating carrier level is 100%.) With the NEGative button depressed, this meter indicates the negative AM modulation of the RF carrier. The indication has a *semi-peak* characteristic. The indication is accurate when both the rear panel REFerence switch is in the "AGC" (upper) position and the CARRIER ALARM LED is extinguished. If the REFerence switch is in the "FIXED" (lower) position, accurate indications require the carrier level, as indicated in the CARrier mode, to be 100%. When the rear panel REFerence switch is in the "AGC" position and the carrier level falls below 50%, negative modulation indications are reduced to less than one quarter of their actual value. This provides clear visual evidence that the monitor is receiving insufficient carrier level.

POSITIVE/NOISE Meter: With the OPERate button depressed, this meter indicates the positive AM modulation of the RF carrier. The indication has a *semi-peak* characteristic. With the NOISE button depressed, this meter indicates the RMS level of the AM noise present on the RF carrier. The indication is scaled so an indication of "0 dB" corresponds to an AM noise 40 decibels below 100% AM modulation. Decibel indications above and below -40 dB are read by adding the decibel reading displayed by the POSITIVE/NOISE Meter to -40 dB. For example, if the meter reads "-8 dB" on the lower red meter scale, the AM noise is -48 decibels relative to 100% sine wave modulation, or 48 dB below 100% modulation. The POSITIVE modulation and the NOISE indications are both accurate when both the rear panel REFerence switch is in the "AGC" (upper) position and the CARRIER ALARM LED is extinguished. If the REFerence switch is in the "FIXED" (lower) position, accurate indications require the carrier level, as indicated in the CARrier mode, to be 100%. When the rear panel "REF" switch is in the "AGC" position and the carrier level falls below 50%, positive modulation indications are reduced to less than one quarter of their actual value. This provides clear visual evidence that the monitor is receiving insufficient carrier level.

-100% (LED): This red indicator lights when negative AM modulation excursions of the carrier exceed 99% negative modulation. Minimum duration of the *indication* of *all* negative modulation peaks is approximately 150 milliseconds. This display time is extended by prolonged or repeated peaks. Accuracy of indications is maintained over input carrier levels ranging from 50% to 133% of nominal level.

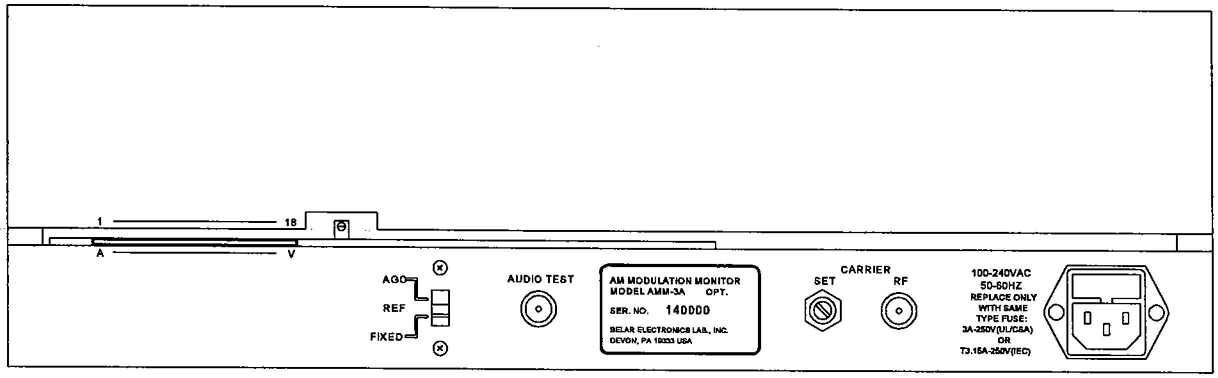
NEGative (LED): This green indicator lights when the negative AM modulation excursions of the carrier exceed the setting of the NEGative thumbwheel located directly below the LED. Minimum duration of the *indication* of *all* negative modulation peaks is approximately 150 milliseconds. This display time is extended by prolonged or repeated peaks. Accuracy of indications is maintained over input carrier levels ranging from 50% to 133% of nominal level.

CARRIER ALARM (LED): This red indicator is lighted when the input carrier level falls below 50% or rises above 133% of the prescribed input level. As long as this indicator is extinguished, all modulation and NOISE indications are accurate. An open-collector output and relay contacts accessible at P1 on the rear panel provide means for remote display of this indication.

POSitive (LED): This yellow indicator lights when positive AM modulation excursions of the carrier exceed the setting of the POSitive thumbwheel located directly below the LED. Minimum duration of the *indication* of *all* positive modulation peaks is approximately 150 milliseconds. This display time is extended by prolonged or repeated peaks. Accuracy of indications is maintained over input carrier levels ranging from 50% to 133% of nominal level.

+125% (LED): This red indicator lights when the positive AM modulation excursions of the applied carrier exceed 125% positive modulation. Minimum duration of the *indication* of *all* positive modulation peaks is approximately 150 milliseconds. This display time is extended by prolonged or repeated peaks. Accuracy of indications is maintained over input carrier levels ranging from 50% to 133% of nominal level.

5 AMM-3A Rear Panel



Features of the rear panel are illustrated in the rear view drawing of the AMM-3A above. The features are described from right to left as seen facing the rear panel.

Power Entry Module: This module accepts the AC power line input and mates with the three-conductor PH-386/IEC 320-C-13 connector of the power cord supplied with the AMM-3A. Acceptable AC power ranges from 100 VAC to 240 VAC and from 50 Hz to 60 Hz. The Power Entry Module houses one 3A−250V (UL/CSA) or T3.15A−250V (IEC) fuse, along with a spare. Both are contained in the removable fuse compartment in the module. The fuses are accessed by first removing the power cord, then using a small common screwdriver to pull out the small tab at the bottom of the plastic insert located just above the AC connector in the module.

CARRIER RF (J2): This is a BNC jack that accepts an AM RF sample in range of 5 Vrms to 10 Vrms. It presents a 1000 Ω load (optionally 50 Ω) to the input line.

CARRIER SET (R1): This potentiometer allows adjustment of the level of the RF sample applied to the AMM-3A circuitry. It is usually set to obtain a 100% relative carrier indication as shown on the left-hand meter in the CARrier mode.

AUDIO TEST OUTPUT (J3): The audio output of the AMM-3A envelope detector appears at this BNC jack. The level for 100% sine wave AM modulation is 2.45 Vrms at into a high impedance load. Audio at this output is low-pass filtered to suppress extraneous noise and distortion products. Nominal cutoff of the filter is 23 kHz. The detected audio may be de-emphasized in accordance with the NRSC standard by setting of internal jumper P2. (See *NRSC De-emphasis* in *Section 2-4, Preparation for Use.*)

REFerence Switch (S1): This switch controls the analog divider circuitry in the AMM-3A. In the lower, or FIXED position, the AMM-3A modulation indications are proportional to the RF level supplied to the monitor. In the FIXED mode, accurate modulation indications require setting the carrier input level to 100% on the CARRIER meter. When the REFerence switch is in the upper, or AGC position, the AMM-3A analog divider circuitry is active. In this mode, all modulation and front panel AM noise indications are accurate as long as the front panel carrier level indication is between 50% and 133%. Equivalently, indications are correct as long as the front panel CARRIER ALARM LED is **not** lit.

MODULATION ALARM THRESHOLD ADJUST (A1-R114): This multiturn potentiometer sets the modulation threshold for operation of the Modulation Alarm. If the peak negative modulation remains below the modulation threshold setting for longer than approximately 15 seconds, the alarm is activated. Range of adjustment is from approximately 30% to 100% negative modulation. When the rear panel REFerence switch is in the AGC position and the front panel CARRIER ALARM LED is not lit, the modulation alarm is insensitive to variations in the carrier level supplied to the AMM-3A. (See *Section 3-4, Modulation Level Alarm,* for instructions on making this adjustment.)

REMOTE CONNECTOR (P1): This set of 36 plated circuit board traces extends out the back of the AMM-3A. It provides external connections for remote modulation meters, remote peak modulation indicators, the carrier and modulation alarms, and the detected audio and carrier samples. Connections are made through the mating 36 contact connector provided with the AMM-3A (Cinch 50-36SN-9, or equivalent).

6 Calibration/Maintenance

6-1 Test Equipment Required

1. An amplitude modulation (AM) test source (or transmitter) with an RF output of 5 Vrms to 10 Vrms and capable of less than 1% total harmonic envelope distortion at greater than 90% sine wave modulation.*
2. A low distortion audio oscillator (≤ 0.1% total harmonic distortion.)
3. An oscilloscope with a 3 dB bandwidth at least twice the carrier frequency of test.
4. An audio frequency AC voltmeter with either a 3½ digit display, or with linearity of voltage indications of better than 1%.

6-2 Modulation Monitor Alignment Procedure

Note that in the following, labels that are capitalized refer to designations on the chassis that are visible from the front or rear of the unit. Descriptors that are enclosed in quotations (" & ")refer to labels as read from the schematic diagram or the markings on the A1 printed circuit board. Examples are 'NEGative' and 'POSITIVE/NOISE', which refer to the negative pushbutton labeled 'NEG' and the right-hand meter on the front panel, respectively. "CALIBRATE SYMMETRY" refers to the label read from the A1 board schematic describing potentiometer A1-R53.

1. Remove AC line power to the AMM-3A by removing the power cord. Set the mechanical zeros on the two front panel meters. (If adjustment is required, turn the meter adjustment screw counterclockwise until the pointer goes slightly below zero. Then, turn the adjustment screw clockwise until the pointer just reaches zero. Finally, turn the adjustment screw a very small amount counterclockwise to release any pressure on the zeroing fork in the meter mechanism.)

2. Connect AC power to the monitor and allow the unit to warm up for 15 minutes.

3. Press the ZERO and NEGative buttons and release the REMote button on the front panel. Set the rear panel REFerence switch to AGC Verify that both AMM-3A modulation meters read zero. If either modulation meter reading is below -0.5% or above +0.5%, the unit requires repair. Consult with Belar.

4. Set the output voltage of the AM test source to 5 to 10 Vrms and connect its output to the AMM-3A rear panel CARRIER RF input jack J2. Depress the CARrier pushbutton and adjust the rear panel CARRIER SET potentiometer to obtain a reading of "100%" carrier level on the NEGATIVE/CARRIER meter. Set the rear panel REFerence switch to the FIXED (lower) position. Release the front panel REMote meter

pushbutton. Monitor the RF signal at J2 with an oscilloscope having an operating bandwidth at least double the carrier frequency of the AM source. (Alternately, the output sample of a well functioning AM transmitter may be used for the calibration procedure. The harmonic distortion of the transmitter AM output envelope should not exceed 1% at high modulation levels.)

5. Apply a 1 kHz sine wave of less than 0.1% harmonic distortion to the modulation input of the AM test source and adjust the oscillator level to obtain 99+% negative AM modulation (onset of carrier shutoff) as observed on the expanded vertical scale of the oscilloscope. Check that the carrier level still indicates 100%. On the A-1 board of the AMM-3A, adjust R67, the "- 100% ADJUST" potentiometer so the - 100% LED just remains lit. (It is necessary to remove the AMM-3A cover to gain access to the A1 circuit board. This is done by removing the six 4-40 Phillips head screws which fasten the cover to the chassis.) Set the NEGative thumbwheel to "99%" and adjust R58, the "NEGATIVE PEAK ADJUST" potentiometer so the green NEGative LED just remains lit.

6. With negative AM modulation of the test signal still greater than 99%, measure the AC output voltage of the audio oscillator connected to the modulation input of the AM test source (or transmitter) using an accurate AC voltmeter. Lower the oscillator output level to exactly 90% of this voltage so the test source produces 90% negative (and positive) AM modulation.

7. Depress the NEGative button on the AMM-3A. Then, adjust the "NEGATIVE METER ADJUST" potentiometer (A1-R126) for an indication of 90.0% on the AMM-3A NEGATIVE/CARRIER meter.

8. With the negative AM modulation of the test source still 90% as indicated on the NEGATIVE/CARRIER meter, check that OPERate pushbutton on the AMM-3A is still depressed. Set the POSitive thumbwheel to "90%". Adjust the R85, the "POSITIVE PEAK ADJUST" potentiometer, so the yellow POSitive LED just remains lit. Adjust R135, the "POSITIVE METER ADJUST" potentiometer so that the POSITIVE/NOISE meter indicates "90%".*

9. Remove the modulating signal from the AM test source. Depress the CARrier pushbutton. Set the rear panel CARRIER SET potentiometer for an indication of 50% or less on the NEGATIVE/ CARRIER meter. The CARRIER ALARM LED should be on. Set the rear panel CARRIER SET potentiometer for an indication of 133% or more on the NEGATIVE/CARRIER meter. The CARRIER ALARM LED should be on. There are no adjustments for these indications. Readjust the CARRIER SET potentiometer for 100% carrier level.

10. Set the rear panel REFerence switch to the "AGC" (upper) position. No change in modulation indications should occur. This indicates the analog divider circuitry of the AMM-3A is working correctly and that the sensitivity of the CARRIER meter (M1) has been properly set.

11. Apply a sine wave between 400 Hz and 1000 Hz to the AM source to produce 99% AM modulation. Using a precision AC voltmeter, measure the voltage of the sine wave applied to the modulation input of the AM test source. Reduce the level of the oscillator 40 decibels, or to one hundredth (0.01) of the original level. Press NOISE on the AMM-3A. Adjust the "NOISE GAIN ADJUST" potentiometer R122 to obtain a reading of "0 dB" on the right-hand POSITIVE/NOISE meter. Depress the OPERate pushbutton.

The AMM-3A is now calibrated for accurate modulation indications of external AM RF carriers.

The following steps adjust the internal calibrator of the AMM-3A:

12. Press the CALibrate and CARrier buttons on the AMM-3A. If necessary, adjust the "CALIBRATE LEVEL" potentiometer R81 to obtain an indication of approximately 100% carrier level indication on the NEGATIVE/CARRIER meter. (This is the average DC level of the internally generated calibrating waveform used for checking negative and positive modulation indications.)

13. Press the NEGative button. Adjust the "CALIBRATE SYMMETRY" potentiometer R53 so the negative and positive modulation meter indications are *equal*. (Note, the modulation readings need not be 100%, but they must be *identical*.)

14. Depress the CARrier pushbutton. Adjust the "CALIBRATE OFFSET" potentiometer R79 to make the carrier level reading on the NEGATIVE/CARRIER meter and the positive modulation indication on the POSITIVE/NOISE meter *equal*. (Again, the readings only need to be the same.)

15. With the CARrier and OPERate buttons depressed, readjust R81 ("CALIBRATE LEVEL") to obtain a reading of 100% on the NEGATIVE/CARRIER meter. Depress the NEGative button and verify that both the negative and positive modulation indications are 100%. If the carrier level and negative and positive modulation readings are not all "100%", readjust R79 and R81 as described in steps 12 and 14 above. When the adjustments are complete, the – 100%, the NEGative, and the POSitive LED's should all be lit when the thumbwheels are set to "99%" and "100%" respectively. The POSitive LED should also extinguish when the POSitive thumbwheel is set to "101%". The CARRIER ALARM LED should be extinguished.

16. With the CALibrate button depressed, adjust the "+125% ADJUST" potentiometer R94 so the +125% LED just remains lit.

Alignment of the calibrator system has been completed. Depressing the NEGative and OPERate pushbuttons returns the monitor to normal operation.

*NOTE: Modulation meters and the peak flashers respond to *peak* values of modulation. If there is distortion in the modulator (or test transmitter), the peak indications will be the true peak values of the modulation envelope, i.e. the sum of the fundamental and its harmonics, or distortion products. A common mistake made in calibrating AM monitors is to adjust both negative and positive modulation indications at carrier shutoff. Carrier shutoff does represent 100% negative modulation. However, due to the presence of distortion products in the modulator, the positive modulation at carrier shutoff is not necessarily 100%. If the harmonic distortion of the envelope at carrier shutoff is 2% and even-order (typical of many transmitters), the actual positive modulation may be anywhere from 98% to 102%, depending on the phases of the harmonics. The monitor will indicate this positive modulation percentage. For this reason, we suggest the monitor be calibrated at 100% only for negative indications. For calibration of positive indications, modulation should be reduced to 90% positive, so the settings may be made in a region where the source (or transmitter) is more linear.

6-3 Maintenance

The AMM-3A is a highly stable instrument. Other than verifying that the unit is clean and that free air circulation is maintained, no regular maintenance is required.

6-4 Theory of Operation

The AMM-3A chassis contains of a self-contained triple-output power supply, the A1 printed circuit board, and a number of chassis mounted electrical and electronic components. Operation of the major elements of the AMM3-3A monitor is explained below.

Chassis Power Supply

Line power enters the chassis through the fused power entry module and passes directly to the self-contained chassis mounted power supply via a Molex® connector. This switching-mode power supply produces regulated outputs at ±15 VDC for analog circuitry on the A1 card, and at +5 VDC for the two A1 relays, two chassis meter lamps, five LED's, and external loads connected to the A1 circuit board card-edge contact P1-3. Chassis mounted fuse F2 (2 amp, AGC) protects the +5 VDC supply output from possible overload. (The power supply module is not user serviceable. Due to the voltages present in the module, field repair of the power supply should not be attempted.)

Power from the chassis power supply enters the A1 card via A1 board connection pins 22–26. Shunt diodes CR19, CR20, and CR21 protect the board from accidental reversal of supply voltages. Capacitors C79–C84 bypass each of the supply buses. Positive 5 VDC for driving the logic on the A1 card is produced by A1 board regulator U33, which derives its power from the +15 VDC bus on the A1 board.

Chassis lamps DS1 and DS2 backlight the two chassis meters when the AMM-3A is receiving AC line power. The lamps receive +5 VDC from the chassis supply through the front panel LAMPS pushbutton of the S2 switch assembly attached to the A1 circuit board. Operation of the switch, and modification of the switch wiring for alternate operation are discussed in the *LAMPS* paragraph near the beginning of *Section 4, AMM-3A Front Panel.* Diode CR6 provides a 0.8 VDC drop for dimming the lamps.

RF Detector

The RF sample is applied to chassis BNC jack J2 and passes, via coaxial cable, through the CARRIER LEVEL SET potentiometer (chassis R1) and to pins 1 and 2 (2 for ground) of the A1 circuit board. A 56 Ω noninductive resistor soldered to the chassis ground lug at J2 may be paralleled across the RF input to match 50 Ω cables.

The attenuated AM RF sample applied to pins 1 and 2 of the A1 card is detected by a shunt, biased-diode AM detector. The detector consists of a biased diode, a linear-phase low-pass filter and a protection circuit. Detector diode CR2 is biased on by the current passing through R3 and the diode from the +15 VDC supply. The RF input is coupled into CR2 by capacitors C1 and C2, which are also part of the detector's low-pass filter.

Shunt diode CR1 protects CR2 from large negative voltage impulses at the RF input, possibly caused by lightning or similar disturbances. Under normal conditions, CR1 is reverse-biased by connections through R1 and R2 to the positive and negative supplies. The cathode of CR1 is held at +15 VDC by R1, while the anode is maintained at − 15 VDC by R2. Negative impulses at the RF input which exceed about 30 volts in amplitude momentarily turn on CR1, and charge C1. C3 momentarily holds the anode of CR1 at − 15 VDC, and the network composed of R2 and C4 isolate the negative supply from the transient.

Detector diode CR2 feeds the carrier filter composed of C1, C2, C5–C7, L1–L3, and the resistive termination formed by the R4-R5 combination. The filter is a 7th-order Bessel (constant-delay, or Thomson) low-pass, with a −3 dB frequency of 50 kHz. This filter passes the AM envelope with minimum overshoot. Carrier frequency components above 250 kHz in the detector output are attenuated more than 60 dB. The divider formed by R4 and R5 attenuates the detector output before application to buffer amplifier U1A.

At this point in the circuit, the detected AM signal consists of an AC waveform superimposed on a DC voltage. Positive peaks in the envelope of the AM signal result in negative voltage excursions in the filter and at the output of U1A. Increases in average carrier level cause larger negative DC voltages to appear at the U1A output.

Diode CR3 is biased with the same DC current as CR2 by the network formed by R8, R9, and R10. The differential amplifier formed by U1B and R6, R7, R9, and R10 effectively subtracts the turn-on voltage of CR3 from the detector output at pin 7 of U1B, just canceling the DC bias voltage of detector diode CR2. Simultaneously, the output of the detector is inverted by U1B, giving the detector output at pin 7 of U1B a positive sense (larger carrier levels produce larger positive voltages). At the pin 7 of U1B, positive voltage swings correspond to positive modulation peaks of the AM envelope, and negative excursions correspond to negative modulation peaks. The average DC voltage at the U1B output corresponds to the average carrier level of the RF signal applied to the A1 board—increased carrier levels increase the average (DC) voltage.

The combined AC-plus-DC detector output signal at U1B pin 7 passes to three different sections of the A1 circuitry. The detector output is AC coupled through C10 and divider R11-R12 to amplifier U2 and the audio output circuitry. The detector output also passes through contacts of the CALibrate section of push-button switch A1-S2 to the carrier level circuitry, and also on through to contacts of the ZERO section of the switch to the modulation measurement circuitry.

The signal from contact 23 of S2 passes through the low-pass filter formed by R26 and C27. The modulation component of the envelope is removed by this low-pass filter, leaving a DC voltage at pin 3 of U6A which is proportional to the carrier level driving the AMM-3A. This DC carrier voltage is amplified and buffered by amplifier U6A, and then distributed to the carrier level meter, the carrier level buffer amplifier U6B, and the CARRIER REFERENCE OUTPUT at P1-15. The detector signal leaving switch contact S2-32 passes to the audio buffer amplifier, U18, through the high-pass filter formed by C44 and the resistive voltage divider R55-R56. (The carrier DC from the detector is blocked by C44.) The AC modulation waveform at the output of U18 then passes to the multiplying digital-to-analog converter U16 for processing prior to measurement by the metering and peak flasher circuitry. The low-pass and high-pass R-C filters have matching cutoff frequencies of 0.7 Hz. This low cutoff frequency minimizes the tilt of clipped envelope waveforms passed to the measuring circuits from U18. Waveform tilt results in erroneously high peak modulation readings. Diodes CR4 and CR7 prevent reverse-biasing of tantalum capacitors C27 and C44, respectively.

Carrier Level & Carrier Level Alarm Circuitry

When the CARrier button is depressed, the carrier DC at the output of U6A drives the chassis NEGATIVE/CARRIER meter through resistor R29. Resistor R29 is factory adjusted so with nominally 5 Vrms RF input and 5.0 VDC output at P1-15, the CARRIER level reading is 100%.

Resistive attenuator R30-R31 and buffer amplifier U6B provide carrier DC of appropriate voltage to drive the analog-to-digital converter U12 and the carrier level window comparator formed by comparators U7A and U7B and associated circuitry. The resistive divider consisting of R33, R34, and R35 provides limit voltages of +0.625 VDC and +1.656 VDC for the window comparator derived from the precision +2.5 VDC voltage reference U34.

Since a 100% carrier level nominally produces +1.25 VDC at U6 pin 7, the limit voltages correspond to relative carrier levels of 50% and 133% respectively.

Comparator U7 is a dual unit driven from a single-ended +15 VDC supply. The combination of R32 and germanium diode CR5 prevents a negative output at U6B from drawing current from the U7 input. Both U7 output pins 1 and 7 are low when the carrier DC from U6B falls between the +0.625 and +1.656 limit voltages. With both comparator outputs low, the output of OR gate U8A stays at logic **1** (HIGH). This turns on transistor Q1 through R40, activating relay RL1. (Note that RL1 is operated in a *fail-safe* mode, indicating an alarm condition when the coil is de-energized.) With U8A pin 1 HIGH, pin 4 of OR gate U8B is LOW. This holds the base of Q2 low through resistor R41, extinguishing the front panel CARRIER ALARM LED and de-activating any remote device connected to card-edge connector P1-6. Similarly, if the DC rises above +1.656 VDC or falls below +0.625 VDC (correspondingly, above 133% or below 50% relative carrier), either pin 1 or pin 7 of U7 will be pulled HIGH by R37 or R39, respectively. The output U8A goes LOW, turning Q1 off and de-energizing fail-safe relay RL1. With the carrier outside one of its limits, the output of U8B goes HIGH, turning on the CARRIER LEVEL LED and any remote devices connected to P1-6. Resistors R36 and R38 provide hysteresis (positive feedback) around comparators U7A and U7B (working against R32 and resistors R33–R35). The hysteresis prevents small fluctuations in carrier level from cycling the carrier alarm.

Note that a remote negative modulation meter connected to the AMM-3A indicates negative modulation whether or not the CARrier button is depressed.

Analog Divider

In the AMM-3A, meter and flasher indications, as well as noise readings, are processed by an analog divider prior to display. This allows the monitor to provide accurate indications despite variations in the RF carrier level applied to the monitor. Carrier level may vary from 50% to 133% of the nominal carrier level (as indicated on the left-hand meter when operating in the "CARrier" mode) without reducing the accuracy of the indications. A slide switch on the rear panel of the monitor allows the divider to be disabled so the AMM-3A behaves like a conventional, fixed reference AM modulation monitor. With the divider disabled, the meter, flasher, and noise indications are proportional to the input carrier level as indicated on the monitor's CARRIER meter. They are then correct *only* when the relative carrier level, as indicated on the left-hand meter, is 100%.

The core of the divider circuitry consists of analog-to-digital (ADC) converter U12, multiplying digital-to-analog converter (DAC) U16, and associated operational amplifier U17. Digital logic in IC's U8 through U15 controls the divider system. Essentially, the divider provides a through-gain which is inversely proportional to the amplitude of the DC component of detected carrier. If the carrier input amplitude changes while the modulation percentage remains constant, at the detector the AC component of the detected carrier increases in proportion to the DC component. Since the through-gain of the divider is *inversely* proportional to the carrier DC, the voltage of the AC component at the output of the divider (pin 6, U17) remains constant with the change in carrier level. Said another way, the output at U17 is equal to *ratio* of the detected AC component to the detected DC component (times a constant set by the hardware).

The through-gain of the divider system is set to one of approximately 1600 equally spaced discrete values as the carrier level varies from 50% to 133% of the nominal level. The divider circuit is *analog* in the sense that the AC signal at the output of the divider is *continuous* and can attain any value within the operating range of the system. The analog divider is a digital system in that it is controlled digitally and provides only discrete values of through-gain. The through-gain of the divider is adjusted approximately every 160 microseconds, or at a rate of about 6250 Hz.

The basic operation is as follows. The detected and scaled carrier DC at the output of U6B is applied to analog-to-digital converter U12. Under the control of digital logic in IC's U9—U11 and U13—U15A, a serial 12 bit word representing the applied DC carrier voltage is transferred from U12 into multiplying DAC U16 by the clock signal from the digital multivibrator in U15. When held at ground potential, the output of a multiplying DAC sources a current which is proportional to the product of the binary value of the digital word stored in its internal register *and* the analog voltage applied to its reference input VREF.

Multiplying DAC U16 is in the feedback path of inverting operational amplifier U17. VREF, the input to the DAC's digitally controlled resistive current divider, is driven by the output voltage of the analog divider system at pin 6 of U17. The modulation (AC) component of the detected AM signal (U18 pin 6) is applied to the inverting input of U17 through an internal resistor connecting the RFB and IOUT terminals of U16. The AC modulation current flowing into the RFB terminal is summed with the output current of the DAC's digitally controlled current divider at IOUT. Operational amplifier U17 draws negligible input current. Therefore, the negative feedback around U17 acts to balance the current supplied by U18 with the current emerging from the resistive divider sourced from VREF.

As the carrier level applied to U12 increases, the digital current divider in U16 returns more of the current supplied to VREF to the summing junction IOUT. This effectively increases the negative feedback around U17, decreasing its gain proportionately. If the AM modulation percentage were held constant as the carrier level rose, the increase in detected AC voltage (due to the increase in carrier level) would be just offset by the decreased through-gain of the system. So, the amplitude of the AC (modulation component) at the output of U17 would remain constant.

With a nominal carrier level input, the output of U6A is approximately +5 volts. The voltage divider at the input to buffer U6B reduces the DC signal applied to the signal input of ADC U12 to +1.25 volts. A +2.5 volt reference voltage for the ADC is supplied by reference U34. So at nominal carrier level, the ADC produces a 12 bit word with an approximate value of (1.25 / 2.5) × (2 ↑ 12) = (1 / 2) × 4096 = 2048.

Details of Divider Operation

The clock signal generated in U15, along with digital logic in IC's U9—U11 and U13—U15 control operation of the analog divider. The sequence of operation is as follows. The DC voltage at the output of buffer amplifier U6B is proportional the detected carrier level. This voltage, nominally +1.25 volts at 100% carrier, is applied to VIN (pin 2) of analog-to-digital converter U12. A falling edge at the $\overline{\text{CONVST}}$ input (pin 7) of analog-to-digital (ADC) converter U12 initiates a conversion of the carrier voltage at pin 2. After a delay for completion of the conversion, 16 pulses of the 200 kHz clock signal are applied simultaneously to SCLK (pin 4) of the ADC and CLK (pin 7) of the multiplying DAC U16. This causes the serial transfer of the 12 data bits representing the carrier level from SDATA (pin 5) of the ADC to the SRI (pin 6) input of the DAC. The falling edge of the clock signal shifts the binary digits out of U12. The serial data passes via gates U11D, U8C, and U14C and U14D to the SRI input (pin 6) of U16. Rising edges of the clock signal at the CLK input (pin 7) of the DAC shifts the data present at SRI (pin 6) into the registers of the DAC. The leading four bits from U12 are zeros. The MSB is clocked out first; the LSB last. When the transfer is complete, the clock signal is removed and the digital-to-analog output conversion is initiated by a falling edge at the $\overline{\text{LD}}$ input (pin 5) of DAC U16. By action of the feedback around U17, the voltage appearing at pin 6 of U17 then represents the ratio of the modulation to the relative carrier level (see the discussion above). At 100% relative carrier level, the nominal through-gain of the divider system, taken from pin 6 of U18 to pin 6 of U17 is two. (The output polarity at U17 is reversed, however.) Since the modulation waveform from the AM detector applied to U18 is halved by resistive divider R55-R56, the peak-to-peak swing at the output of U17 is nominally equal to that at the AM detector output at U1B.

Four-bit binary synchronous counter U9 and D flip-flop U13A provide the timing for operation of the analog divider. The RCO output (pin 15) of the counter goes HIGH for 1 count of every 16 clock cycles. This pulse is applied to the CLK input (pin 3) of the flip-flop. Since the D input of U13A is connected to its own $\overline{Q}$ output, the RCO output toggles U13A every 16 clock cycles.

The Q and $\overline{Q}$ outputs of U13A gate the clock signal to both the ADC and the DAC and control the conversion processes of both devices. When the Q output (U13A pin 5) is HIGH, the output of NOR gate U11A is held LOW and the clock signal is blocked from passing through the gate to the SCLK input of U12 and CLK input of U16. Simultaneously, the LOW $\overline{Q}$ output (pin 6) of U13A enables passage of the $\overline{CONVST}$ and $\overline{LD}$ pulses, respectively, to the ADC and DAC. This occurs as follows. The Q2 and Q3 outputs of counter U9 are used to set timing for the $\overline{CONVST}$ and $\overline{LD}$ pulses. The control pulse occurs while the count in U9 is "4", "5", "6", and "7". During this interval, Q2 is HIGH and Q3 is LOW. With both Q3 of U9 and $\overline{Q}$ of U13A LOW, the output of NOR U14A is HIGH. When Q2 goes HIGH at the count of "4", both inputs to NAND U10C are HIGH, forcing U10C pin 8 LOW. This drives the $\overline{LD}$ of U16 LOW for four clock cycles, initiating an output conversion. Simultaneously, the output of U8D (and $\overline{CONVST}$) goes HIGH for four clock cycles. At the end of the four cycles, $\overline{CONVST}$ is driven LOW by U10C and U8D and a new conversion of the carrier level is initiated. Through the logical combination of a HIGH at $\overline{Q}$ of U13A, a HIGH at Q3, or LOW at Q2 of U9, the output of NAND U10C and the $\overline{LD}$ input of U16 remain HIGH for the remaining 28 clock cycles of the 32-clock-cycle logic sequence. Likewise, $\overline{CONVST}$ remains LOW for 28 clock cycles. The control sequence then repeats.

U13A is again toggled at the end of the fifteenth count of U9. The Q output goes LOW. This allows the (inverted) clock signal to pass to the SCLK and CLK inputs of the ADC and DAC, respectively. Since the gating of the clock is controlled directly by flip-flop U13A, and it's state changes every sixteen counts, alternately sixteen pulses are allowed pass to the ADC and the DAC while the following sixteen clock pulses are blocked.

Operation of the analog divider may be disabled by the rear panel REFerence switch (chassis slide switch S1). (An open switch activates the divider.) However, the clock and control signals are always updating the analog divider. When the analog divider is disabled by the REFerence switch or a low carrier condition, its through-gain is set to one of two alternate fixed values by logical control of the serial data applied to the DAC.

With the rear panel switch open (REFerence switch in the AGC position), the output of inverter U15E is held LOW by pullup resistor R45 at its input. This forces pin 11 of inverter U10D HIGH and pin 4 of U14B LOW. Pin 9 of NOR U14C is held LOW by U15E, allowing the serial data (which has been twice inverted in U11D and U8C) to pass through NOR's U14C and U14D to the SRI input of the DAC. The analog divider system remains active during CALibrate, regardless of the position of the REFerence switch. In CALibrate, Q3 is turned on by base current supplied through R51, pulling the inputs to U10D and U14C LOW through R46. The divider then operates as if the chassis REFerence switch were open and pin 10 of U15E were low.

When the divider is disabled by the switch, a binary 2048 is fed to SRI of U16 in place of the serial data stream from ADC U12. The serial word consists of a stream of four clock cycles of "0" (LOW), a "1" (HIGH) for one clock cycle, followed by eleven clock cycles of "0". Gates U10A, U10B, U11B, and U11C, in conjunction with U13A produce the properly timed binary digit. When Q0 and Q1 are both HIGH and Q2 and Q3 are both LOW, the count of U9 is "3". (This is the *fourth* count in the "0" to "15" count sequence of U9.) The output of U10A is then LOW, and the output of U11C is HIGH. When this count occurs during the data transfer interval (when the $\overline{Q}$ output of U13A is HIGH), the HIGH appearing at pin 5 of NAND U10B, combined with the HIGH from pin 10 of U11C forces pin 6 of U10B LOW. With both inputs to NOR U11B LOW, pin 4 of U11B goes HIGH, driving pin 5 of NOR gate U14B HIGH. With the input of U15E grounded through the switch, the path for the serial data through NOR U14C is blocked by the HIGH at pin 9 of the gate. The single binary digit from U11B, however, is allowed to pass through U14B and U14D to the SRI input of the DAC. Due to the phase inversion of the clock in

U11A, this single digit at count "3" of U9 is clocked into U16 on the rising edge of the (inverted) fifth clock pulse at pin 1 of U11A. The most significant bit (MSB) is then "1", and the remaining 11 bits are "0". The binary number "2048" is thus loaded into the DAC. This repeating sequence sets and holds the through-gain of the analog divider at two.

When the relative carrier level indicated on the CARRIER meter exceeds 50% the output of low-carrier-limit comparator U7B is LOW. This allows the serial data from ADC U12 to pass through U11D, U8C, and on to U16 when the rear panel switch is open (in the AGC position). When the carrier level falls below 50%, the comparator output goes HIGH and locks the NOR U11D output LOW. This forces pin 10 of U8C HIGH. So, with the rear panel switch set at AGC and the monitor *not* in CALibrate, the HIGH held at U8C is repeatedly clocked into the DAC. The effective value clocked in is then "4095". The through-gain of the analog divider is then 1.0, half its normal value. The low through-gain, combined with a carrier level no greater than half its normal value, results in modulation indications that do not exceed 25% modulation (for 100% modulated input signals). This provides immediate visual indication of a low RF input level.

Peak Flasher Circuits

Two fixed modulation flasher circuits independently indicate modulation peaks exceeding −100% and +125% modulation. Another two adjustable peak modulation indicators separately indicate peaks of negative and positive modulation that exceed thresholds set by the two associated front panel thumbwheel switches. The range of modulation thresholds for negative indications is 1% to 99%; the range of thresholds for positive indications is 1% to 199%.

With the exception of the thumbwheel threshold adjustment, the basic operation of the four circuits is the same. Each flasher is triggered when the modulation (AC) component of the detected signal reaches the threshold set by the appropriate DC reference voltage. At that instant, the output of a voltage comparator changes state, going LOW. This *enables* triggering of a monostable multivibrator. The output pulse of the monostable turns on a driver transistor, which then draws current through the appropriate LED and any attached external load.

Only the operation of the −100% flasher circuitry and the operation of the thumbwheel for positive peaks will be described in detail. Operation of the +125% fixed flasher and the negative thumbwheel differ only in minor ways.

The inverted and scaled modulation waveform appears at the output of the analog divider circuitry (pin 6 of U17). Here, higher *negative* modulation causes the instantaneous voltage to become more positive. This AC waveform is applied to the inverting input (pin 6) of comparator U20B through an adjustable voltage divider formed by R66, the "−100% ADJUST" potentiometer R67, and R68. A fixed reference voltage of +2.5 VDC from U34 is applied to the noninverting input of U20B (pin 5) through R69. Potentiometer R67 is set so the voltages at pins 5 and 6 of U20B are equal at −100% modulation. When the modulation waveform rises above the threshold for −100% modulation, the open-collector output at pin 7 of U20B is pulled LOW, enabling triggering of integrated circuit monostable U21A. The combination of R69 and R70 provide positive feedback around the comparator, causing about 9 millivolts of hysteresis of—equivalent to approximately 0.4% modulation. This minimizes oscillation in the comparator for slowly changing modulation signals near the triggering threshold. Diode CR9 prevents negative voltage excursions of U17 from damaging the comparator input.

Monostable multivibrator U21A is *enabled* by a low at the output of comparator U20B. Actual *triggering* of the monostable is controlled by the logic states of *both* of its triggering inputs (pins 4 and 5). Explanation follows. The output period of each of the four flasher monostables (U21A, U21B, U25A, and U25B) is approximately 150 milliseconds. In U21A, the interval is set by R72 and C52. The monostables are *retriggered* by peaks occurring before the end of the 150 millisecond interval. Retriggering extends the duration of the output pulse. However, if the peak indicator relied solely on the output *transition* of the comparator for triggering, modulation peaks lasting longer than 150 ms. would allow the peak indicator LED's to extinguish before the peak had ended. To prevent this possibility, the second, inverting trigger input of each peak monostable (at either pin 5 or 11) is driven by a 200 kHz square wave generated by inverters U15B through U15D. Pins 4 and 5 of monostable U21A and pins 12 and 11 of U21B are inputs to *internal* OR gates. (Pins 5 and 11 are inverting inputs.) It is the rising edge at the output of the internal OR gate that actually initiates (or retriggers) the monostable's output pulse. Under normal conditions, the comparator output is HIGH. This holds the output of the internal OR gate HIGH, initially firing the monostable, but then locking out any possible subsequent retriggering of the monostable by falling edges of the square wave applied to pin 5. When the modulation signal exceeds the triggering threshold, the comparator output goes LOW. The next falling edge of the clock signal from at U21A pin 5 then triggers the monostable. While the comparator output remains low, every falling edge of the clock at U21A pin 5 retriggers the monostable and extends the output pulse to 150 milliseconds following the falling clock edge. While the Q output at U21A pin 6 is HIGH, current flows through current limiting resistor R73 into the base of Q5. Q5 saturates, sinking current from the chassis +5 VDC supply through the – 100% LED (designated chassis CR1), and current limiting resistor A1-R74. Current may also flow through Q5 from card-edge contact P1-4. Ceramic capacitor C54 provides a low impedance path to ground for RF current coupled into P1–P-4 by any attached external circuitry.

The clock signal supplied to the five active monostables and the analog divider circuitry is generated by an oscillator made up of three Schmitt-input inverters (U15B–U15D). The 200 kHz clock frequency is set by R47, R48, and C40. A three-inverter circuit is guaranteed to be self-starting, even without the hysteresis of the Schmitt inputs. Edge speed of the distributed clock signal is slowed by R49 and the distributed capacitance of the circuit board traces.

Comparator U24A controls the monostable U25A and the adjustable positive peak flasher LED (chassis CR4). As for U20A, discussed above, when the modulation waveform applied to the inverting input (pin 2) of comparator U24A exceeds the reference voltage applied to the noninverting input (pin 3), the output of U24A goes LOW, enabling monostable U25A. However, since the modulation signal output at U17 is inverted, an additional inversion of the modulation signal is required before application to the POSitive peak flasher comparator, the +125% comparator, and the positive modulation metering rectifier. This inversion occurs in unity gain inverting amplifier U30. The reference voltage for the POSitive LED differs from the fixed -100% flasher as well, in that it is set by the right-hand thumbwheel, chassis switch S3. Operation of the thumbwheel is as follows.

The +2.5 VDC output of precision voltage reference A1-U34 is inverted by U35 to create –2.5 VDC for use in the two adjustable peak flasher circuits. Both thumbwheels are BCD (binary-coded-decimal). The rotors of the thumbwheels are coded and work in conjunction with the resistor networks constructed on the small A2 and A3 circuit boards soldered to the back of the S3 and S4 thumbwheel switch assemblies, respectively. Resistors A2-R1 through A2-R9 are paralleled in appropriate combinations so that the equivalent resistance between pins 1 and 2 of the A2 card is inversely proportional to the decimal thumbwheel setting. For a setting of "100%", only A2-R9 is employed, creating a 1.00 kΩ resistance across the thumbwheel. When the setting is "60%", resistors A2-R6 and A2-R7 are paralleled, giving a parallel resistance of 1.66 kΩ. Contacts A2 board pins 1 and 2 are connected to board pins 11 and 12 of the A1 card. This places the resistance of the S3 switch assembly in series between the –2.5 VDC line and the inverting input of inverting operational amplifier U19B. Resistor R84 and "POSITIVE PEAK ADJUST" potentiometer R85 complete the feedback connection around inverting amplifier U19B. The output voltage at pin 7 of U19B is then a positive voltage equal to 2.5 VDC times the ratio of the sum of resistances R84 plus R85 to the resistance of the parallel combination on A2 set by POSITIVE thumbwheel S3. As a result, the positive reference voltage applied to the inverting input of comparator U24A from U19B is directly proportional to the numerical setting of the thumbwheel. At a "100%" setting, the reference voltage from U19B is approximately +4.2 VDC. Higher thumbwheel settings increase the threshold voltage at the comparator, increasing the modulation signal level required to change the output state of comparator U24A. As in the case for U20B, R86 and R88 provide hysteresis and the R87-CR11 combination provides input protection for the comparator.

In addition to the signal inversion required for the POSitive modulation flasher, one significant difference exists between the −100% and the +125% flasher circuits. Rather than requiring a precise positive 125% modulated signal for calibration, a resistor network is used to change the operating level of the +125% flasher between the OPERate and CALibrate modes. Resistors R110, R111, and R112 form a precision attenuator. The amplitude of the modulation waveform appearing at the R110-R111 junction is 1.25 times the amplitude of the voltage at the R111-R112 junction. When the CALibrate button is depressed, the symmetric AC calibration signal is passed to U24B from the R110-R111 junction at 1.25 times the peak voltage that appears at the R111-R112 junction for 100% positive modulation. It is at this higher voltage that the U24B comparator threshold is set with the "+125% ADJUST" potentiometer R94. When the OPERate button is depressed, the modulation waveform applied to the comparator is taken from the junction of R111 and R112. As a result, positive modulation signals that are 1.25 of the 100% modulation voltage, or those reaching +125%, would just reach the U24B comparator threshold set during CALibrate mode by R94 and trigger the +125% flasher.

Finally, the NEGative thumbwheel operates much the same way as described for the POSitive thumbwheel. Comparator U20A enables monostable U21B to drive the red NEGative LED (chassis CR2). The "NEGATIVE PEAK ADJUST" potentiometer R58, sets the modulation threshold for U20A. There are two minor differences, however. NEGative thumbwheel (chassis S4) spans just two decades from 1% to 99%, since no indications above negative 100% are possible. As a result, a third wire connects switch-mounted circuit board A3 pin 3 with A1 board pin 19. This is so the −100% flasher may be set to "−100%" in CALibrate mode. During CALibrate, the OPERate button is released. This substitutes the 1.00 kΩ resistor A3-R9 (on the switch assembly) for the parallel combination of resistors A3-R1–A3-R8 selected by the NEGative thumbwheel. Push-button contact S2-17 breaks contact with S2-18 and makes contact with S2-16, substituting A3-R9 for the parallel resistance combination from A3 pin 2 (and connected to A1 board pin 18).

Modulation Metering Rectifiers

Two active, half-wave metering rectifiers provide simultaneous semi-peak indications of negative and positive AM modulation on the two front panel meters. The two rectifiers are identical, so only operation of the negative modulation metering rectifier will be described.

Operational amplifiers U31A and U31B form an active, half-wave peak rectifier which provides semi-peak meter indications of negative AM modulation. The input to the rectifier is taken from the output of the analog divider at U17 pin 6. The divider formed by R127 and the "NEGATIVE METER ADJUST" potentiometer R126 adjusts sensitivity of the rectifier for proper indications. Positive voltage excursions (corresponding to negative modulation peaks) at U31A pin 3 are amplified, passing through signal diode CR16 to charge metering capacitor C72. The high input impedance of JFET input unity gain buffer U31B isolates C72 from external loads while its output provides negative feedback for U31A.

With a rising positive input voltage at pin 3, the output voltage of U31A rises until the voltage fed back to pin 2 from the output of U31B just equals the input voltage at pin 3. At this point, the rectifier output voltage is equal to the peak voltage at the input to the rectifier. (Note that pin 1 of U31A is now higher than the rectifier output at pin 7 to offset the forward voltage drop across CR16.) As the rectifier input voltage drops from this peak, the charge on C72 remains momentarily constant, and the voltage at pin 2 of U31A is held by U31B. The large open-loop gain of U31A causes pin 1 to slew lower until diode CR15 turns on. The U31A output now tracks the falling rectifier input voltage, though shifted lower in voltage by the forward drop of CR15. The rectifier discharges with a time constant set by C72 and R129. When the rectifier input at pin 3 again exceeds the voltage on C72 (and thus pin 2), the U31A output slews positive until CR16 again turns on and the feedback path is completed through U31B. A divider network composed of R130 and R131 provides a small negative bias voltage to R129. This permits the meter rectifier to discharge to below "0%" indication so that any negative offset in the analog divider and measurement circuitry can be read on the modulation meter when the monitor is operating in the ZERO mode. Without the bias network, the rectifier output would not go below ground potential.

The meter build-out network R133–R134 provides the proper source resistance and attenuation to drive the NEGATIVE/CARRIER meter (chassis M1). With the NEGative button depressed, the DC at U31B pin 7 passes through switch contacts of the released CARrier button to the meter. Resistors R132 and R142, combined with C77 provide protection to the internal circuitry of the AMM-3A from transients that may occur on any external metering circuit attached to the card-edge connection P1-2.

The positive modulation metering rectifier obtains an upright modulation waveform (positive modulation causes positive voltage swings) from the output of inverting amplifier U30. Metering sensitivity is adjusted by R135, the "POSITIVE METER ADJUST" potentiometer. Circuit operation is as described above for the negative modulation meter rectifier. Positive modulation indications from U32B pass through contacts on the released NOISE pushbutton and appear on the POSITIVE/NOISE meter (chassis M2). Unless the NOISE button is depressed, the right-hand meter indicates positive modulation. The connection for remote positive modulation meters is card-edge contact P1-1.

Pushing the REMote button connects the negative and positive modulation meters to the outputs of rectifier amplifiers U31B and U32B, respectively, through the R-C RF suppression networks. Releasing the REMote pushbutton disconnects all remote modulation meters from the two rectifier outputs, minimizing the chance of damage to the monitor from excessive external voltages.

Audio Outputs

The three audio outputs of the AMM-3A are taken from the buffered AC coupled detector output signal at U2 pin 6. The resistive divider consisting of R11 and R12 sets the audio output level at approximately 2.45 Vrms for the AUDIO TEST OUTPUT and the AUXILIARY DETECTOR OUTPUT with 100% sine wave modulation. The AURAL MONITOR OUTPUT is set at +16 dBu, or 4.9 Vrms. Capacitor C10 sets the −3.0 dB cutoff frequency of the three outputs at 3.4 Hz. The setting of internal jumper P2 determines whether or not the NRSC de-emphasis characteristic is applied to the output audio. With jumper P2 in the "FLAT" position, the audio from U2 passes through R13-R14 to the noninverting input of unity gain isolation amplifier U3 without alteration. With P2 set at "NRSC", the network composed of R13–R16 and C11 provides the NRSC response characteristic. (The network produces a 75 microsecond de-emphasis. The combination of R15, R16, and C11 produce the required break in the curve at 8700 Hz.) Isolation amplifier U3 supplies the AUXILIARY DETECTOR OUTPUT at card-edge P1-18 through build-out resistor R25 and nonpolarized blocking capacitor C21 (10 microfarads). C22 suppresses RF from external circuits connected to P1-18.

Amplifier U3 also provides a low impedance source for the active balanced output driver U5. The *differential* output level of this device at contacts P1-16 (+) and P1-17 (−) is 4.9 Vrms, or +16 dBu, at 100% sine wave modulation. This device drives 150 Ω and 600 Ω balanced lines with the differential characteristic of an output transformer. It does **not** provide DC isolation.

The AUDIO TEST output jack J3 on the rear panel is driven at 2.45 Vrms through an active band-limiting filter consisting of amplifiers U4A and U4B and associated components. The filter employs infinite gain, multiple feedback topology to realize a fourth-order Chebyshev low-pass filter. The overall response at the TEST output is approximately −1 dB at 24 kHz. Build-out resistor R24 limits the current of U4B.

Calibrator Circuitry

A calibration system in the AMM-3A permits the operator to determine whether the modulation indications of the monitor have changed since the last full calibration. When activated by pressing the CALibrate button, integrated circuits U22 and U23 produce an amplified logic square wave that is substituted for the AM detector output signal. The square wave passes through the monitor's carrier and modulation separation filters to provide simultaneous indications of carrier level and modulation. Three calibrator adjustments closely match the indications obtained when the AMM-3A is set up using a high accuracy RF test source.

Digital binary ripple counter U22 receives power from the precision +2.5 volt DC reference regulator U34. In all modes *except* CALibrate, the clock signal passing from U15 to U22 through R75 and R76 is shunted to ground by diode CR10 through contacts S2-19 and S2-20 of the front panel switch. When the CALibrate button is depressed, the cathode of CR10 is connected to the +2.5 VDC from U34. This allows the clock signal from U15D and the R75-R76 voltage divider to pass to the input of ripple counter U22 with a 2.5 volt logic swing. The 200 kHz clock signal is divided by 256 to provide a logic square wave of approximately 780 Hz at the output of U22. This wave is smoothed by R77 and C56. Precision amplifier U23 and resistors R78 through R83 amplify and shift the square wave to obtain a swing of roughly 0 to +8 volts, mimicking the output of the monitor's AM detector with a fully modulated RF carrier at nominal input level.

During normal operation, the AM detector output signal from U1B passes through contacts S2-22 and S2-23 of the front panel switch and on to carrier amplifier U6A and modulation buffer U18 (through the ZERO switch). When the CALibrate button is depressed, the path through contacts S2-22 and S2-23 is broken, and the calibration signal from U23 passes to U6A and U18 through switch contacts S2-23 and S2-24.

"CALIBRATE LEVEL" potentiometer R81 adjusts the gain of U23 so that the CARRIER level reads 100% during CALibrate operation. "CALIBRATE OFFSET" potentiometer R79 provides fine adjustment of the DC (carrier) component of the calibrator output signal relative to the AC (modulation) component.

Depressing the CALibrate button also applies +2.5 VDC to R52 and the "CALIBRATE SYMMETRY" potentiometer R53. This control balances the indications of negative and positive modulation, but only during operation of the calibrator. In all other modes, R52 is grounded, and no DC offset is applied to the modulation signal at the input to U18.

The +2.5 VDC switched on by the CALibrate pushbutton also turns on transistor Q3 through base resistor R51. The collector of Q3 forces inputs to U10D and U14C LOW, so the analog divider is operational in CALibrate mode, regardless of the position of the rear panel REFerence switch. This is so proper operation of the analog divider can be confirmed in CALibrate.

Note that the modulation signal from the RF detector passes directly to the audio output amplifiers no matter what the operating mode of the monitor.

Noise Metering

The AMM-3A has an internal AM noise metering system which provides RMS indications of carrier noise on the chassis POSITIVE/NOISE meter M2. When the NOISE button is depressed, an indication of "0 dB" on the meter corresponds to an RMS AM noise reading 40 decibels below 100% sine wave AM modulation. If the rear panel REFerence switch is in the AGC position and the CARRIER ALARM LED is extinguished, correct noise readings are guaranteed by the analog divider. With the REFerence switch in the FIXED (lower) position, the carrier level must be set to indicate "100%" (with the CARrier button depressed) for proper normalization of the AM noise readings.

Amplifiers U26A and U26B and RMS-to-DC converter IC U27 are the active elements of the voltmeter. The modulation signal for the noise meter is taken from the output of the analog divider at pin U17 pin 6 and is AC coupled by C70 to the resistive divider formed by R123 and the "NOISE GAIN ADJUST" potentiometer R122. Depressing the NOISE pushbutton replaces the ground connection (at contact S2-37) to the noninverting input of U26A with the center tap of potentiometer R122 (present at contact S2-39). The pushbutton also breaks the connection between the positive metering rectifier and chassis M2, and connects the output of U26B to the meter (through contacts S2-41 and S2-42). Resistors R104 and R105 set the gain of U26A to 35 (30.9 dB). Shunt input resistor R103 holds the amplifier input at ground during switching. The C65-R106 combination couples the modulation signal from U26A pin 1 into the converter with a 3.3 Hz cutoff frequency. Capacitor C66 averages the rectifier output in U27. The smoothed DC output of U27 is approximately 0.75 VDC when the AM noise is 40 decibels below 100% modulation. The DC is amplified with a gain of three by U26B. Build-out resistor R109 controls the damping of meter M2 for noise indications.

Modulation Alarm

The AMM-3A modulation alarm senses when negative modulation of the RF input falls below a user adjustable percentage for longer than approximately 15 seconds. The alarm output is in the form of dry SPDT relay contacts which are accessible at the rear panel card-edge connecter P1. The alarm operates by comparing the output of the negative modulation metering rectifier at U31B pin 7, with an adjustable reference voltage. Since the negative modulation indications are leveled by the analog divider, the modulation alarm threshold, in terms of modulation percentage and U31B output voltage, is independent of carrier level as long as the REFerence switch is in the AGC position (and the CARRIER ALARM LED is extinguished). The modulation alarm threshold is set by the voltage divider consisting of R113, R115, and MODULATION ALARM THRESHOLD potentiometer R114. (R114 is accessible through an opening at the rear of the AMM-3A.) The metering rectifier output voltage is applied to the noninverting input of comparator U28A through the voltage divider formed by R116 and R117. R118 provides positive feedback around U28A and the hysteresis necessary for clean output transitions at pin 1 of U28A. The open-collector output of the comparator drives the falling-edge trigger input (pin 5) of monostable U29A via pull-up resistor R119.

The modulation alarm operates in a "fail-safe" mode: the normal, nonalarm condition requires that the entire circuit chain be active and operating properly. Monostable multivibrator U29A receives the 200 kHz clock signal from U15D, as do the peak flasher monostables, but here the two triggering inputs are reversed. As long as the modulation level exceeds the user set reference at pin 2 of U28A, pin 5 of U29A is held HIGH. As a result, U29A is continuously retriggered by the clock signal at pin 4. Pin 6 of U29A is held HIGH, turning on Q8, continuously drawing current through the coil of relay RL2. When the output voltage of the negative metering rectifier falls below the set threshold, the U28A output goes low and further retriggering of U29A by the clock signal is inhibited. The 15 second time-out, initiated by the last falling transition at pin 4 of U29A, has already begun. If the desired modulation level is restored before U29A times out, retriggering of U29A resumes, extending the HIGH pin 6. If modulation remains below the threshold for the full 15 seconds, U29A is allowed to time out, at which point its Q output (pin 6) falls to logic LOW. Transistor Q8 and relay RL2 become inactive, and connector contact P1-9 is shorted to P1-11. The time-out of monostable U29A is set by R120 and C68. Diode CR13 prevents residual charge on C68 from damaging the analog timing input of U29A.

Operational Switching and Calibration

Normal operation of the AMM-3A is controlled via eight pushbuttons in the front panel switch assembly S2. The switch assembly is fastened to the front panel with two screws, but is held captive to the A1 circuit board by pressure-fit electrical contacts. The LAMPS switch is discussed above in this section under *Chassis Power Supply*.

CARrier and NEGative Buttons

The second and third pushbuttons of S2 are mechanically interlocked—pushing either the CARrier or NEGative button releases the other. These buttons determine whether the left-hand front panel meter displays the relative carrier level or negative AM modulation, respectively. With the CARrier button depressed, the NEGATIVE/CARRIER meter (chassis M1) receives a sample of carrier DC from U6A through R29 and switch contacts S2-11 and S2-12. With the NEGative button depressed, M1 receives the negative modulation rectifier output from U31B, meter build-out network R133-R134 and contacts S2-10 and S2-11 of the released CARrier section of S2.

OPERate/CALibrate

The OPERate, CALibrate, ZERO, and NOISE pushbuttons are mechanically interlocked—pressing one button releases any of the other three. Principal operation the AMM-3A is controlled by the OPERate and CALibrate sections of the switch.

With OPERate depressed, the CALibrate and ZERO buttons are released. The AM detector output signal from U1B pin 7 then passes through contacts S2-22 and S2-23 of the released CALibrate button (switch) to the carrier filter (R26-C27) and buffer amplifier U6A for distribution. The detector signal also passes in turn from S2-23 through contacts S2-31 and S2-32 of the ZERO button to the modulation high-pass filter (C44-R55-R56), buffer amplifier U18, and on to the metering circuits. In OPERate, resistors R51 and R52 are grounded through contacts S2-19 and S2-20 of the released CALibrate button. This disables the calibration symmetry adjustment (R53) and turns off transistor Q3. With Q3 off, the activation of the analog divider is controlled *solely* by the position of the rear panel REFerence switch (chassis S1). Additionally, the grounded cathode of CR10 shunts the swing of the clock signal present at the junction of R75 & R76. This disables digital binary counter U22, the source of the calibration signal.

One connection to the resistor network on circuit board A3 (soldered to the rear of NEGative thumbwheel S4) passes through the OPERate section of S2. When the AMM-3A is in OPERate, contacts S2-17 and S2-18 of this button connect the inverting input of the negative flasher reference amplifier to board pin A1-P18. Interconnection wires to the A4 board place the parallel combination of resistors of A4-R1–A4-R8 selected by the NEGative thumbwheel in series with pin 2 of U19A and the −2.5 VDC supply (at A1 board pin 17). Contacts S2-14 and S2-15 of the OPERate switch pass the attenuated modulation signal from the R111-R112 junction to the +125% peak flasher comparator U24B. As explained above under *Peak Flasher Circuits*, the signal at the R111-R112 junction is scaled so that 125% positive modulation peaks light the +125% LED.

Alternatively, pushing the CALibrate button replaces the detector output (U1B pin 7) feeding the AMM-3A measurement circuits with the output of the calibrator circuit. The calibration signal from U23 pin 6 passes through S2-24 to S2-23 of the CALibrate button. The signal then passes along to carrier buffer amplifier U6A and also through contacts S2-31 and S2-32 of the released ZERO button to the modulation amplifier U18. Depressing CALibrate also connects R51, R52, and the cathode CR10 to the +2.5 VDC reference supply through contacts S2-20 and S2-21 of the CALibrate button. This DC allows fine adjustment of the calibrator symmetry via R53, the "CALIBRATE SYMMETRY" potentiometer. Transistor Q3 is turned on via base resistor R51, pulling U10D pins 12 & 13 and U14C pin 9 LOW, sinking current through R46. This causes the analog divider to track changes in carrier level (or calibration signal level) even if the rear panel REFerence switch is in the FIXED (lower) position. The cathode of CR10 is now at +2.5 VDC, so the 2.5 volt swing of the clock signal at the junction of R75 & R76 passes to binary ripple counter U22. The 780 Hz logic square wave required for calibration then appears at U22 pin 13 and is amplified for distribution by U23.

When the CALibrate button is pressed, the OPERate button is released. Through contacts S2-16 and S2-17, A4-R9, the 1 kΩ resistor which is connected between A1 board pins 17 & 19 by the chassis wiring, is substituted for the parallel combination selected by the NEGative thumbwheel. This effectively sets the NEGative peak threshold at 100% for calibration, no matter what the thumbwheel setting. Finally, with CALibrate depressed the modulation signal applied to U24B, the +125% flasher comparator, is taken from the junction of R110-R111. This so the symmetric calibration signal just triggers the +125% LED.

ZERO

Pushing the ZERO pushbutton grounds the input to the modulation buffer amplifier U18 through switch contacts S2-32 and S2-33. The connection between contacts S2-31 and S2-32, which carries either the modulation or calibrator signal to U18 from S2-23 of the CALibrate switch, is broken. With the balance of the metering circuit operating properly, the input to the analog divider from U18 is within a few millivolts of ground. The output of the analog divider (U17 pin 6) should be within ten millivolts of ground. When inverting amplifier U30 is functioning properly, the outputs of both metering rectifiers should be small enough to produce a residual indication of less than "0.5%" on the two modulation meters. Depressing the ZERO button also releases the OPERate button. As a result (and as described above under *OPERate/CALibrate*) the adjustable NEGative flasher threshold is set internally to −100% and the +125% flasher circuit is set as it is in CALibrate. However, with no signal applied to the modulation measurement circuits in ZERO, these changes are of no consequence.

NOISE

The AMM-3A noise amplifier circuitry consists of AC amplifier U26A, RMS-to-DC converter IC U27, and DC metering amplifier U26B. C66 controls averaging of the noise signal in the RMS converter.

Depressing the NOISE button disconnects the right-hand POSITIVE/NOISE meter (chassis M2) from the positive modulation metering rectifier (U32) and connects M2 to the output of the noise amplifier circuitry. When either the OPERate, CALibrate, or ZERO button is depressed, meter M2 is connected through contacts S2-40 and S2-41 of the NOISE switch to the build-out network (R140-R141) across the positive rectifier output at U32B pin 7. Depressing the NOISE button breaks this connection and passes the DC metering signal from pin 7 of U26B, through damping resistor R109, switch contacts S2-42 and S2-41, and on to the POSITIVE/NOISE meter.

The AC coupled modulation (audio) signal from the output of divider amplifier U17 passes through the "NOISE GAIN ADJUST" potentiometer R122 to switch contact S2-39. With the NOISE button released, the input to noise amplifier U26A is grounded through contacts S2-37 and S2-38 of the switch. Depressing the NOISE button connects the AC modulation signal at S2-39 to S2-38 and the input of U26A. When the rear panel REFerence switch is in the AGC position, the modulation signal applied to R122 is leveled by the analog divider. So, as long as the CARrier LED is extinguished, properly referenced noise readings can be read directly from the right meter.

REMote

The REMote button is wired in a double-pole, single-throw configuration. The negative and positive modulation metering rectifier outputs pass through current limiting resistors R132 and R139 and appear respectively at REMote switch contacts S2-44 and S2-47. Depressing the REMote switch passes the negative and positive rectifier outputs to switch contacts S2-45 and S2-48, and on to card-edge connector contacts P1-2 and P1-1. With the push-push REMote switch released, the rectifier outputs are disconnected from any remote modulation meters connected to P1-2 and P1-1. Note that outputs of the negative and positive metering rectifiers are available for display on the internal meters regardless of the position of the REMote button.

7 Diagrams, Schematics, and Parts Lists

Replaceable Parts. This page contains information for ordering replaceable parts for the AMM-3A. The tables that follow list the parts in alphanumeric order by reference designation and provides a description of the part with the Belar part number.

Ordering Information. To order a replacement part from Belar, address the order or inquiry to Belar and supply the following information:

a. Model number and serial number of unit.
b. Description of part, *including the reference designation and location.*

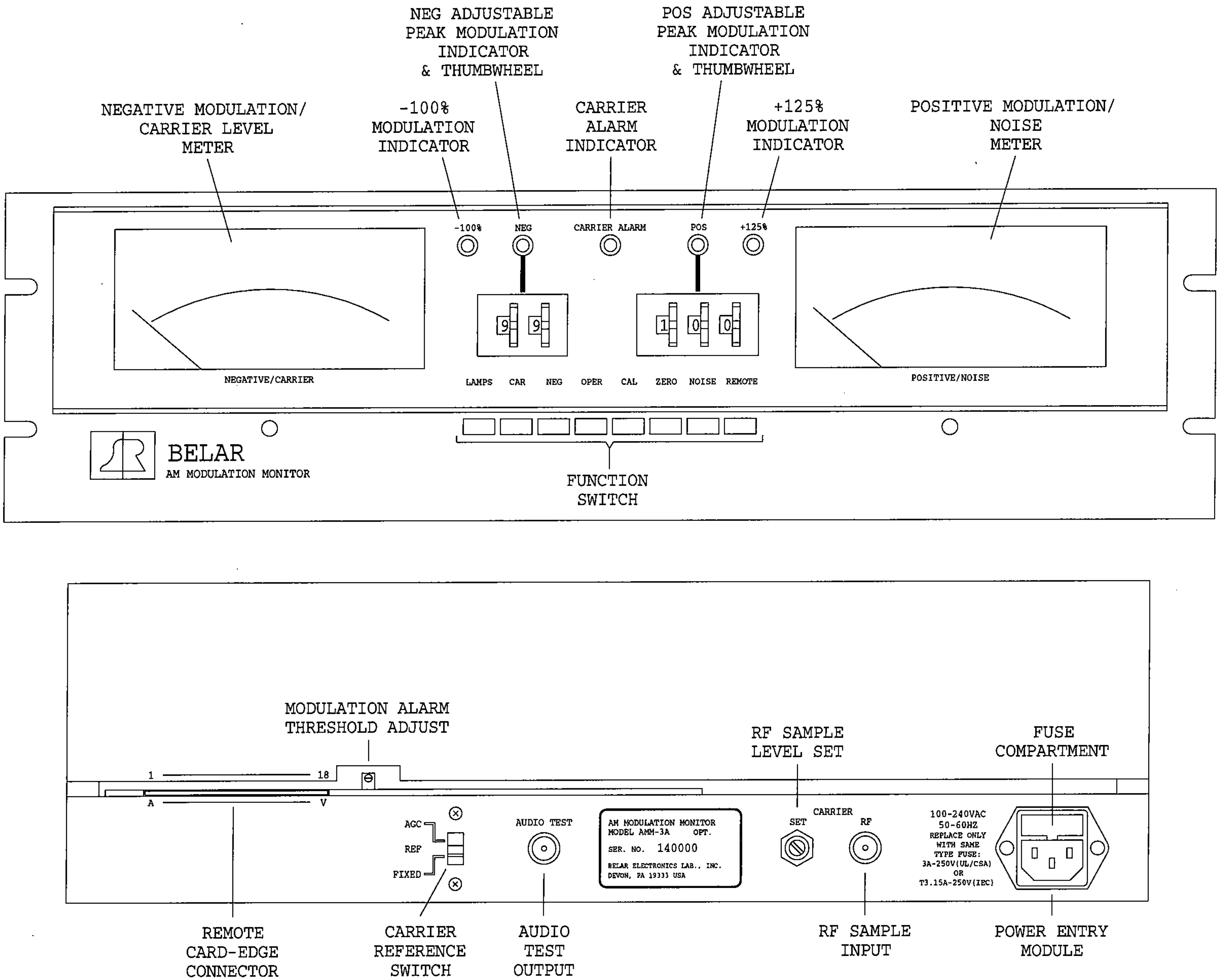
Orders may also be taken over the telephone. Parts orders can be put on your VISA, MasterCard, or American Express card, or we can ship them COD.

REFERENCE DESIGNATORS

A	= assembly	J	= jack	S	= switch
BR	= diode bridge	L	= inductor	T	= transformer
C	= capacitor	M	= meter	TB	= terminal block
CR	= diode or LED	P	= plug	U	= integrated circuit
DS	= display or lamp	Q	= transistor	W	= cable
F	= fuse	R	= resistor	X	= socket
FL	= filter	RL	= relay	Y	= crystal
HDR	= header connector	RN	= resistor network		

ABBREVIATIONS

ADC	=analog-to-digital converter	PIV	= peak inverse voltage
BCD	= binary coded decimal	POLY	= polystyrene
CER	= ceramic	PORC	= porcelain
COMP	= composition	POT	= potentiometer
CONN	= connector	SEMICON	= semiconductor
DAC	=digital-to-analog convertor	SI	= silicon
DPM	= digital panel meter	TANT	= tantalum
ELEC	= electrolytic	uF	= microfarads
GE	= germanium	V	= volt
IC	= integrated circuit	VAR	= variable
k	= kilo = 1,000	VDCW	= dc working volts
M	= meg = 1,000,000	W	= watts
MOD	= modulation	WW	= wirewound
MY	= Mylar		
PC	= printed circuit		
pF	= picofarads		



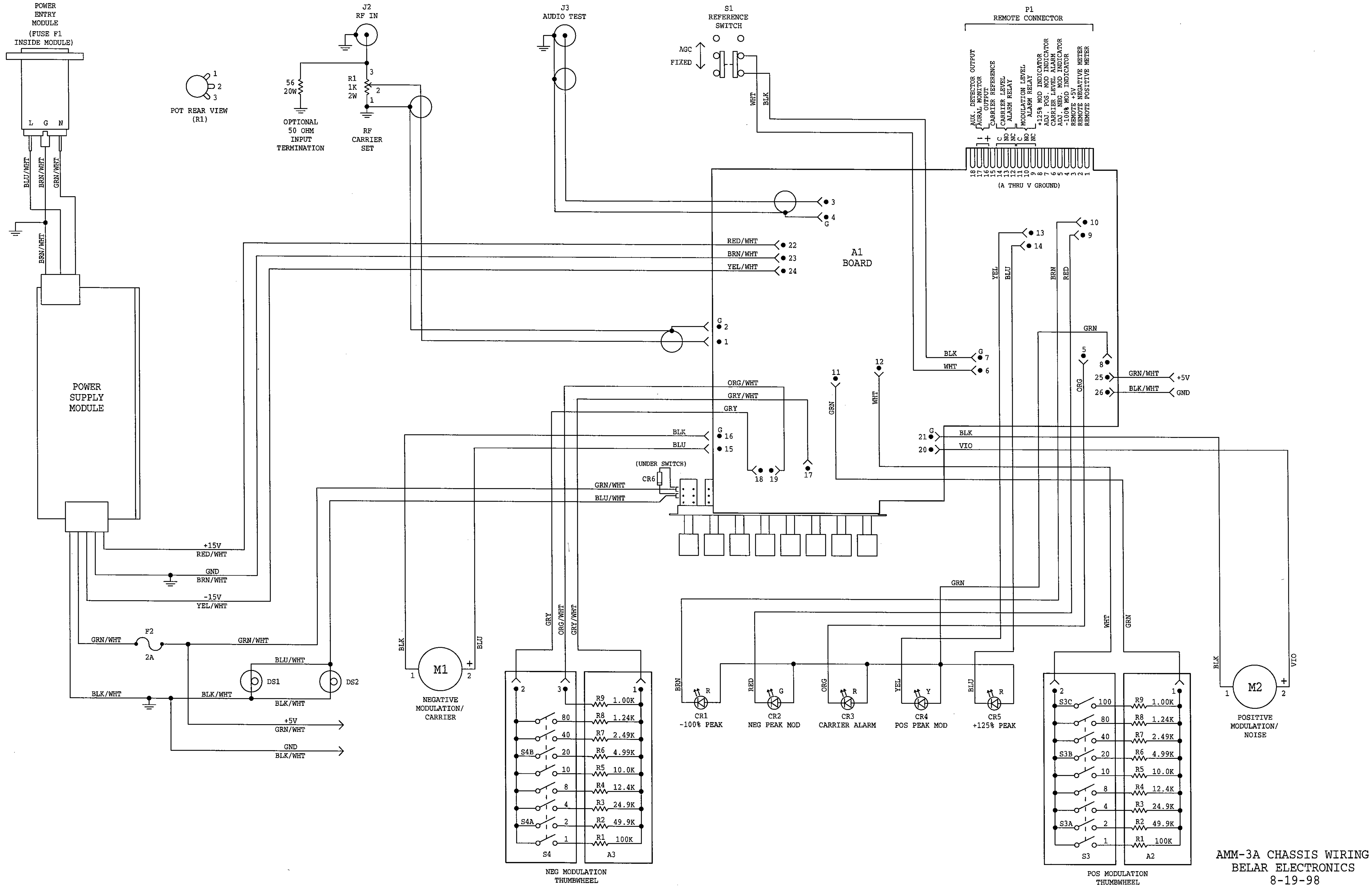
AMM-3A FRONT & REAR VIEWS
BELAR ELECTRONICS
8-19-98

AMM-3A PARTS LISTS

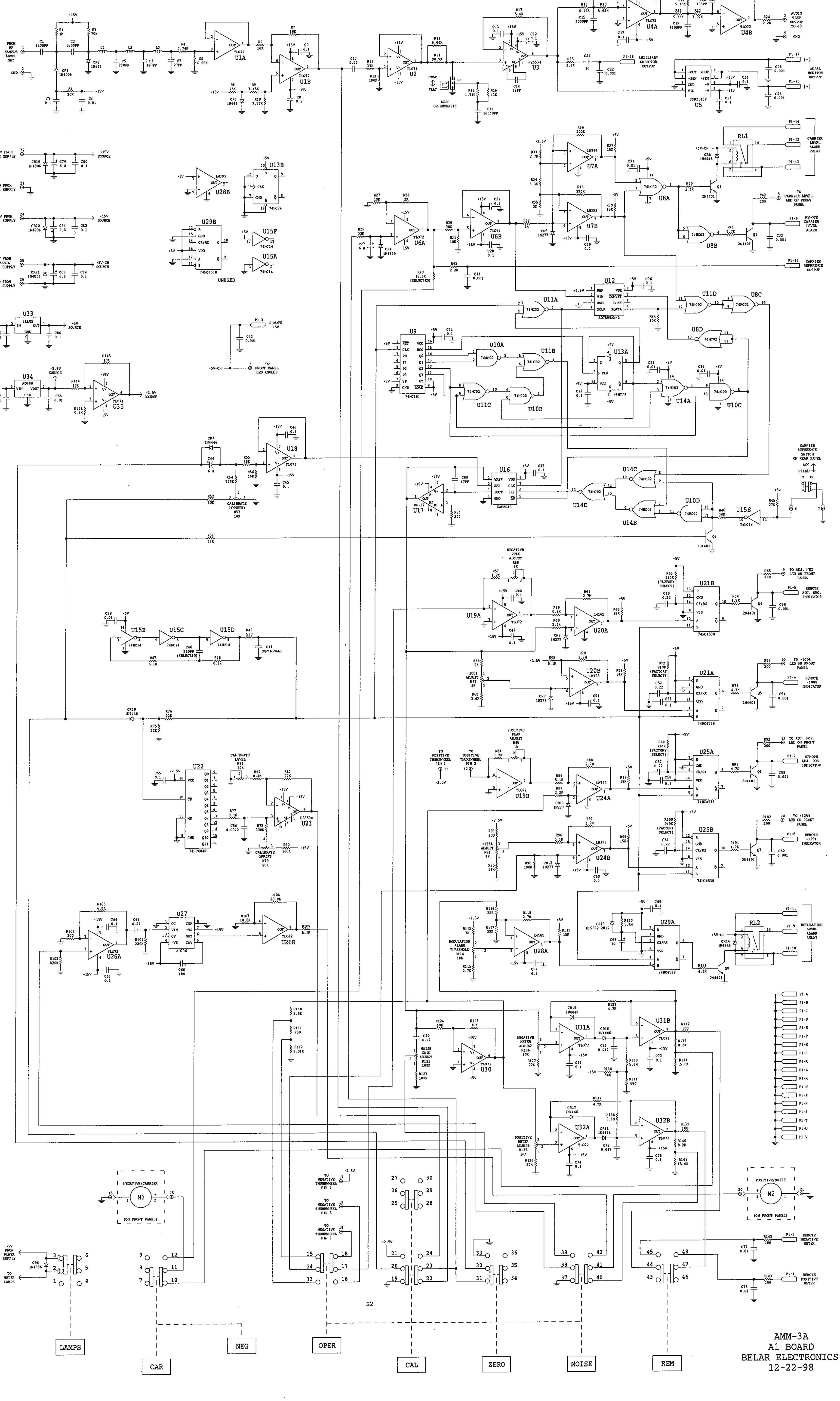
MAIN CHASSIS

Reference Designation	Description		Part Number
--	POWER SUPPLY MODULE: 15W		4005-0019A
CR1	LED: RED		1910-0001
CR2	LED: GREEN		1910-0003
CR3	LED: RED		1910-0001
CR4	LED: YELLOW		1910-0002
CR5	LED: RED		1910-0001
CR6	DIODE: 1N4006		1900-0016
DS1,DS2	LAMP: 755		2140-0005
--	SOCKET: LAMP		1450-0012
F1	FUSE: GMA-3A 250V(UL/CSA) or T3.15A-250V(IEC)		2110-0009
--	FUSE HOLDER: CHASSIS MOUNT		2110-0010
F2	FUSE: AGC-2A 250V		2110-0006
J1	POWER ENTRY MODULE: 6EGG1-1		0360-0021
J2,J3	JACK: BNC		0360-0005
M1,M2	METER: MOD 0-133%		1120-0012
R1	R: VAR COMP 1k 2W		2100-0007
--	R: FIXED NON-IND 56 20W	(NOTE 1)	0811-0021
S1	SWITCH: SLIDE, DPDT		3102-0001
S3	SWITCH: THUMBWHEEL (3 Section)		3103-0002A
S4	SWITCH: THUMBWHEEL (2 Section)		3103-0003A
--	LINE CORD (115 Vac line voltage)		8120-0002
--	LINE CORD (230 Vac line voltage)		8120-0004
--	CONNECTOR: CARD EDGE, 36 PIN (CINCH 50-36SN-9 or equivalent)		0365-0055

NOTE 1: Optional 50 ohm input termination.



AMM-3A CHASSIS WIRING
BELAR ELECTRONICS
8-19-98



AMM-3A
A1 BOARD
BELAR ELECTRONICS
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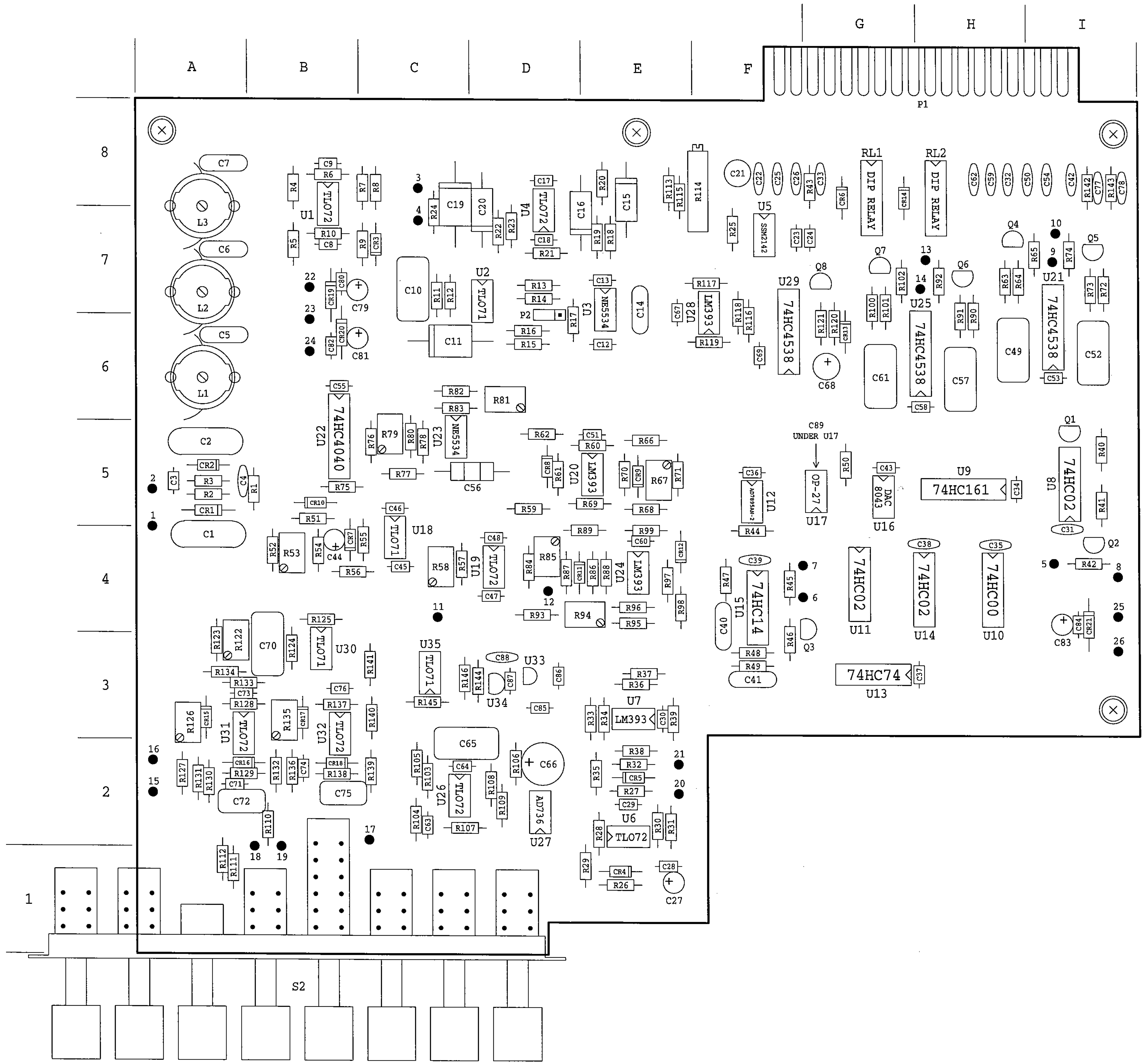


AMM-3A A1 BOARD
COMPONENT LAYOUT
BELAR ELECTRONICS

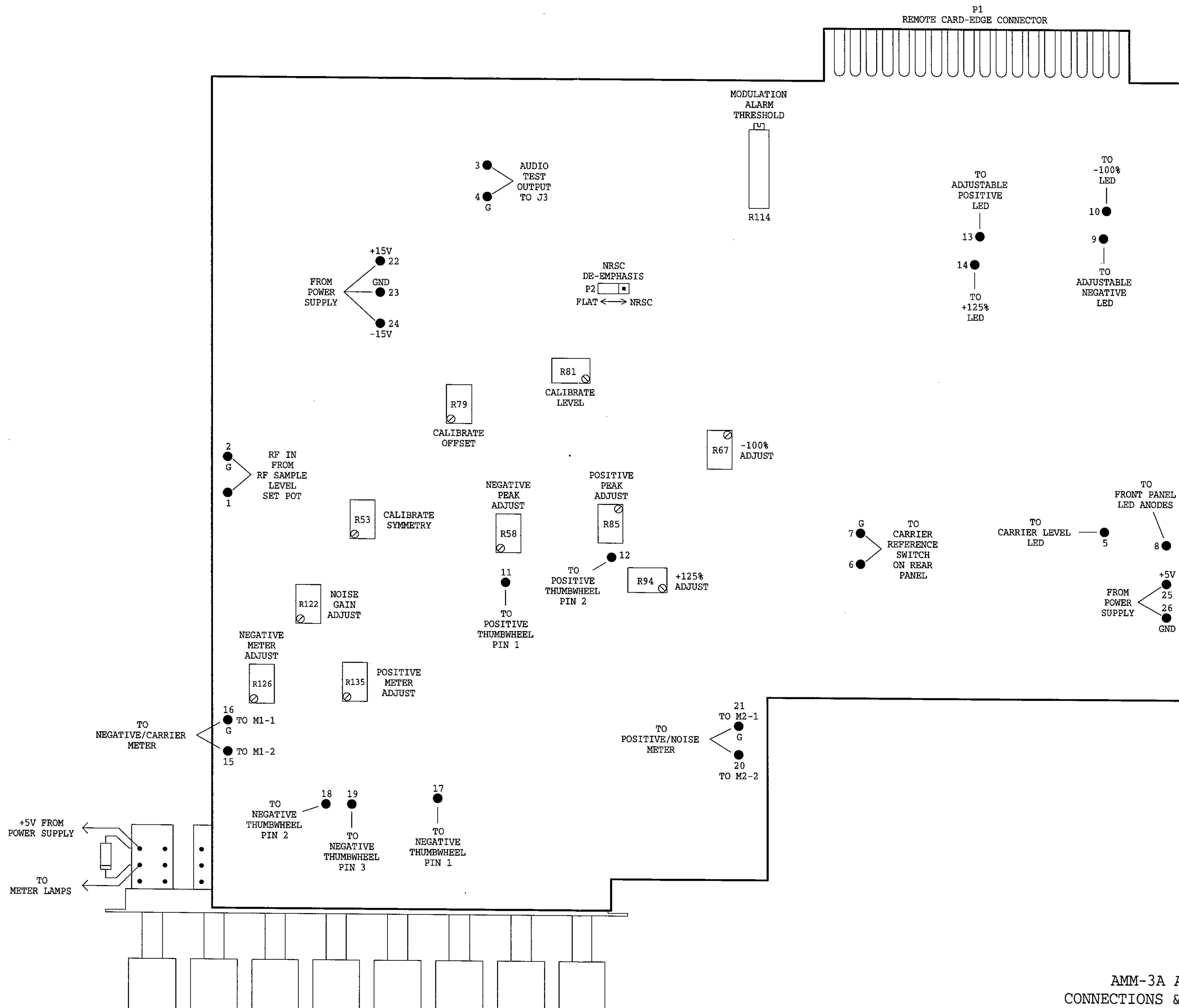
AMM-3A A1 BOARD
PART LOCATIONS

Desig/Loc		Desig/Loc		Desig/Loc		Desig/Loc		Desig/Loc		Desig/Loc	
C1	A4	C39	F4	C77	I8	L3	A8	R25	F7	R63	H7
C2	A5	C40	F4	C78	I8			R26	E1	R64	H7
C3	A5	C41	F3	C79	B7	P1	H8	R27	E2	R65	I7
C4	A5	C42	I8	C80	B7	P2	D6	R28	E2	R66	E5
C5	A6	C43	G5	C81	B6			R29	E1	R67	E5
C6	A7	C44	B4	C82	B6	Q1	I5	R30	E2	R68	E5
C7	A8	C45	C4	C83	I4	Q2	I4	R31	E2	R69	E5
C8	B7	C46	C5	C84	I4	Q3	G4	R32	E2	R70	E5
C9	B8	C47	D4	C85	D3	Q4	H7	R33	E3	R71	E5
C10	C7	C48	D4	C86	D3	Q5	I7	R34	E3	R72	I7
C11	C6	C49	H6	C87	D3	Q6	H7	R35	E2	R73	I7
C12	E6	C50	I8	C88	D3	Q7	G7	R36	E3	R74	I7
C13	E7	C51	E5	C89	G5*	Q8	G7	R37	E3	R75	B5
C14	E7	C52	I6					R38	E2	R76	C5
C15	E8	C53	I6	CR1	A5	R1	B5	R39	E3	R77	C5
C16	D7	C54	I8	CR2	A5	R2	A5	R40	I5	R78	C5
C17	D8	C55	B6	CR3	C7	R3	A5	R41	I5	R79	C5
C18	D7	C56	D5	CR4	E1	R4	B8	R42	I4	R80	C5
C19	C8	C57	H6	CR5	E2	R5	B7	R43	G8	R81	D6
C20	D7	C58	H6	CR6	G8	R6	B8	R44	F4	R82	C6
C21	F8	C59	H8	CR7	B4	R7	C8	R45	F4	R83	C6
C22	F8	C60	E4	CR8	D5	R8	C8	R46	F4	R84	D4
C23	F7	C61	G6	CR9	E5	R9	C7	R47	F4	R85	D4
C24	G7	C62	H8	CR10	B5	R10	B7	R48	F3	R86	E4
C25	F8	C63	C2	CR11	D4	R11	C7	R49	F3	R87	D4
C26	F8	C64	C2	CR12	E4	R12	C7	R50	G5	R88	E4
C27	E1	C65	C2	CR13	G6	R13	D7	R51	B5	R89	E4
C28	E1	C66	D2	CR14	G8	R14	D7	R52	B4	R90	H6
C29	E2	C67	E7	CR15	A3	R15	D6	R53	B4	R91	H6
C30	E3	C68	G6	CR16	A2	R16	D6	R54	B4	R92	H7
C31	I4	C69	F6	CR17	B3	R17	D6	R55	C4	R93	D4
C32	H8	C70	B3	CR18	B2	R18	E7	R56	B4	R94	E4
C33	G8	C71	A2	CR19	B7	R19	E7	R57	C4	R95	E4
C34	H5	C72	A2	CR20	B6	R20	E8	R58	C4	R96	E4
C35	H4	C73	A3	CR21	I4	R21	D7	R59	D5	R97	E4
C36	F5	C74	B2			R22	D7	R60	E5	R98	E4
C37	H3	C75	B2	L1	A6	R23	D7	R61	D5	R99	E4
C38	H4	C76	B3	L2	A7	R24	C7	R62	D5	R100	G7

*C89 is on pc bottom

AMM-3A A1 BOARD
PART LOCATIONS
CONT.

Desig/Loc		Desig/Loc		Desig/Loc	
R101	G7	R140	C3	U27	D2
R102	G7	R141	C3	U28	F7
R103	C2	R142	I8	U29	F6
R104	C2	R143	I8	U30	B3
R105	C2	R144	D3	U31	A3
R106	D2	R145	C3	U32	B3
R107	C2	R146	C3	U33	D3
R108	D2			U34	D3
R109	D2	RL1	G8	U35	C3
R110	B2	RL2	H8		
R111	A1			pins	
R112	A1	S2	B1	1	A5
R113	E8			2	A5
R114	F8	U1	B8	3	C8
R115	E8	U2	D7	4	C7
R116	F6	U3	E7	5	I4
R117	F7	U4	D7	6	F4
R118	F7	U5	F7	7	F4
R119	F6	U6	E2	8	I4
R120	G6	U7	E3	9	I7
R121	G6	U8	I5	10	I7
R122	A3	U9	H5	11	C4
R123	A3	U10	H4	12	D4
R124	B3	U11	G4	13	H7
R125	B4	U12	F5	14	H7
R126	A3	U13	G3	15	A2
R127	A2	U14	H4	16	A2
R128	A3	U15	F4	17	C2
R129	A2	U16	G5	18	B1
R130	A2	U17	G5	19	B1
R131	A2	U18	C4	20	E2
R132	B2	U19	D4	21	E2
R133	A3	U20	E5	22	B7
R134	A3	U21	I6	23	B6
R135	B3	U22	B5	24	B6
R136	B2	U23	C5	25	I4
R137	B3	U24	E4	26	I3
R138	B2	U25	H6		
R139	C2	U26	C2		



AMM-3A A1 BOARD
CONNECTIONS & ADJUSTMENTS
BELAR ELECTRONICS

A1 BOARD AMM-3A

Reference Designation	Description	Part Number
C1,C2	C: FIXED MICA 1500pF 5%	0141-1525
C3	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C4	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C5	C: FIXED MICA 270pF 5%	0140-2715
C6	C: FIXED MICA 160pF 5%	0140-1615
C7	C: FIXED MICA 27pF 5%	0140-2705
C8,C9	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C10	C: FIXED POLY 0.22uF 10% 100V	0122-2241
C11	C: FIXED POLY 10,000pF 2.5% 160V	0130-1032
C12,C13	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C14	C: FIXED MICA 22pF 5%	0140-2205
C15	C: FIXED POLY 3,000pF 2.5% 160V	0130-3022
C16	C: FIXED POLY 820pF 2.5% 160V	0130-8212
C17,C18	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C19	C: FIXED POLY 9,100pF 2.5% 160V	0130-9122
C20	C: FIXED POLY 180pF 2.5% 160V	0130-1812
C21	C: FIXED ELEC 10uF 35V NON-POLAR	0180-0029
C22	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C23,C24	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C25,C26	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C27	C: FIXED TANT 6.8uF 25V	0185-0002
C28 thru C30	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C31	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C32,C33	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C34	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C35	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C36,C37	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C38,C39	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C40*	C: FIXED MICA 360pF 5%	0140-3615
(*Note: C40 is factory select, nominal value shown.)		
C41	C: FIXED MICA 5% (select by test)	
C42	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C43	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C44	C: FIXED TANT 6.8uF 25V	0185-0002
C45 thru C48	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C49	C: FIXED POLY 0.22uF 10% 100V	0122-2241
C50	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C51	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C52	C: FIXED POLY 0.22uF 10% 100V	0122-2241
C53	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C54	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C55	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C56	C: FIXED FILM 0.0022uF 10% 200V	0120-2221
C57	C: FIXED POLY 0.22uF 10% 100V	0122-2241
C58	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C59	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C60	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C61	C: FIXED POLY 0.22uF 10% 100V	0122-2241
C62	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C63,C64	C: FIXED CERAMIC 0.1uF 50V	0151-0006

Reference Designation	Description	Part Number
C65	C: FIXED POLY 0.22uF 10% 100V	0122-2241
C66	C: FIXED ELEC 100uF 35V	0180-0018
C67	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C68	C: FIXED TANT 10uF 16V	0185-0007
C69	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C70	C: FIXED POLY 0.22uF 10% 100V	0122-2241
C71	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C72	C: FIXED POLY 0.047uF 10% 100V	0122-4731
C73,C74	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C75	C: FIXED POLY 0.047uF 10% 100V	0122-4731
C76	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C77,C78	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C79	C: FIXED TANT 6.8uF 25V	0185-0002
C80	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C81	C: FIXED TANT 6.8uF 25V	0185-0002
C82	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C83	C: FIXED TANT 6.8uF 25V	0185-0002
C84 thru C87	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C88	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C89	C: FIXED MICA 47pF 5%	0140-4705
CR1	DIODE: 1N4006	1900-0016
CR2,CR3	DIODE: 1N643	1900-0017
CR4	DIODE: 1N4446	1900-0002
CR5	DIODE: 1N277 GERMANIUM	1900-0001
CR6,CR7	DIODE: 1N4446	1900-0002
CR8,CR9	DIODE: 1N277 GERMANIUM	1900-0001
CR10	DIODE: 1N4446	1900-0002
CR11,CR12	DIODE: 1N277 GERMANIUM	1900-0001
CR13	DIODE: HP5082-2810	1900-0032
CR14 thru CR18	DIODE: 1N4446	1900-0002
CR19 thru CR21	DIODE: 1N4006	1900-0016
L1	INDUCTOR:	Belar
L2	INDUCTOR:	Belar
L3	INDUCTOR:	Belar
P2	PLUG: 3 PIN, PC MOUNT	0365-0030
--	JUMPER: 2 PIN (USED WITH P2)	0365-0028
Q1 thru Q8	TRANSISTOR: 2N4401	1850-0028
R1	R: METAL FILM 1M 2% 1/4W	0751-1052
R2	R: METAL FILM 20k 2% 1/4W	0751-2032
R3	R: METAL FILM 75k 2% 1/4W	0751-7532
R4	R: METAL FILM 3.74k 1%	0721-3741
R5	R: METAL FILM 6.65k 1%	0721-6651
R6,R7	R: METAL FILM 10k 2% 1/4W	0751-1032
R8	R: METAL FILM 75k 2% 1/4W	0751-7532
R9	R: METAL FILM 7.15k 1%	0721-7151

A1 BOARD AMM-3A cont.

Reference Designation	Description	Part Number
R10	R: METAL FILM 3.32k 1%	0721-3321
R11	R: METAL FILM 33k 2% 1/4W	0751-3332
R12	R: METAL FILM 180k 2% 1/4W	0751-1842
R13	R: METAL FILM 6.04k 1%	0721-6041
R14	R: METAL FILM 90.9k 1%	0721-9092
R15	R: METAL FILM 1.91k 1%	0721-1911
R16	R: METAL FILM 43k 2% 1/4W	0751-4332
R17	R: METAL FILM 5.6k 2% 1/4W	0751-5622
R18,R19	R: METAL FILM 6.19k 1%	0721-6191
R20	R: METAL FILM 5.62k 1%	0721-5621
R21,R22	R: METAL FILM 5.36k 1%	0721-5361
R23	R: METAL FILM 3.92k 1%	0721-3921
R24,R25	R: METAL FILM 2.2k 2% 1/4W	0751-2222
R26	R: METAL FILM 33k 2% 1/4W	0751-3332
R27	R: METAL FILM 10k 2% 1/4W	0751-1032
R28	R: METAL FILM 2k 2% 1/4W	0751-2022
R29*	R: METAL FILM 15.8k 1%	0721-1582
(*Note: R29 is factory select, nominal value shown.)		
R30	R: METAL FILM 30k 2% 1/4W	0751-3032
R31	R: METAL FILM 10k 2% 1/4W	0751-1032
R32	R: METAL FILM 2k 2% 1/4W	0751-2022
R33	R: METAL FILM 2.7k 2% 1/4W	0751-2722
R34	R: METAL FILM 3.3k 2% 1/4W	0751-3322
R35	R: METAL FILM 2k 2% 1/4W	0751-2022
R36	R: METAL FILM 200k 2% 1/4W	0751-2042
R37	R: METAL FILM 15k 2% 1/4W	0751-1532
R38	R: METAL FILM 330k 2% 1/4W	0751-3342
R39	R: METAL FILM 15k 2% 1/4W	0751-1532
R40,R41	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R42	R: METAL FILM 200 2% 1/4W	0751-2012
R43	R: METAL FILM 2.2k 2% 1/4W	0751-2222
R44	R: METAL FILM 10k 2% 1/4W	0751-1032
R45	R: METAL FILM 27k 2% 1/4W	0751-2732
R46	R: METAL FILM 10k 2% 1/4W	0751-1032
R47,R48	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R49	R: METAL FILM 510 2% 1/4W	0751-5112
R50	R: METAL FILM 200 2% 1/4W	0751-2012
R51	R: METAL FILM 47k 2% 1/4W	0751-4732
R52	R: METAL FILM 10k 2% 1/4W	0751-1032
R53	R: VAR COMP 10k, 10 TURN	2100-0024
R54	R: METAL FILM 330k 2% 1/4W	0751-3342
R55,R56	R: METAL FILM 18k 2% 1/4W	0751-1832
R57	R: METAL FILM 1.2k 2% 1/4W	0751-1222
R58	R: VAR COMP 1k, 10 TURN	2100-0021
R59	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R60	R: METAL FILM 2.2k 2% 1/4W	0751-2222
R61	R: FIXED CARBON 2.7M 5% 1/4W	0683-2755
R62	R: METAL FILM 15k 2% 1/4W	0751-1532
R63*	R: METAL FILM 910k 2% 1/4W	0751-9142
(*Note: R63 is factory select, nominal value shown.)		

A1 BOARD AMM-3A cont.

Reference Designation	Description	Part Number
R64	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R65	R: METAL FILM 200 2% 1/4W	0751-2012
R66	R: METAL FILM 2k 2% 1/4W	0751-2022
R67	R: VAR COMP 2k, 10 TURN	2100-0031
R68	R: METAL FILM 3.6k 2% 1/4W	0751-3622
R69	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R70	R: FIXED CARBON 2.7M 5% 1/4W	0683-2755
R71	R: METAL FILM 15k 2% 1/4W	0751-1532
R72*	R: METAL FILM 910k 2% 1/4W	0751-9142
(*Note: R72 is factory select, nominal value shown.)		
R73	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R74	R: METAL FILM 200 2% 1/4W	0751-2012
R75,R76	R: METAL FILM 22k 2% 1/4W	0751-2232
R77	R: METAL FILM 9.1k 2% 1/4W	0751-9122
R78	R: METAL FILM 330k 2% 1/4W	0751-3342
R79	R: VAR COMP 50k, 10 TURN	2100-0025
R80	R: METAL FILM 180k 2% 1/4W	0751-1842
R81	R: VAR COMP 10k, 10 TURN	2100-0024
R82	R: METAL FILM 8.2k 2% 1/4W	0751-8222
R83	R: METAL FILM 27k 2% 1/4W	0751-2732
R84	R: METAL FILM 1.2k 2% 1/4W	0751-1222
R85	R: VAR COMP 1k, 10 TURN	2100-0021
R86	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R87	R: METAL FILM 2.2k 2% 1/4W	0751-2222
R88	R: FIXED CARBON 2.7M 5% 1/4W	0683-2755
R89	R: METAL FILM 15k 2% 1/4W	0751-1532
R90*	R: METAL FILM 910k 2% 1/4W	0751-9142
(*Note: R90 is factory select, nominal value shown.)		
R91	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R92,R93	R: METAL FILM 200 2% 1/4W	0751-2012
R94	R: VAR COMP 5k, 10 TURN	2100-0020
R95	R: METAL FILM 11k 2% 1/4W	0751-1132
R96	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R97	R: FIXED CARBON 2.7M 5% 1/4W	0683-2755
R98	R: METAL FILM 100k 2% 1/4W	0751-1042
R99	R: METAL FILM 15k 2% 1/4W	0751-1532
R100*	R: METAL FILM 910k 2% 1/4W	0751-9142
(*Note: R100 is factory select, nominal value shown.)		
R101	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R102	R: METAL FILM 200 2% 1/4W	0751-2012
R103	R: METAL FILM 820k 2% 1/4W	0751-8242
R104	R: METAL FILM 200 2% 1/4W	0751-2012
R105	R: METAL FILM 6.8k 2% 1/4W	0751-6822
R106	R: METAL FILM 220k 2% 1/4W	0751-2242
R107	R: METAL FILM 10.0k 1%	0721-1002
R108	R: METAL FILM 20.0k 1%	0721-2002
R109	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R110	R: METAL FILM 3.6k 2% 1/4W	0751-3622
R111	R: METAL FILM 750 1%	0721-7500
R112	R: METAL FILM 3.01k 1%	0721-3011

A1 BOARD AMM-3A cont.

Reference Designation	Description	Part Number
R113	R: METAL FILM 3k 2% 1/4W	0751-3022
R114	R: VAR COMP 10k, 10 TURN	2100-0018
R115	R: METAL FILM 2.7k 2% 1/4W	0751-2722
R116,R117	R: METAL FILM 22k 2% 1/4W	0751-2232
R118	R: FIXED CARBON 2.7M 5% 1/4W	0683-2755
R119	R: METAL FILM 15k 2% 1/4W	0751-1532
R120	R: FIXED CARBON 1.5M 5% 1/4W	0683-1555
R121	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R122	R: VAR COMP 100k, 10 TURN	2100-0030
R123	R: METAL FILM 100k 2% 1/4W	0751-1042
R124,R125	R: METAL FILM 10k 2% 1/4W	0751-1032
R126	R: VAR COMP 10k, 10 TURN	2100-0024
R127	R: METAL FILM 22k 2% 1/4W	0751-2232
R128	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R129	R: FIXED CARBON 5.6M 5% 1/4W	0683-5655
R130	R: METAL FILM 56k 2% 1/4W	0751-5632
R131	R: METAL FILM 680 2% 1/4W	0751-6812
R132	R: METAL FILM 100 2% 1/4W	0751-1012
R133	R: METAL FILM 8.2k 2% 1/4W	0751-8222
R134	R: METAL FILM 15.0k 1%	0721-1502
R135	R: VAR COMP 10k, 10 TURN	2100-0024
R136	R: METAL FILM 22k 2% 1/4W	0751-2232
R137	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R138	R: FIXED CARBON 5.6M 5% 1/4W	0683-5655
R139	R: METAL FILM 100 2% 1/4W	0751-1012
R140	R: METAL FILM 8.2k 2% 1/4W	0751-8222
R141	R: METAL FILM 15.0k 1%	0721-1502
R142,R143	R: METAL FILM 100 2% 1/4W	0751-1012
R144,R145	R: METAL FILM 10k 2% 1/4W	0751-1032
R146	R: METAL FILM 5.1k 2% 1/4W	0751-5122
RL1,RL2	RELAY: JWD-172-1	1600-0006
S2	SWITCH: PUSHBUTTON (8 BUTTON)	3101-0014
U1	IC: TL072	1826-0038
U2	IC: TL071	1826-0004
U3	IC: NE5534	1826-0025
U4	IC: TL072	1826-0038
U5	IC: SSM2142P	1827-0005
U6	IC: TL072	1826-0038
U7	IC: LM393	1826-0011
U8	IC: 74HC02A	1822-0040
U9	IC: 74HC161	1822-0080
U10	IC: 74HC00	1822-0039
U11	IC: 74HC02A	1822-0040
U12	IC: AD7895AN-2	1827-0013
U13	IC: 74HC74	1822-0067
U14	IC: 74HC02A	1822-0040
U15	IC: 74HC14A	1822-0042

A1 BOARD AMM-3A cont.

Reference Designation	Description	Part Number
U16	IC: DAC8043	1830-0001
U17	IC: OP-27	1826-0066
U18	IC: TLO71	1826-0004
U19	IC: TLO72	1826-0038
U20	IC: LM393	1826-0011
U21	IC: 74HC4538A	1822-0076
U22	IC: 74HC4040A	1822-0062
U23	IC: NE5534	1826-0025
U24	IC: LM393	1826-0011
U25	IC: 74HC4538A	1822-0076
U26	IC: TLO72	1826-0038
U27	IC: AD736	1827-0009
U28	IC: LM393	1826-0011
U29	IC: 74HC4538A	1822-0076
U30	IC: TLO71	1826-0004
U31,U32	IC: TLO72	1826-0038
U33	IC: 78LO5CP	1826-0012
U34	IC: AD680	1826-0051
U35	IC: TLO71	1826-0004