Model FMM-2
FM MODULATION MONITOR

Guide to Operations

Rev 1-24-03

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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 FMM-2 FM Modulation Monitor (FCC ID: C459W1FMM-2) is a wideband FM monitor designed to meet the Federal Communications Commission requirements for measuring the total modulation characteristics of monaural as well as multiplexed FM transmitters having a center frequency range of 88 to 108 MHz. In addition, the FMM-2 may be used as a low distortion and low noise FM demodulator for driving audio monitor amplifiers and the companion Belar FMS-2 Stereo Modulation Monitor and SCM-2 SCA Modulation Monitor. The FMM-2 incorporates a deviation type modulation calibrator to insure the accuracy of the modulation measurements at any time.

1-2 Physical Description

The FMM-2 is constructed on a standard 5¼ X 19 inch EIA rack mount panel. Factory adjustments are located within the shielded compartment of the monitor. The AC power input, line voltage selector, RF and IF inputs and monitor outputs are located on the rear of the FMM-2 chassis on individual BNC connectors and on a card edge connector.

1-3 Electrical Description

The FMM-2 is a solid state, low sensitivity, crystal controlled, superheterodyne FM receiver incorporating a highly linear and stable digital pulse counting discriminator to demodulate the FM signal. Various metering and test provisions are contained within the monitor to measure transmitter output characteristics. These provisions include a selectable true-peak or FCC defined semi-peak modulation meter and thumbwheel controlled peak modulation indicator, both switchable to positive, negative or independent modulation polarity; metering circuits to set the incoming RF level; a standard deviation and zero deviation calibration oscillator to check monitor calibration and permit a signal-to-noise test of the monitor and provisions for measurement of AM and FM noise. A carrier alarm and fixed 100% peak modulation indicator are also provided.

Outputs obtained from the monitor include two composite wideband outputs for stereo and SCA monitoring; a de-emphasized audio output; balanced and unbalanced audio monitor outputs; modulation meter, 100% peak indicator, adjustable peak indicator and carrier alarm indicator.

1-4 Electrical and Mechanical Specifications

Frequency Range . . . . . 88 to 108 MHz std.

RF Input . . . . . 1 to 10 volts RMS
50 Ω, BNC connector

IF Input . . . . . 650 kHz from Belar RFA-1A RF Amplifier or
Belar RFA-4 Frequency Agile RF Amplifier

Modulation Metering:

Deviation Indication . . . . . 100% @ ±75 kHz,
0 to 133% range

Accuracy . . . . . ±2% @ all modulation levels

Characteristics . . . . . Selectable: peak (sample hold) or semi-peak

Noise Measurement:

FM Noise Range . . . . . -50 dB to -70 dB

AM Noise Range . . . . . -50 dB to -70 dB

Test Function:

Calibrate . . . . . Provides internal std. deviation reference

Zero . . . . . Provides zero deviation for S/N

RF Level . . . . . Calibrates AM noise function and carrier alarm reference level

Carrier Alarm . . . . . Indicator adjusted for 90% carrier level

Outputs:

Stereo Monitor ..... Wideband, 1.5V RMS @ 1kΩ unbalanced

SCA Monitor ..... Wideband, 1.5V RMS @ 1kΩ unbalanced

Audio (Program) ..... +10 dBm, 600 Ω, balanced
Audio (Test) ..... 5V RMS, 10kΩ, unbalanced

Audio Output Specifications

Frequency Response ..... ±0.01 dB
Harmonic Distortion ..... 0.01% max
Intermodulation Distortion ..... 0.01% max (SMPTE)
Signal-to-Noise Ratio ..... 90 dB, min

Remote Outputs:

Carrier Level Alarm ..... Provides "open collector" output, capable of sinking 20 mA @ 15 Vdc

Meter, 100% Peak Indicator, Adjustable Peak Indicator ..... For interface to Belar Model MP-8 or MP-9 Remote Meter Panels (opt)

Dimensions ..... 5¼"H x 10½"D x 19"W (EIA Rack Mount)
Power Consumption ..... 10 watts, 117/234 Vac, 50/60 Hz
Shipping Weight ..... 13 lbs

1-5 Accessories

The Belar FMM-2 FM Modulation Monitor may be used for remote monitoring of an FM transmitter with the Belar MP-8 or MP-9 Remote Meter Panel, or, for off-air monitoring, with the Belar RFA-1 FM RF Amplifier, the Belar RFA-1A FM RF Amplifier, or the Belar RFA-4 Frequency Agile RF Amplifier. The MP-8 and MP-9 meter panels contain a total modulation meter and carrier alarm, adjustable peak modulation and 100% modulation LEDs. The MP-8 also serves as remote metering for the FMS-2 Stereo Modulation Monitor, and includes metering for left and right channels along with a stereo pilot LED indicator.

The RFA-1 and RFA-1A RF Amplifiers provide pre-amplification and selectivity to permit direct off-air monitoring with the FMM-2. The RFA-4 adds frequency agility.

1-6 Addendum for FMM-2 Serial Numbers beginning 162167

Belar FMM-2 FM Modulation Monitors with serial numbers 162167 and above contain the following circuit enhancements:

1. A DC servo circuit to stabilize peak metering indications
2. The availability of one of two composite output levels
3. Selectable compensation for Belar RF amplifiers
4. A true differential audio monitoring output
5. True RMS indications for FM and AM noise measurements
6. Independent front panel meter calibration
7. Jumper selection of de-emphasis curve.

Each enhancement will be discussed individually.

NOTE: In the following discussions, all positions on the main circuit board (A2 REV A) are described as would be seen by facing the front panel of the instrument, removing the cover, and looking down onto the exposed component side of the circuit board.

1. DC SERVO

This circuit greatly lowers the effective cutoff frequency of the peak measurement circuits and eliminates the need to check and adjust the DC offset of the discriminator. With the lowered cutoff frequency, any increase in modulation indications for asymmetric or clipped waveforms is negligible.

Units are sent from the factory with the DC servo activated. To *de-activate* the circuit, both jumpers P2 and P3 must be changed. Move blue jumper P2, next to amplifier U11, to the left position. This disconnects the feedback connection from servo amplifier U11 and terminates it to ground. Move blue jumper P3, next to C33, towards the front panel of the monitor. This removes the short placed across C33 and places AC coupling between the discriminator output and the metering and output circuitry.

2. COMPOSITE OUTPUT LEVEL ADJUSTMENT

There are two nominal composite levels available at the wideband STEREO and SCA outputs--3.5 V peak-to-peak (1.237 VRMS) or 4.2 V peak-to-peak (1.5 VRMS) for 75 kHz peak deviation. Instruments are set up at the factory to match the input sensitivities of monitors with which they are paired.

The FMM-2 is normally shipped with the composite output level set up for 1.5 VRMS. To reduce the output level from 1.5 VRMS to the newer 1.237 VRMS level, simply cut R50, which is a 10k, 2% resistor, from the A2 board using fine-pointed wire cutters (see the drawings at the rear of this manual for R50's location). *After making this change, any minor adjustments required to calibrate accompanying monitors with the FMM-2 should be made by adjusting the input level sensitivities of the attached monitors.*

3. RF AMPLIFIER COMPENSATION

For maximum performance, the RF amplifier compensator must be engaged when the FMM-2 is used in conjunction with Belar RF amplifier models RFA-1A or RFA-4. To engage the compensator move blue circuit jumper P1 to its extreme right position.

4. DIFFERENTIAL AUDIO OUTPUT

Integrated circuit U18 provides a true differential audio output at contacts 1 and 2 of the rear panel card edge connector. The output level is +10 dBm into 600 ohms at 75 kHz peak deviation. The output is capable of driving balanced lines of 500 feet of more length when terminated in 600 ohms or higher resistance. Standard broadcast-type twisted-pair cables such as Belden 8451 are recommended for long runs. For best common mode rejection, it is recommended that no build-out resistance or pads be used between the card edge contacts 1 and 2 and the line.

The two differential output connections are interactive. Therefore, for single-ended outputs, it is important to tie the unused output securely to the circuit board ground via one of the terminals of the card-edge connector.

5. RMS NOISE INDICATIONS

FM and AM NOISE indications now have true RMS indications. No operational change is necessary. Zero DB on the meter corresponds to 50 decibels below 75 kHz deviation for FM NOISE and 50 decibels below 100 percent AM modulation for AM NOISE.

6. METER CALIBRATION

If it becomes necessary to replace a front panel meter, METER CAL potentiometer R88 allows adjustment for changes in meter sensitivity. After the meter has been replaced, place the FMM-2 in ZERO mode. Check and adjust the meter zero if necessary. Next place the FMM-2 in CALIBRATE mode. Adjust R88 for 100 % indication.

7. DE-EMPHASIS SELECTION

The de-emphasis time constants for the audio monitoring output and noise indications may be selected by the positions of blue circuit jumpers P4 and P5. Selection of either 50 or 75 microsecond de-emphasis for the audio monitoring output is chosen by P4. The appropriate positions are marked on the circuit board. De-emphasis for noise readings is set by P5. The fifty microsecond position is towards the rear of the board. Seventy-five microseconds is toward the front of the board and is unmarked.

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 be present when the unit is unpacked. Carefully unpack the unit to avoid damaging the equipment through use of careless procedures. Inspect all 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 for the recommended claim procedure. Keep all packing material for proof of damage claim or for possible future use.

The FMM-2 is shipped with an instruction book, three wire line cord, four beige rack mount screws, and a 10 position, dual readout remote connector.

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 to arrange the repair or replacement of the unit without waiting for a claim to be settled with the carrier.

2-3 Repacking for Shipment

If the unit is to be returned to Belar, attach a tag to it showing owner and owner's address. A description of the service required should be included on the tag. The original shipping carton and packaging materials should be used for reshipment. If they are not available or reusable, the unit should be repackaged in the following manner:

a. Use a double-walled carton with a minimum test strength of 275 pounds.
b. Use heavy paper or sheets of cardboard to protect all surfaces.
c. Use at least 4 inches of tightly packed, industry approved, shock absorbing material such as extra firm polyurethane foam or rubberized hair. NEWSPAPER IS NOT SUFFICIENT FOR CUSHIONING MATERIAL.
d. Use heavy duty shipping tape to secure the outside to the carton.
e. Use large FRAGILE labels on each surface.
f. Return the unit, freight prepaid. Be sure to insure the unit for full value.

2-4 Preparation for Use

The FMM-2 Modulation Monitor is designed to be mounted in a standard 19-inch rack. When mounted in a rack, a slight air space should be provided above and below the unit. When the monitor is mounted above high heat generating equipment such as power amplifiers, consideration should be given to cooling requirements which allow a free movement of cooler air through and around the FMM-2. In no instance should the ambient chassis temperature be allowed to rise above 50°C (122°F).

Units beginning with serial number 163360:
These units can be operated from a 100 to 240 Vac, single phase, 50-60 Hz power source with no user adjustments. The fuse should be a 5 mm x 20 mm type GMA-3, 3 AMP-250 V (UL/CSA) or T3.15 A-250 V (IEC) fuse only. A spare fuse is stored in the removable fuse compartment.

Units with serial number 161720 to 163359:
Unplug the line cord. Open the fuse compartment door and pull lever to remove fuse. Using needlenose pliers, pull the voltage select board straight out of the power entry module. While facing the rear of the unit, orient the voltage select board so the desired line voltage is face up and reads correctly ("120" for 115Vac operation, "240" for 230Vac operation. The "100" and "220" positions on the bottom of the board are not used.) Reinsert the board into the power entry module, reinstall the fuse, close the fuse door, and plug the line cord back in.

Units with serial number 161719 and lower:
Unplug the line cord. Slide the switch (S1) to 115V or 230V position. Plug the line cord back in.

If you are using the FMM-2 at the transmitter, or with the Belar RFA-1:

Set the input selector slide switch to the RF position. Connect a 50Ω coaxial cable (such as RG-174 or RG-58) between the monitor probe on the transmitter (or RF amplifier) and the RF input connector J2 at the rear of the main chassis.

CAUTION: DO NOT APPLY MORE THAN 10 VOLTS RF TO THE MONITOR OR THE RF INPUT LEVEL CONTROL (CARRIER SET) MAY BE DAMAGED.

If you are using the FMM-2 with the Belar RFA-1A RF amplifier or the Belar RFA-4 Frequency Agile RF Amplifier:

> Set the input selector switch to the IF position. Connect a 50Ω coaxial cable (such as RG-174 or RG-58) between the IF out jack on the RF Amplifier (Belar RFA-1A or Belar RFA-4 only) and the IF input connector J3 at the rear of the main chassis.

If desired, connect an external aural monitoring amplifier to pins 1 and 2 on the remote connector. This is a balanced 600Ω output. Pin 3 or Pin 4 may also be used, but note that these outputs are 10kΩ, unbalanced, with pins B and C connected to ground.

A remote total modulation meter may be connected to pin 5 on the remote connector, with a total loop resistance of 3750Ω. Pins 8/9, 7 and 6 may be connected to LEDs to remotely indicate carrier level alarm, adjustable peak modulation and 100% peak modulation respectively. A current limiting resistor, typically 160Ω, should be connected in series with the LEDs. A +5 Vdc source is available on pin 10. Ground is available on pins A thru L.

The Belar MP-8 Remote Meter Panel contains an illuminated total modulation meter and LEDs for the above indicators, along with the necessary meter calibration and LED current limiting resistors.

2-5 Interconnections and Controls

Model FMM-2 Rear Panel Jacks

JACK Function

J2 RF Input: set input selector switch to this direction and use this jack when using transmitter sample or Belar RFA-1 RF Amplifier

J3 IF input (650 kHz): set input selector to this direction and use this jack when using IF output from Belar RFA-1A RF Amplifier or Belar RFA-4 Frequency Agile RF Amplifier

J4 1½ Vrms @ 1kΩ, unbalanced, composite wideband output to SCA monitor

J5 1½ Vrms @ 1kΩ, unbalanced, composite wideband output to stereo monitor

J6 Test audio output, 10kΩ, unbalanced, de-emphasized

NOTE: WE RECOMMEND COAXIAL CABLES 36" OR SHORTER WHEN CONNECTING THE FMM-2 TO A STEREO MONITOR AND/OR SCA MONITOR.

Model FMM-2 Remote Connector

Pin	Function
1	Audio out, 600Ω, balanced (de-emphasized) (-)
2	Audio out, 600Ω, balanced (de-emphasized) (+)
3	Audio out, 10kΩ, unbalanced (de-emphasized)
4	Audio out, 10kΩ, unbalanced (de-emphasized)
5	Remote total modulation meter
6	Remote 100% peak LED
7	Remote Adjustable peak LED
8	Remote Carrier alarm
9	Remote Carrier alarm
10	+5 Vdc
A - L	Ground

3 Operation

3-1 Initial Operation

1. Before applying power, ensure that the meter reads 0%. If not, use a small screwdriver to turn the meter adjust screw (below the meter on the front panel) so that it reads 0%.

2. Ensure that the rear panel input selector switch is set to match the proper input (RF for transmitter sample or if used with Belar RFA-1 RF Amplifier; IF if used with Belar RFA-1A RF Amplifier or Belar RFA-4 Frequency Agile RF Amplifier) and that the carrier set control is turned to its maximum counterclockwise position.

3. Plug in the line cord, depress the ZERO switch and allow a 15 minute warm up.

4. Depress the CAL and SEMI switches and check for a 100% reading.

5. (RF INPUT ONLY) Apply the RF input to the RF input jack, depress the front panel RF LEVEL switch and adjust the carrier set control (R1) until the meter reads 100%. The FMM-2 will operate with as little as 20%, but a 100% level is required to calibrate the AM noise measurement.

6. Depress the OPERate switch and the FMM-2 is now ready for operation.

3-2 Normal Operation

For normal operation, leave the FMM-2 in OPERate position. Changes in RF level will not affect the accuracy of modulation measurements.

The PEAK MOD thumbwheel switch is usually set to the maximum allowable peak modulation according to the services being transmitted, and the PEAK MOD LED will flash at this preset level or greater.

The CARRIER ALARM LED will illuminate when the carrier falls below 90% of the preset level (as set in 3-1, step 5, above).

3-3 Functions

OPERATE - When depressed, places the unit into operation. In this mode, the modulation meter as well as the PEAK MOD and 100% modulation indicators are independent of modulation polarity.

PLUS - When depressed, places the unit into operation. The modulation meter, PEAK MOD and 100% indicators measure positive modulation excursions.

MINUS - When depressed, places the unit into operation. The modulation meter, PEAK MOD and 100% indicators measure negative modulation excursions.

CAL - When depressed, applies a standard deviation to the monitor to check modulation calibration.

ZERO - When depressed, applies a zero deviation calibration oscillator to the monitor. This function permits a signal-to-noise ratio test of the monitor.

RF LEVEL (RF INPUT ONLY) - When depressed, measures the RF level applied to the monitor. When the RF is set to 100%, the AM NOISE function is correctly calibrated.

PEAK - When depressed, places the meter into a true peak reading mode by introducing a sample-hold circuit into the metering circuit.

SEMI - When depressed, returns the metering circuit to a semi-peak mode that conforms to the FCC modulation meter requirements.

FM NOISE - When depressed, inserts a 50 dB gain, de-emphasized, metering amplifier into the circuit so that with an unmodulated carrier applied to the monitor, a monaural signal-to-noise ratio measurement can be made. Note that a 100% (0 dB) reading is now -50 dB and a -20 dB reading is now -70 dB. Thus the algebraic sum of the meter reading and -50 dB is the noise reading.

AM NOISE - When depressed, applies the 50 dB gain, de-emphasized, metering amplifier to the AM noise detector and amplifier so that an AM noise measurement can be made. When the RF level is set to 100%, the circuit is calibrated to read AM noise directly, with a 100% (0 dB) meter reading representing -50 dB. Again the algebraic sum of the meter reading and -50 dB is the noise reading.

MODULATION METER - Measures modulation, RF level, FM noise, or AM noise, depending on the function selected.

PEAK MOD THUMBWHEEL - Pre-sets, in 1% increments, the PEAK MODulation indicator to light at the indicated modulation setting. This circuit follows the modulation polarity set by the function switch.

CARRIER ALARM INDICATOR - Indicates when the carrier level falls below 90%.

PEAK MOD INDICATOR - Indicates when the modulation level equals or exceeds the level set by the PEAK MOD thumbwheel. This indicator follows the modulation polarity set by the function switch.

100% MOD INDICATOR - Indicates when the modulation level equals or exceeds 100%. This indicator follows the modulation polarity set by the function switch.

3-4 Transmitter Measurements

Normal transmitter proof-of-performance measurements may be made with the FMM-2. Distortion measurements may be made through the audio test jack on the rear of the chassis. Five volts RMS is available at 100% modulation so that most distortion analyzers may be used. The audio test output and the remote audio outputs are de-emphasized according to the standard 75 μsec curve, while the modulation meter has a flat frequency response characteristic which follows the pre-emphasized audio curve.

3-5 Field Changes and Modifications

If not performed by request at the time of manufacture, the following changes may be made in the field:

Audio De-emphasis

The FMM-2 standard de-emphasis curve (75 μsec) may be changed to 50 μsec de-emphasis moving jumpers P4 and P5 on the A2 board to the appropriate positions as shown in the *FMM-2 A2 Board Rev. A Connections & Adjustments* drawing in *Section 6*.

P4 controls the audio output de-emphasis and P5 controls the de-emphasis in the noise metering amplifier.

Frequency Change

Before starting, ensure that the RF/IF switch on the back of the unit is in the RF position.

1. Unplug crystal (Y1) on the A1 circuit board and plug in new crystal.

2. Unplug green lead from RF input pin (pin 4) on A1 circuit board.

3. Place FMM-2 into operation and depress the RF LEVEL switch.

4. Adjust the slug in the oscillator coil (L3) for maximum reading on meter (typically 20% - 60%). Note this reading.

5. Turn L3 slug counter-clockwise until meter reading just reaches a minimum value (typically 0% - 10%). Note this value.

6. Now turn L3 so meter reads at or just above the midpoint of the minimum and maximum values you noted above.

7. Reconnect the green wire to the RF input pin (pin 4).

If you are using the FMM-2 with the IF input (i.e. with an RFA-4 or an RFA-1A), remember to put the RF/IF switch back in the IF position.

4 Maintenance

4-1 Field Calibration Procedure

1. With the FMM-2 unplugged, make sure the meter is set at mechanical zero. Plug the unit in and warm up the FMM-2 in the ZERO mode for 15 minutes.

A2 Board

2. With the monitor in the ZERO mode, measure the width of the pulse seen at pin 7 of U6. With the *Pulse Width* potentiometer (R18), set the pulse width to 440 nsec.

3. Set an external low distortion FM signal generator to the assigned frequency and apply its output to the RF jack (J2). Adjust the generator output level for 100% indication in the RF LEVEL mode. Modulate the generator with 1 kHz at precisely 75 kHz peak deviation. Adjust the *Meter Balance* potentiometer (R72) so that the modulation meter indication in the SEMI mode does not change when switching between PLUS and MINUS positions.

4. Place the monitor in the SEMI mode and adjust the *Calibrate* potentiometer (R32) for 1.50 VRms on J4 or J5. Adjust the Meter Cal (R88) for 100% indication on the modulation meter.

5. Apply a 1 Vrms RF signal at precise carrier frequency to the RF jack (J2) on the rear panel. With the unit in the OPER mode, measure the DC voltage at pin 6 of U10. Adjust the *Offset* potentiometer (R34) for a reading of 0.0 volts (within 50 mv).

6. To adjust the fixed red 100% peak flasher, place the monitor in the CALibrate mode. Adjust the *100% Flasher Adjust* potentiometer (R107) so that the 100% LED just comes on.

7. To set the adjustable, yellow PEAK MOD flasher, set the thumbwheel switch to read "100" and place the monitor in the CALibrate mode. Adjust the *Peak Mod Flasher Adjust* potentiometer (R110) so that the PEAK MOD flasher just comes on.

8. Apply the 1 Vrms output of an FM generator set to carrier frequency to the RF jack. FM modulate the generator with 200 Hz audio to 100% FM modulation as indicated on the monitor in the OPER mode. Using an audio attenuator, reduce the FM modulation level of the generator 50 decibels. Switch the monitor to the FM NOISE position. Adjust the *FM Noise* potentiometer (R49) for a reading of 100% on the modulation meter.

9. Apply the output of an AM signal generator at carrier frequency to the RF input jack. Adjust the generator output level to obtain a reading of 100% on the meter in the RF LEVEL mode. Modulate the generator to 100% AM modulation with 200 Hz audio. Using an audio attenuator reduce the modulation level 50 decibels. Switch the monitor to the OPERate and AM NOISE modes and adjust the *AM Noise* potentiometer (R126) for a reading of 100% on the meter.

A1 Board

10. Apply an unmodulated RF signal at carrier frequency to the RF input jack (J2). Place the monitor in the RF LEVEL mode and adjust the generator output level for a reading of 90% on the monitor meter. Adjust the *Carrier Alarm* potentiometer (R18) on the RF board (A1) so that the front panel red CARRIER ALARM LED lights when the RF level indication goes below 90%.

5 Theory of Operation

5-1 FMM-2 A1 Board

Q1 is the active element of a crystal oscillator operating 650 kHz offset from the carrier frequency. It is activated by the application of -15 volts which occurs when the chassis switch is in the "RF" position. The oscillator output is coupled to the gate of Q2, a junction FET acting as an active mixer. Incoming RF is applied to the source of Q2, and the sum and difference mixer products appear at the drain. A pi output filter removes the upper product, leaving a 650 kilohertz modulated IF signal for application to the A2 board through the chassis input selector switch.

The input RF signal is also rectified by a high-frequency diode, filtered, and applied to non-inverting amplifier U1. The output of U1 thus consists of an amplitude modulated DC signal in which the ac component is proportional to the AM component of the carrier and a dc component proportional to the amplitude of the carrier. The output of U1 is connected through a series resistor to the A2 board where it is either applied directly to the chassis meter for RF LEVEL readings or ac coupled to the noise amplifier for AM NOISE readings. The series resistance controls meter damping in the RF LEVEL mode.

The output of U1 is also applied to the inverting input of comparator U2. When this voltage, corresponding to a relative carrier level, falls below the reference voltage set by the associated voltage divider and trimpot, the output of U2 goes high. This turns on Q3, lighting the CARRIER ALARM LED on the front panel. When the monitor is accepting IF inputs, -15V through the rear panel input switch biases pin 2 of U2 to a negative voltage, disabling the CARRIER ALARM function.

5-2 FMM-2 A2 Board

Discriminator. U34 supplies regulated +5V to U1, the input signal limiter and U5, the detecting monostable. Diode switching controls input signal selection. An IF input is selected in all operating modes except CALibrate and ZERO. In these two modes, the limiter is fed a 650 kHz signal from oscillator U3.

During normal operation, the monostable, U5, is triggered on negative transitions of the limiter. It generates an inverted output pulse of approximately 440 nsec duration which is applied to an inverting digital level translator, U6. Approximately +7.35 volts is supplied to U6 by regulator U8. The stream of positive-going output pulses is applied to the integrating filter through an emitter follower. The detected signal is inverted and amplified by differential amplifier U9. The average dc value of the pulse train is canceled in U9 by applying a positive voltage from U8 to the non-inverting input of U9. U9 drives a

phase equalizer and, in turn, non-inverting amplifier U10, which provides full level for the composite baseband output (the STEREO and SCA outputs on the rear panel).

In the CALibrate mode, U7, a digital oscillator circuit, alternately enables and disables the monostable with a 50% duty cycle at a 2395 Hz rate. With the 650 kHz signal from the oscillator U3 applied to the input of the monostable, this is equivalent to detecting a squarewave modulated signal of 650 kHz peak-to-peak deviation. An RC attenuation and wave-shaping circuit at the output of U10 reduces the amplitude of the detected calibration signal to that corresponding to a standard 75 kHz-deviation signal. The CALibrate switch not only selects the output of the wave-shaping circuit for the CALibrate function, but disables the phase equalizer, thus eliminating a precursor in the calibration wave form that would cause erroneous readings. The output of U10 selected by the CALibrate button feeds the STEREO and SCA output jacks through a 1 kΩ series resistor and a shunt analog switch. (See the *Muting Circuits* section that follows.)

In ZERO mode the discriminator is fed an unmodulated 650 kHz signal from the oscillator U3. (Diodes are employed on the main board to switch the discriminator between the IF and oscillator inputs.)

Output. U16 buffers the selected output of U10 and feeds the detected signal to the other output and metering circuitry. U17 is a non-inverting amplifier with a 75 microsecond de-emphasis characteristic which provides the AUDIO TEST output and two auxiliary high-impedance outputs. Inverting amplifier and non-inverting amplifier U18 provide a +10 dBm, 600Ω, balanced, and de-emphasized output for aural monitoring.

Metering. U14 drives non-inverting amplifier U19 and inverting amplifier U20A which feed the metering, flasher, and muting circuits. The outputs of U19 and U20A feed the metering and flasher circuits through 2.2 kΩ resistors. The PLUS and MINUS polarity switches select the appropriate signal polarity by shorting the resistor output corresponding to the opposite signal polarity to ground. U20B, U21A, and U21B, working in conjunction with U19 and U20A, comprise an active full-wave peak rectifying circuit. If the feedback paths of U20B and U21A were closed between the cathodes of their series output diodes and their inverting inputs, they would act as half-wave rectifiers. Since the feedback is from the combined outputs through U21B, the amplitude of the larger of the inputs to U20B and U21A appears at the output of U21B. Since U19 and U20A provide signals of equal amplitude and opposite polarity, the complete circuit acts as a full-wave rectifier. The output of U21B is applied to the chassis meter through a resistive divider, which controls meter damping, and the metering section of the front-panel switch assembly. A low - resistance R-C protection network (R84, R85 and C48) allows coupling of external meters to U21B as well. Meter ballistics in the SEMI-peak mode are controlled by an R-C network (C41, R94) at the U20B-U21A output. Decay of the DC peak is controlled by the 5.6 MΩ resistor which is grounded through the metering switch assembly in the SEMI-peak mode.

In PEAK mode, a sample-hold circuit is employed which stops the discharge of the metering capacitor for approximately 150 milliseconds each time a new peak is reached. When the higher voltage of the two outputs of U19 and U20A, (possibly controlled by the setting of the PLUS or MINUS switches) falls below the output voltage of U21B, the output of comparator U23 falls, triggering a non-retriggerable monostable in U24. The output of the monostable goes low for 150 milliseconds, turning Q4 off and breaking the discharge path through the 5.6 MΩ resistor to the metering capacitor. Once the 150 milliseconds passes, with Q4 now on, metering ballistics remain the same as those in SEMI-peak until the next peak is reached.

Flashers. The outputs of U19 and U20A are combined through diodes so that the more negative voltage of their two outputs (possibly controlled by the setting of the PLUS or MINUS switches) is applied to non-inverting buffer U27B. The output of U27B is applied to one input of U28, the comparator for the adjustable PEAK MODulation flasher, and one input of U29, the comparator for the 100% flasher. The trigger reference voltage for the PEAK MOD flasher is set by U26 and U27A, in conjunction with the thumbwheel switch. U26 provides a regulated +5V which is applied the inverting input of amplifier U27A through the variable resistance of the thumbwheel switch. As the dialed modulation percentage on the thumbwheel is increased, the series resistance of the thumbwheel switch assembly decreases. With decreased resistance, the gain of inverting amplifier U27A is increased, resulting in a more negative reference voltage applied to U28. When the modulation-induced negative excursion swings below the negative reference from U27A, the output of U28 goes low, triggering a retriggerable monostable in U30. The monostable turns on Q5, which lights the yellow PEAK MOD LED for approximately 3 seconds.

The negative trigger reference voltage for the 100% flasher is derived from an adjustable voltage divider fed from -5V regulator U25. This voltage is applied to the inverting input of U29. Again, when the modulation-induced negative excursion swings below this reference voltage, the output of U29 goes low, triggering a second retriggerable monostable in U30. This in turn, via Q6, lights the 100% LED for approximately 120 milliseconds.

Average Noise Metering. U31A, U31B, and U33 and associated circuitry comprise a de-emphasized, full-wave averaging voltmeter with 50 dB amplification for making FM and AM noise measurements. U31A is a de-emphasis amplifier with a low-frequency gain of approximately 26 dB. U31B and U33 are the active elements of a full-wave rectifying circuit with gain. The chassis meter is fed through a series resistance which controls meter damping. In the FM NOISE and AM NOISE positions, the front panel switches disconnect the chassis meter from the output of U21B and connect it to the output of U33. The input to U21A is appropriately switched to the output of U10 in the FM position or to the rectified

carrier (AM detected) output of the A1 RF-MIXER card in the AM position. Gains in the two modes are controlled by series trimmer resistors.

In the RF LEVEL position, the monitor remains in operation, but the chassis meter is connected directly to the rectified carrier output of the A1 RF MIXER card. The relative dc level of the carrier is thus registered.

Muting Circuits. Because of the large amplitude of the impulse voltages that occur during mode changes, a muting system is employed in the metering and output circuits. Muting is activated by peaks in the 240% to 260% modulation range. The outputs of U19 and U20A are combined ahead of the polarity switching resistors through diodes and applied to the inverting input of U22. When the more positive of their two outputs exceeds the threshold set by the voltage divider at the non-inverting input, the output of U22 goes low, firing a retriggerable monostable in U24. One output of this monostable remains high for a minimum of 270 milliseconds and performs two functions. The positive pulse is applied to the control gates of three analog switches in U15. Two of these switches are connected in parallel to ground and clamp the output of U14 to ground through a series resistance and the dc blocking capacitor. The third switch is connected between a series resistor in the composite baseband output circuit and ground and serves to greatly attenuate the composite baseband signal when activated by U24. The high at pin 6 of U24 also serves to turn on Q3, discharging the metering capacitor. At the same time, the $\overline{Q}$ output at pin 7 of U24 clears the sample-hold monostable, turning on Q4 and providing the additional 5.6 MΩ discharge path for the metering capacitor.

To prevent excessive positive excursions of extended duration from being passed to the output jacks (as would occur when the input signal is removed from the monitor in the OPERate mode), a second muting circuit is employed. The composite baseband output signal line, ahead of the series muting resistor, is applied to the non-inverting input of comparator U13. When the output voltage exceeds the reference voltage applied to the inverting input from a voltage divider, the output of U13 rises. This turns on an analog switch in U15, shunting most of the output signal to ground.

6 Diagrams, Schematics and Parts Lists

Replaceable Parts. This page contains information for ordering replaceable parts for the monitor. 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.*

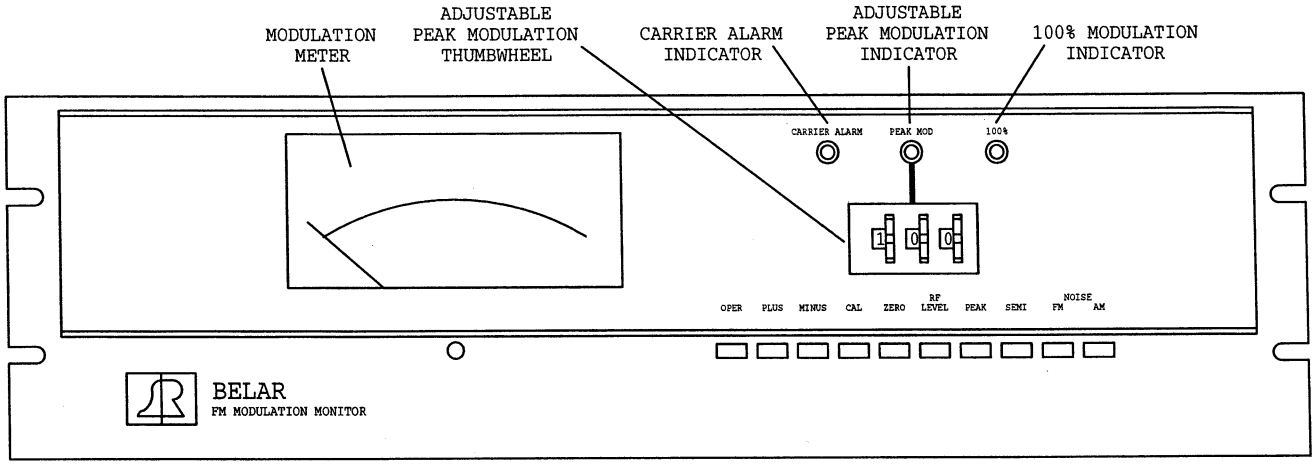
Orders may also be taken over the telephone. Parts orders can be put on your VISA, MasterCard, or American Express card, or we can ship them COD.

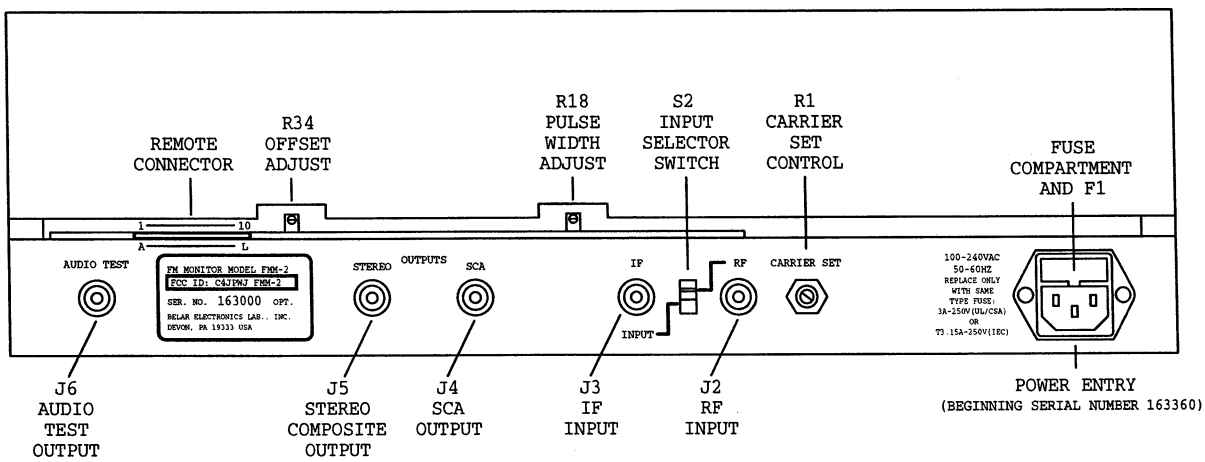
REFERENCE DESIGNATORS

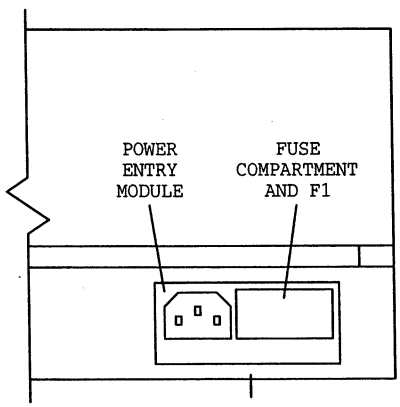
A	= assembly	J	= jack	S	= switch
BR	= diode bridge	L	= inductor	T	= transformer
C	= capacitor	M	= meter	TB	= terminal block
CR	= diode or LED	P	= plug	U	= integrated circuit
DS	= display or lamp	Q	= transistor	W	= cable
F	= fuse	R	= resistor	X	= socket
FL	= filter	RL	= relay	Y	= crystal
HDR	= header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

ABBREVIATIONS

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







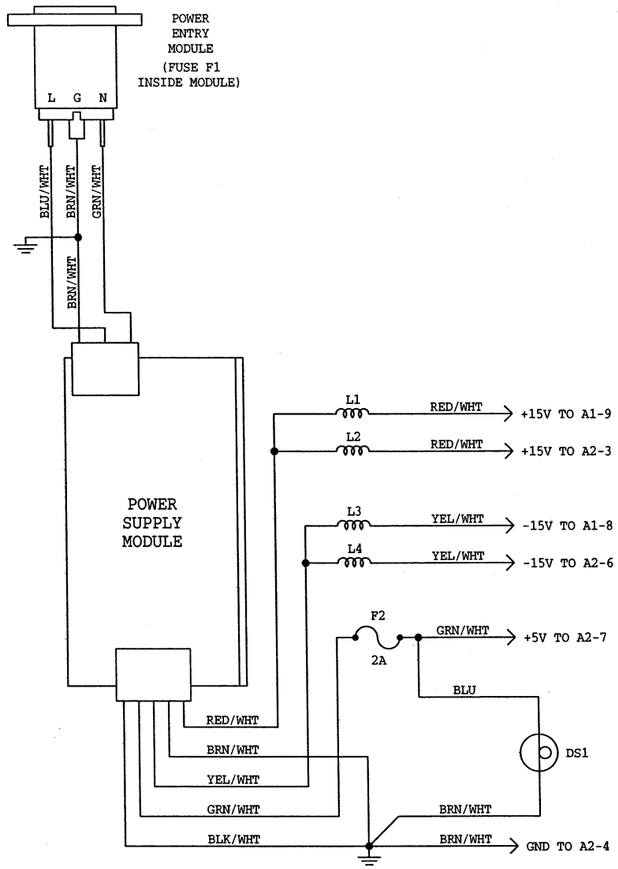
FMM-2 FRONT AND REAR VIEW
BELAR ELECTRONICS
10-8-02

FMM-2 PARTS LISTS

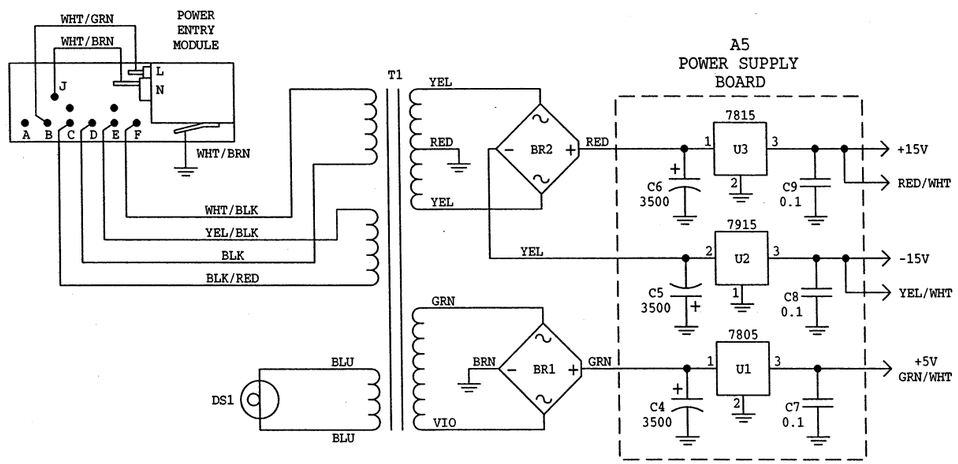
MAIN CHASSIS

Reference Designation	Description		Part Number
A3	POWER SUPPLY MODULE: 15W	(Note 6)	4005-0019A
BR1,BR2	DIODE: BRIDGE KBPC602 GI	(Note 3)	1900-0025
C1,C2	C: FIXED CERAMIC 0.01uF 1.4kV	(Note 2)	0151-0010
C3	C: FIXED MICA 100pF 5%		0140-1015
C4 thru C6	C: FIXED ELECT 1000uF 50V	(Note 1)	0180-0002
C4 thru C6	C: FIXED ELECT 3500uF 40V	(Note 4)	0180-0026
C7 thru C9	C: FIXED CERAMIC 0.1uF 50V	(Note 4)	0151-0006
C10 thru C12	C: FIXED CERAMIC 1.0uF 50V	(Note 6)	0151-0008
CR1,CR3	LED: RED MV5053		1910-0001
CR2	LED: YELLOW MV5353		1910-0002
DS1	LAMP: 755		2140-0005
--	SOCKET: LAMP		1450-0012
F1	FUSE: AGC 1/2A 250V	(Note 2)	2110-0001
--	FUSEHOLDER: REAR PANEL MOUNT	(Note 2)	2110-0003
F1	FUSE: GMA-3A 250V(UL/CSA) or T3.15A-250V(IEC)	(Note 5)	2110-0009
F2	FUSE: AGC-2A 250V	(Note 6)	2110-0006
--	FUSE HOLDER: CHASSIS MOUNT	(Note 6)	2110-0010
J1	JACK: POWER	(Note 2)	0360-0010
J1	JACK: POWER 6J4	(Note 5)	0360-0020
J1	POWER ENTRY MODULE: 6EGG1-1	(Note 6)	0360-0021
J2 thru J6	JACK: BNC		0360-0005
L1 thru L4	CHOKE: RF	(Note 6)	9140-0011
M1	METER: MOD 0-133%		1120-0012
R1	R: VAR COMP 100 ohm 2W		2100-0010
R2	R: METAL FILM 100 ohm 2% 1W		0791-1012
S1	SWITCH: SLIDE 115/230V SELECTOR	(Note 2)	3102-0002
S2	SWITCH: SLIDE IF/RF SELECTOR		3102-0001
S3	SWITCH ASSY: 3 DIGIT BCD THUMBWHEEL		3103-0002A
T1	TRANSFORMER: POWER	(Note 3)	9100-0010
U1	IC: 7805C	(Note 3)	1826-0014
U2	IC: 7915C	(Note 3)	1826-0033
U3	IC: 7815C	(Note 3)	1826-0031
--	LINE CORD (115 Vac line voltage)		8120-0002
--	LINE CORD (230 Vac line voltage)		8120-0004
--	CONNECTOR: CARD EDGE, 20 PIN (CINCH 50-20SN-9 or equivalent)		0365-0023

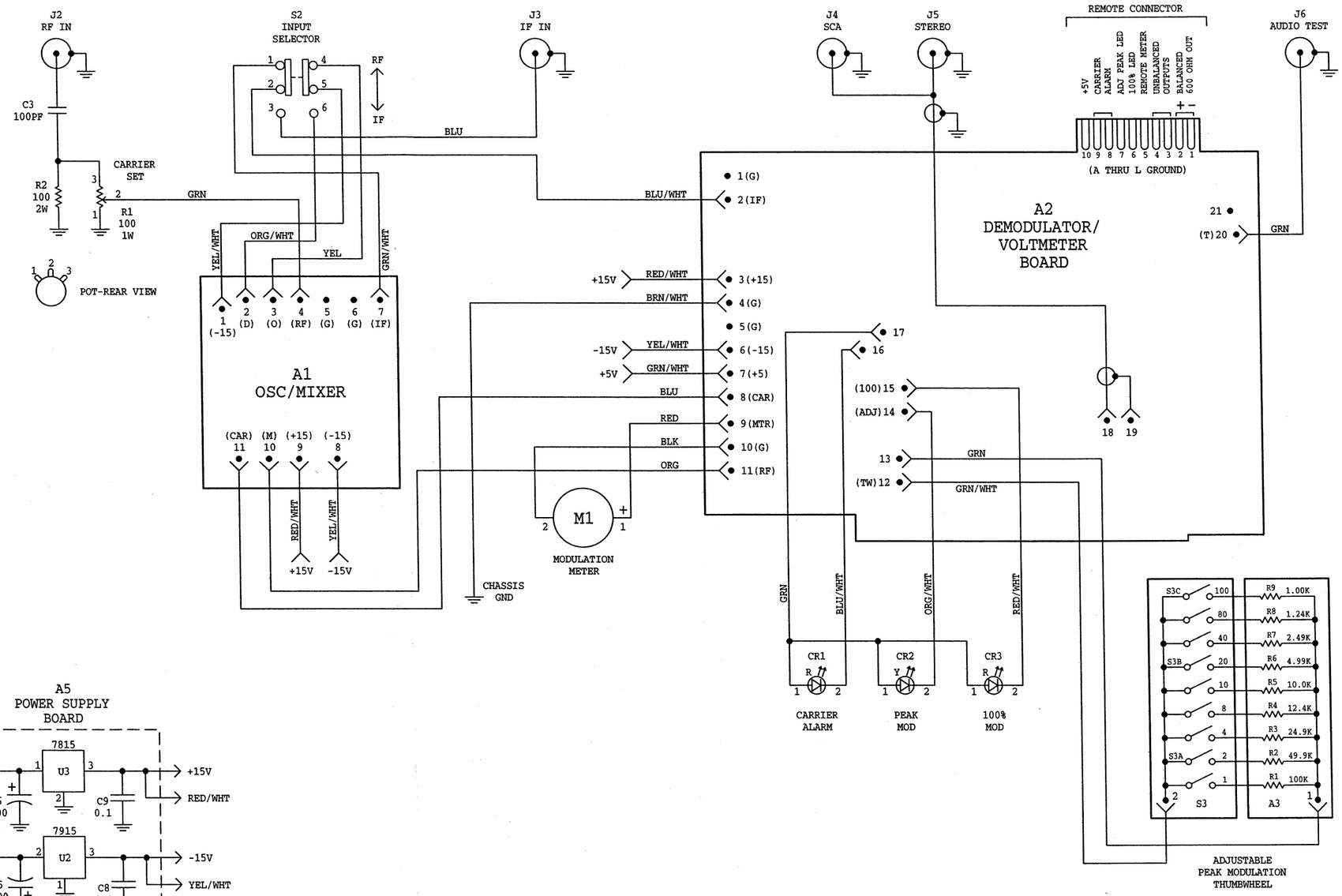
Note 1: Used serial numbers 161001 to 161258.
Note 2: Used serial numbers 161001 to 161719.
Note 3: Used serial numbers 161001 to 163359.
Note 4: Used serial numbers 161259 to 163359.
Note 5: Used serial numbers 161720 to 163359.
Note 6: Used beginning serial number 163360.



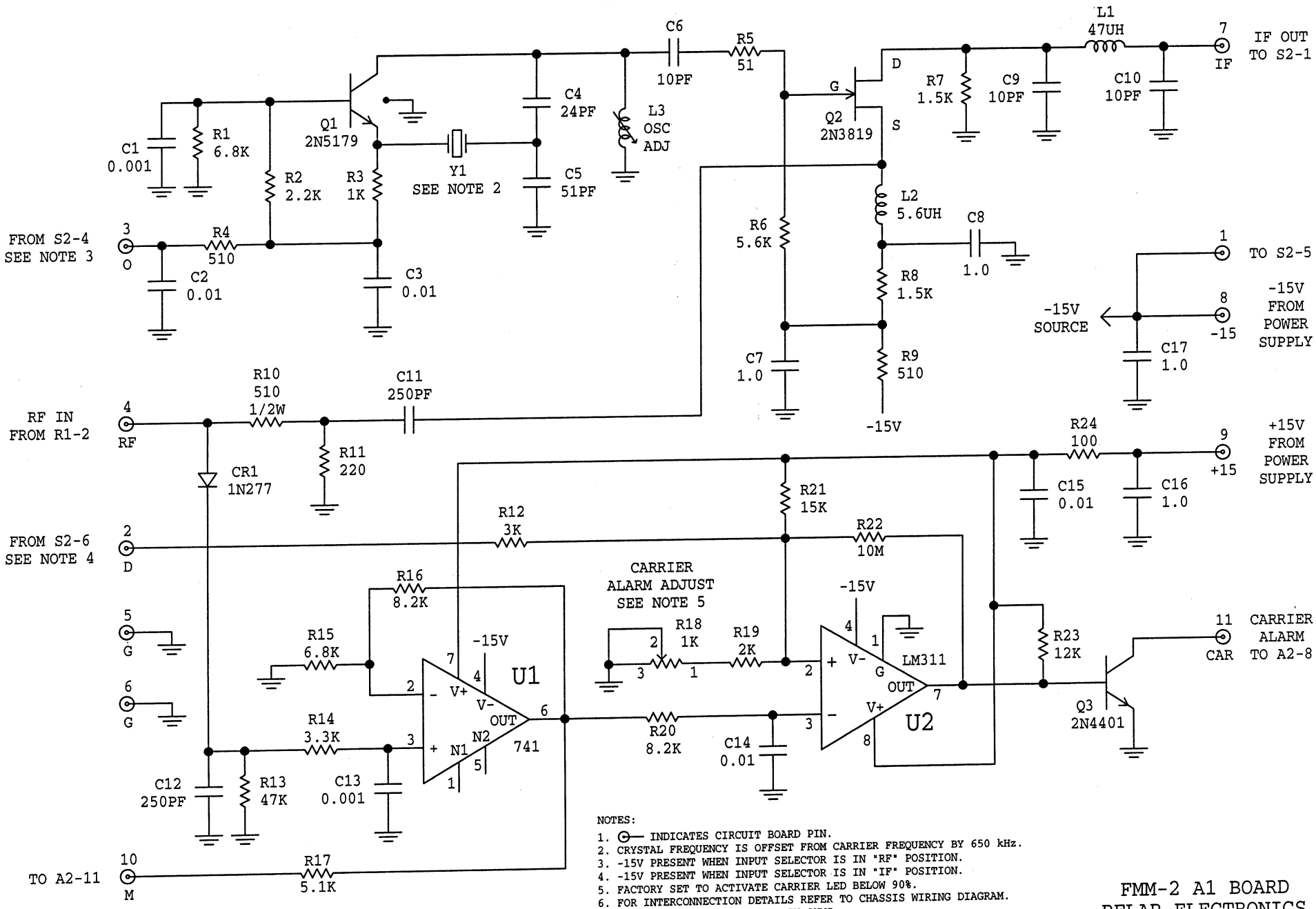
POWER SUPPLY CONFIGURATION-BEGINNING SERIAL NUMBER 163360



POWER SUPPLY CONFIGURATION-SERIAL NUMBERS 161720 TO 163359



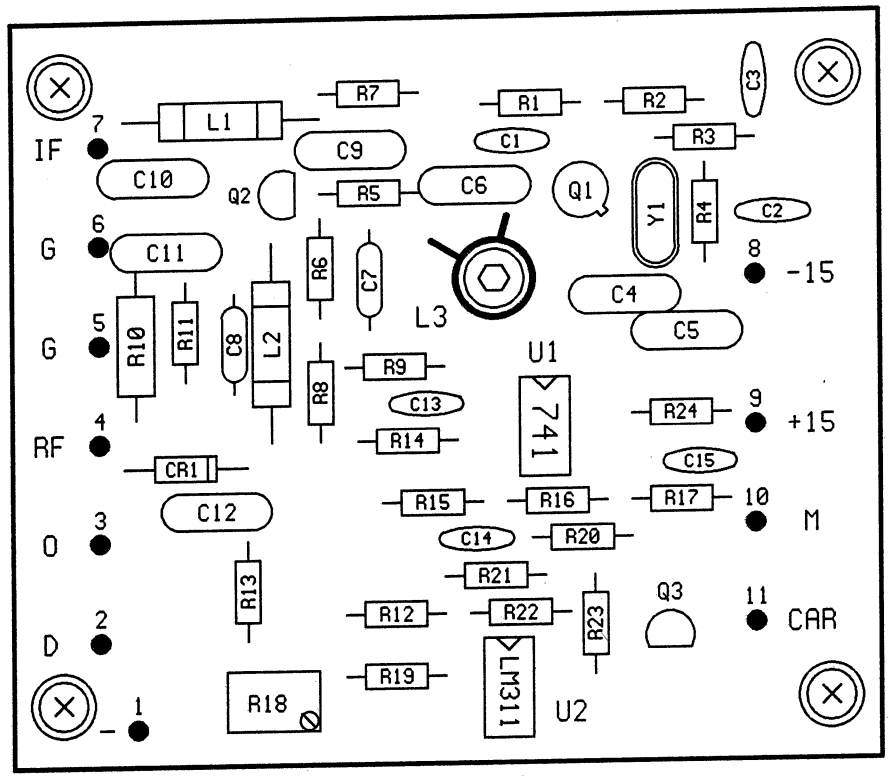
FMM-2 CHASSIS WIRING
BELAR ELECTRONICS
10-8-02



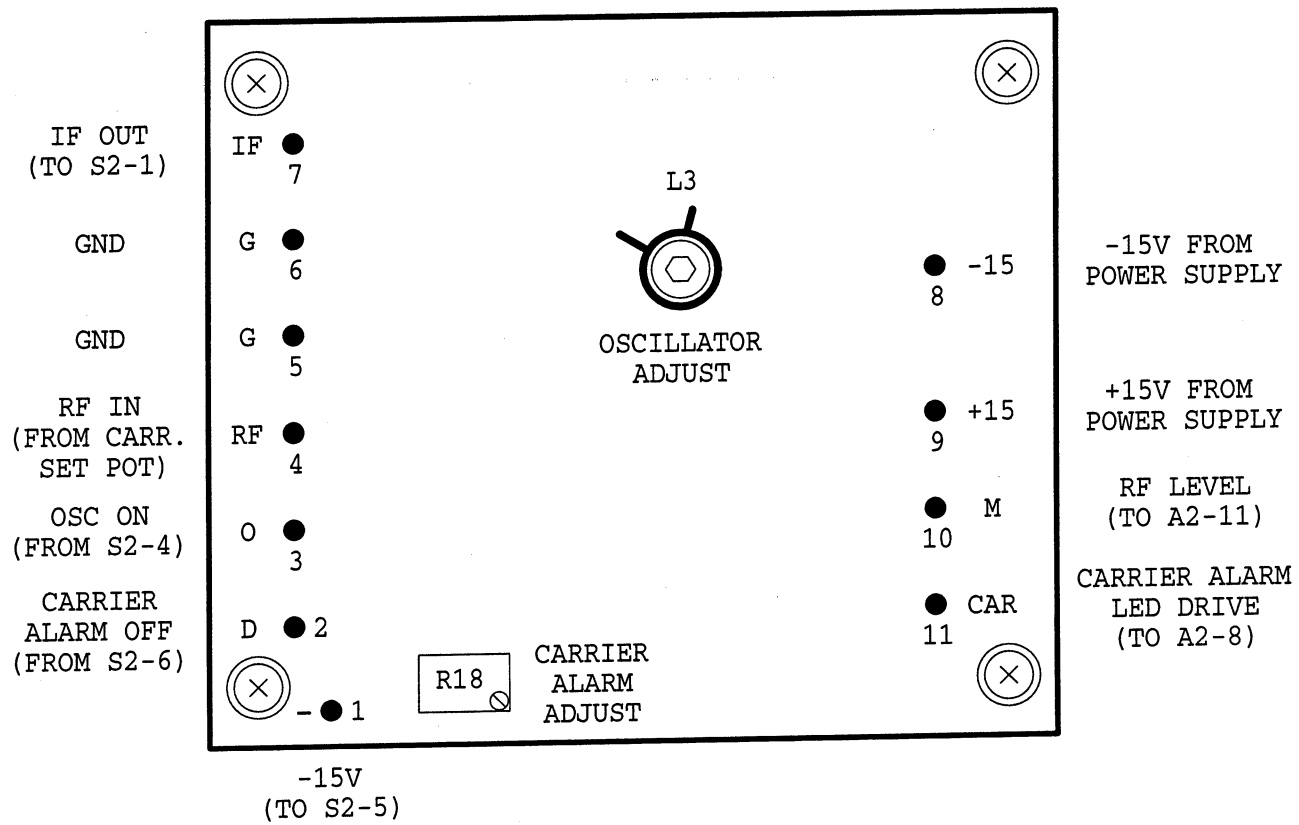
NOTES:

1. ⊙— INDICATES CIRCUIT BOARD PIN.
2. CRYSTAL FREQUENCY IS OFFSET FROM CARRIER FREQUENCY BY 650 kHz.
3. -15V PRESENT WHEN INPUT SELECTOR IS IN "RF" POSITION.
4. -15V PRESENT WHEN INPUT SELECTOR IS IN "IF" POSITION.
5. FACTORY SET TO ACTIVATE CARRIER LED BELOW 90%.
6. FOR INTERCONNECTION DETAILS REFER TO CHASSIS WIRING DIAGRAM.
7. ALL RESISTANCE VALUES ARE IN OHMS.
8. ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE INDICATED.
9. ALL CAPACITANCE VALUES ARE IN UF UNLESS OTHERWISE SPECIFIED.

FMM-2 A1 BOARD
BELAR ELECTRONICS
10-8-02



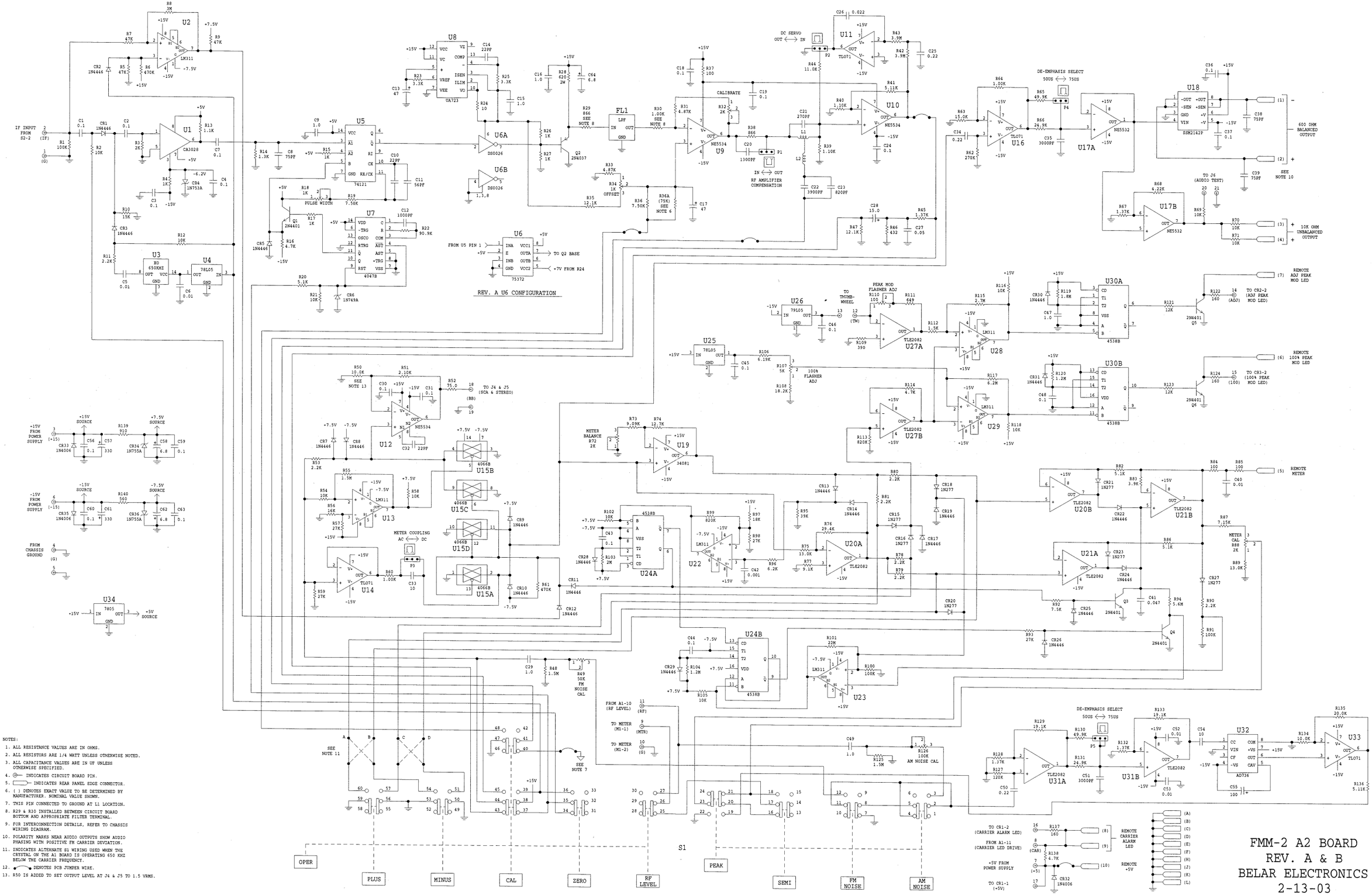
FMM-2 A1 BOARD
COMPONENT LAYOUT
BELAR ELECTRONICS



FMM-2 A1 BOARD
CONNECTIONS & ADJUSTMENTS
BELAR ELECTRONICS

A1 BOARD FMM-2

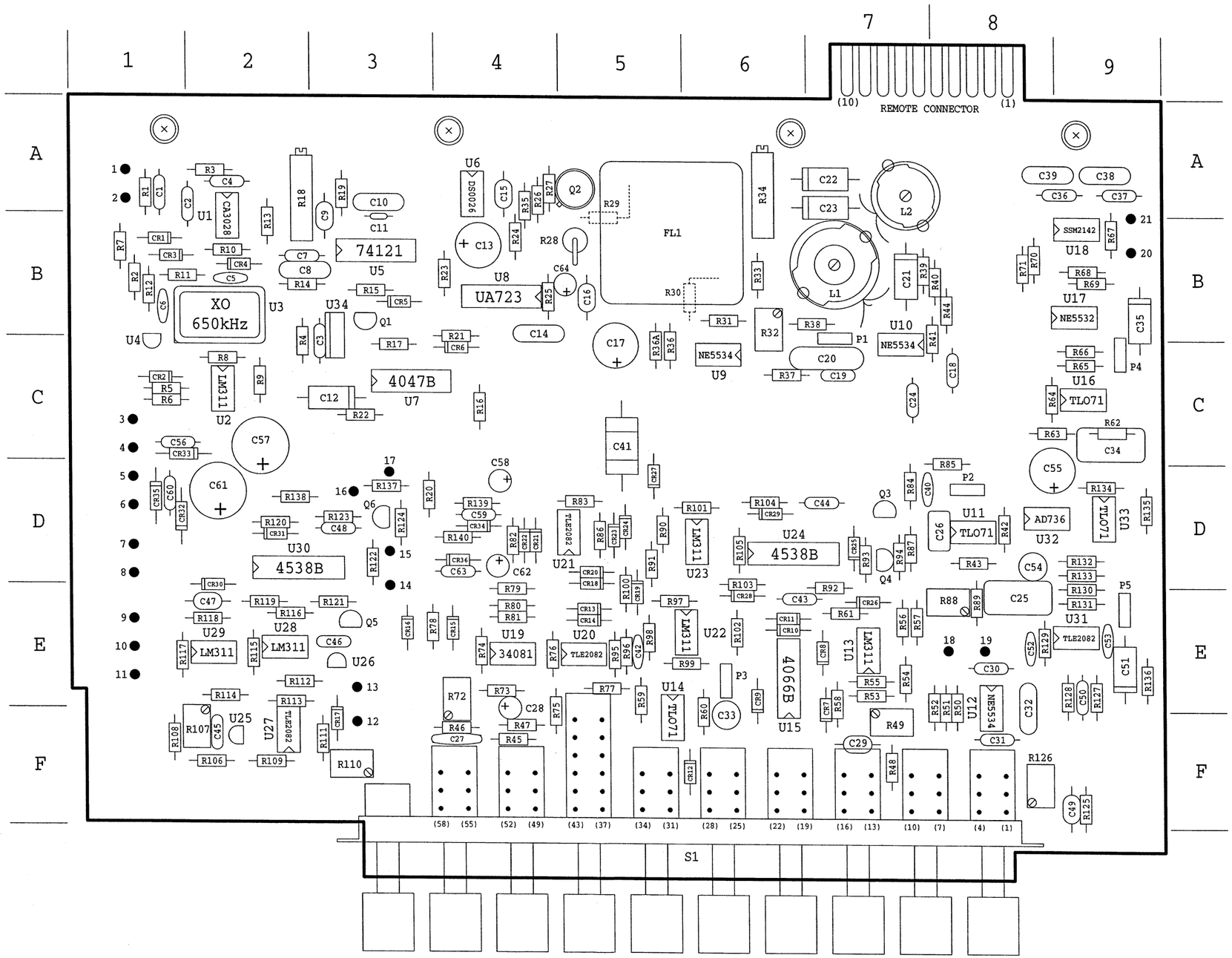
Reference Designation	Description	Part Number
C1	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C2,C3	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C4	C: FIXED MICA 24pF 5%	0140-2405
C5	C: FIXED MICA 51pF 5%	0140-5105
C6	C: FIXED MICA 10pF 5%	0140-1005
C7,C8	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C9,C10	C: FIXED MICA 10pF 5%	0140-1005
C11,C12	C: FIXED MICA 250pF 5%	0140-2515
C13	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C14,C15	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C16,C17*	C: FIXED CERAMIC 1.0uF 50V (*C16 and C17 are on pc bottom)	0151-0008
CR1	DIODE: 1N277 GERMANIUM	1900-0001
L1	CHOKE: 47uH	9140-0003
L2	CHOKE: 5.6uH	9140-0004
L3	COIL: ADJ, BELAR	9140-0025
Q1	TRANSISTOR: 2N5179	1850-0023
Q2	TRANSISTOR: 2N3819	1850-0001
Q3	TRANSISTOR: 2N4401	1850-0028
R1	R: METAL FILM 6.8k 2% 1/4W	0751-6822
R2	R: METAL FILM 2.2k 2% 1/4W	0751-2222
R3	R: METAL FILM 1k 2% 1/4W	0751-1022
R4	R: METAL FILM 510 2% 1/4W	0751-5112
R5	R: METAL FILM 51 2% 1/4W	0751-5102
R6	R: METAL FILM 5.6k 2% 1/4W	0751-5622
R7,R8	R: METAL FILM 1.5k 2% 1/4W	0751-1522
R9,R10	R: METAL FILM 510 2% 1/4W	0751-5112
R11	R: METAL FILM 220 2% 1/4W	0751-2212
R12	R: METAL FILM 3k 2% 1/4W	0751-3022
R13	R: METAL FILM 47k 2% 1/4W	0751-4732
R14	R: METAL FILM 3.3k 2% 1/4W	0751-3322
R15	R: METAL FILM 6.8k 2% 1/4W	0751-6822
R16	R: METAL FILM 8.2k 2% 1/4W	0751-8222
R17	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R18	R: VAR COMP 1k 10 TURN	2100-0021
R19	R: METAL FILM 2k 2% 1/4W	0751-2022
R20	R: METAL FILM 8.2k 2% 1/4W	0751-8222
R21	R: METAL FILM 15k 2% 1/4W	0751-1532
R22	R: FIXED CARBON 10M 5% 1/4W	0683-1065
R23	R: METAL FILM 12k 2% 1/4W	0751-1232
R24	R: METAL FILM 100 2% 1/4W	0751-1012
U1	IC: MC1741	1826-0006
U2	IC: LM311	1826-0009
Y1	CRYSTAL: OFFSET 650kHz FROM CARRIER FREQUENCY	



NOTES:

1. ALL RESISTANCE VALUES ARE IN OHMS.
2. ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE NOTED.
3. ALL CAPACITANCE VALUES ARE IN UF UNLESS OTHERWISE SPECIFIED.
4. ⊖ INDICATES CIRCUIT BOARD PIN.
5. ▭ INDICATES REAR PANEL EDGE CONNECTOR.
6. ( ) DENOTES EXACT VALUE TO BE DETERMINED BY MANUFACTURER. NOMINAL VALUE SHOWN.
7. TP15 PIN CONNECTED TO GROUND AT L1 LOCATION.
8. R29 & R30 INSTALLED BETWEEN CIRCUIT BOARD BOTTOM AND APPROPRIATE FILTER TERMINAL.
9. FOR INTERCONNECTION DETAILS, REFER TO CHASSIS WIRING DIAGRAM.
10. POLARITY MARKS NEAR AUDIO OUTPUTS SHOW AUDIO PHASING WITH POSITIVE FM CARRIER DEVIATION.
11. INDICATES ALTERNATE S1 WIRING USED WHEN THE CRYSTAL ON THE A1 BOARD IS OPERATING 650 KHZ BELOW THE CARRIER FREQUENCY.
12. ⌒ DENOTES PCB JUMPER WIRE.
13. R50 IS ADDED TO SET OUTPUT LEVEL AT J4 & J5 TO 1.5 VRMS.

FMM-2 A2 BOARD
REV. A & B
BELAR ELECTRONICS
2-13-03



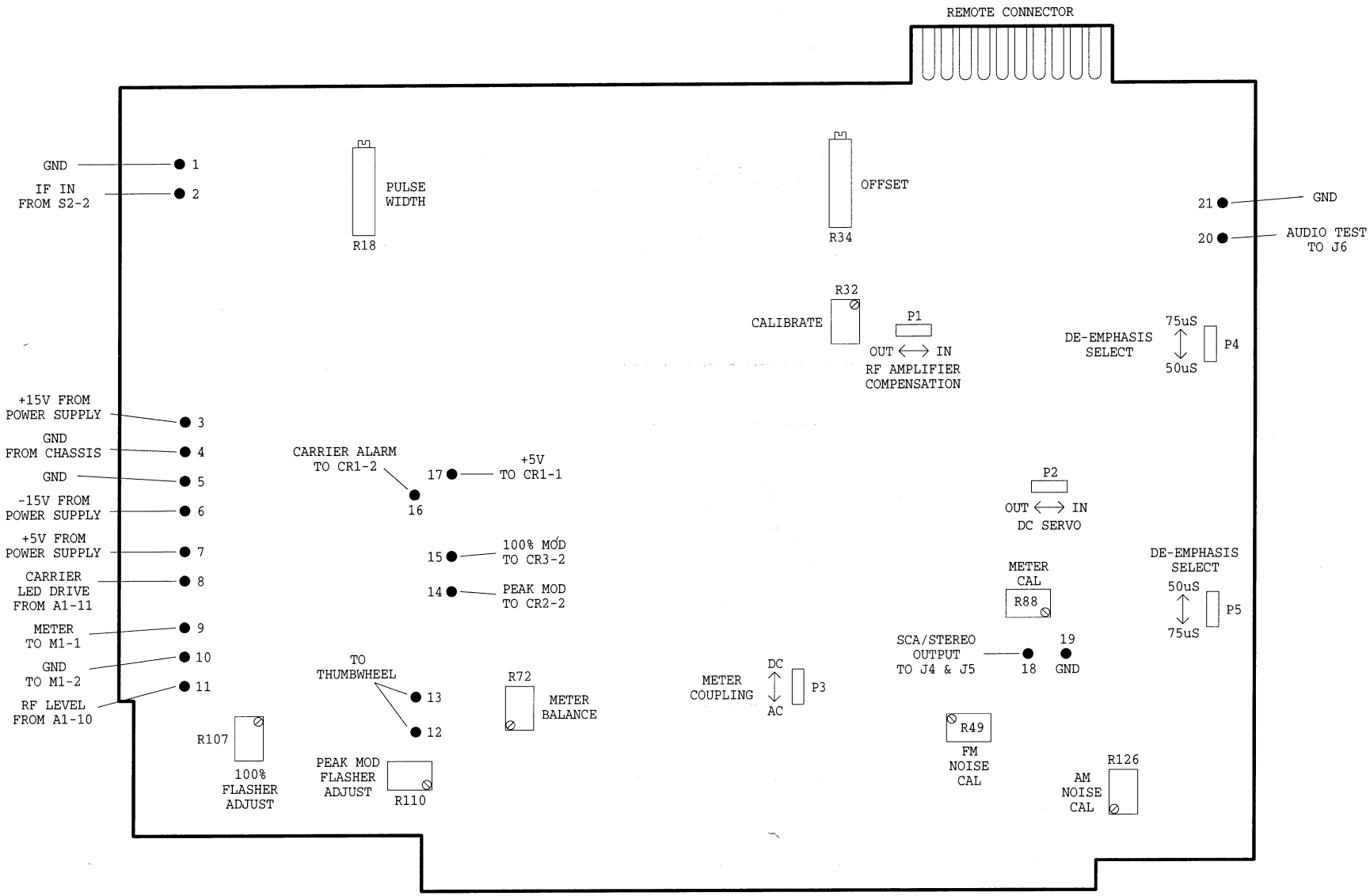
ON REV. A BOARDS, C64 IS ON THE BOTTOM OF THE PCB AND U6 IS A 75372 IC.

FMM-2 A2 BOARD
REV. A & B
COMPONENT LAYOUT
BELAR ELECTRONICS

FMM-2 A2 BOARD, REV. A & B
PART LOCATIONS

Desig/Loc		Desig/Loc		Desig/Loc		Desig/Loc		Desig/Loc		Desig/Loc		Desig/Loc	
C1	A1	C49	F9	CR32	D1	R25	B4	R72	E4	R120	D2	U25	F2
C2	A2	C50	E9	CR33	C1	R26	A4	R73	E4	R121	E3	U26	E3
C3	C3	C51	E9	CR34	D4	R27	A4	R74	E4	R122	D3	U27	F2
C4	A2	C52	E8	CR35	D1	R28	B5	R75	F4	R123	D3	U28	E2
C5	B2	C53	E9	CR36	D4	~R29	B5	R76	E4	R124	D3	U29	E2
C6	B1	C54	D8			~R30	B6	R77	E5	R125	F9	U30	D2
C7	B2	C55	D8	FL1	B5	R31	B6	R78	E3	R126	F8	U31	E9
C8	B2	C56	C1			R32	B6	R79	E4	R127	E9	U32	D8
C9	B3	C57	C2	L1	B7	R33	B6	R80	E4	R128	E9	U33	D9
C10	A3	C58	D4	L2	A7	R34	A6	R81	E4	R129	E8	U34	B3
C11	B3	C59	D4			R35	A4	R82	D4	R130	E9		
C12	C3	C60	D1	P1	B7	R36	C5	R83	D5	R131	E9	pins	
C13	B4	C61	D2	P2	D8	R36A	C5	R84	D7	R132	D9	1	A1
C14	B4	C62	D4	P3	E6	R37	C6	R85	C8	R133	D9	2	A1
C15	A4	C63	D4	P4	C9	R38	B7	R86	D5	R134	D9	3	C1
C16	B5	*C64	B5	P5	E9	R39	B7	R87	D7	R135	D9	4	C1
C17	C5					R40	B8	R88	E8	R136	E9	5	D1
C18	C8	CR1	B1	Q1	B3	R41	B8	R89	E8	R137	D3	6	D1
C19	C7	CR2	C1	Q2	A5	R42	D8	R90	D5	R138	D2	7	D1
C20	C7	CR3	B1	Q3	D7	R43	D8	R91	D5	R139	D4	8	D1
C21	B7	CR4	B2	Q4	D7	R44	B8	R92	E7	R140	D4	9	E1
C22	A7	CR5	B3	Q5	E3	R45	F4	R93	D7			10	E1
C23	A7	CR6	C4	Q6	D3	R46	F4	R94	D7	S1	F5	11	E1
C24	C7	CR7	E7			R47	F4	R95	E5			12	F3
C25	E8	CR8	E7	R1	A1	R48	F7	R96	E5	U1	B2	13	E3
C26	D8	CR9	E6	R2	B1	R49	F7	R97	E5	U2	C2	14	E3
C27	F4	CR10	E6	R3	A2	R50	E8	R98	E5	U3	B2	15	D3
C28	E4	CR11	E6	R4	C2	R51	E8	R99	E6	U4	C1	16	D3
C29	F7	CR12	F6	R5	C1	R52	E8	R100	E5	U5	B3	17	D3
C30	E8	CR13	E5	R6	C1	R53	E7	R101	D6	U6	A4	18	E8
C31	F8	CR14	E5	R7	B1	R54	E7	R102	E6	U7	C3	19	E8
C32	E8	CR15	E4	R8	C2	R55	E7	R103	D6	U8	B4	20	B9
C33	F6	CR16	E3	R9	C2	R56	E7	R104	D6	U9	C6	21	B9
C34	C9	CR17	F3	R10	B2	R57	E7	R105	D6	U10	C7		
C35	B9	CR18	D5	R11	B1	R58	E7	R106	F2	U11	D8		
C36	A9	CR19	E5	R12	B1	R59	E5	R107	F2	U12	E8		
C37	A9	CR20	D5	R13	B2	R60	F6	R108	F1	U13	E7		
C38	A9	CR21	D4	R14	B2	R61	E7	R109	F2	U14	F5		
C39	A8	CR22	D4	R15	B3	R62	C9	R110	F3	U15	E6		
C40	D7	CR23	D5	R16	C4	R63	C8	R111	F3	U16	C9		
C41	C5	CR24	D5	R17	C3	R64	C8	R112	E2	U17	B9		
C42	E5	CR25	D7	R18	A2	R65	C9	R113	E2	U18	B9		
C43	E6	CR26	E7	R19	A3	R66	C9	R114	E2	U19	E4		
C44	D7	CR27	D5	R20	D3	R67	B9	R115	E2	U20	E5		
C45	F2	CR28	E6	R21	B4	R68	B9	R116	E2	U21	D5		
C46	E3	CR29	D6	R22	C3	R69	B9	R117	E1	U22	E6		
C47	E2	CR30	E2	R23	B4	R70	B8	R118	E2	U23	D6		
C48	D3	CR31	D2	R24	B4	R71	B8	R119	E2	U24	D6		

* C64 IS ON PC BOTTOM ON REV. A BOARDS.
~ R29 AND R30 ARE ON PC BOTTOM.



FMM-2 A2 BOARD
REV. A & B
CONNECTIONS & ADJUSTMENTS
BELAR ELECTRONICS

A2 BOARD FMM-2 Rev. A & B

Reference Designation	Description	Part Number
C1 thru C4	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C5,C6	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C7	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C8	C: FIXED MICA 75pF 5%	0140-7505
C9	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C10	C: FIXED MICA 22pF 5%	0140-2205
C11	C: FIXED CERAMIC 56pF 100V N750	0155-0005
C12	C: FIXED POLY 1000pF 2.5% 160V	0130-1022
C13	C: FIXED ELEC 47uF 50V	0180-0017
C14	C: FIXED MICA 22pF 5%	0140-2205
C15,C16	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C17	C: FIXED ELEC 47uF 50V	0180-0017
C18	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C19	C: FIXED CERAMIC 0.1uF 50V	0151-0015
C20	C: FIXED MICA 1300pF 1%	0141-1321
C21	C: FIXED POLY 270pF 2.5% 160V	0130-2712
C22	C: FIXED POLY 3900pF 2.5% 160V	0130-3922
C23	C: FIXED POLY 820pF 2.5% 160V	0130-8212
C24	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C25	C: FIXED POLY 0.22uF 10% 100V	0122-2241
C26	C: FIXED POLY 0.022uF 10% 100V	0122-2231
C27	C: FIXED CERAMIC 0.05uF 75V	0151-0005
C28	C: FIXED TANT 15uF 15V	0185-0003
C29	C: FIXED CERAMIC 1.0uF 50V	0151-0016
C30,C31	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C32	C: FIXED MICA 22pF 5%	0140-2205
C33	C: FIXED ELEC 10uF 35V NON-POLAR	0180-0029
C34	C: FIXED POLY 0.22uF 10% 100V	0122-2241
C35	C: FIXED POLY 3000pF 2.5% 160V	0130-3022
C36,C37	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C38,C39	C: FIXED MICA 75pF 5%	0140-7505
C40	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C41	C: FIXED FILM 0.047uF 10% 200V	0120-4731
C42	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
C43,C44	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C45,C46	C: FIXED CERAMIC 0.1uF 50V	0151-0015
C47	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C48	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C49	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C50	C: FIXED CERAMIC 0.22uF 50V	0151-0007
C51	C: FIXED POLY 3000pF 2.5% 160V	0130-3022
C52,C53	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C54	C: FIXED ELEC 10uF 35V NON-POLAR	0180-0029
C55	C: FIXED ELEC 100uF 35V	0180-0018
C56	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C57	C: FIXED ELEC 330uF 20V	0180-0022
C58	C: FIXED TANT 6.8uF 25V	0185-0002
C59,C60	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C61	C: FIXED ELEC 330uF 20V	0180-0022
C62	C: FIXED TANT 6.8uF 25V	0185-0002
C63	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C64*	C: FIXED TANT 6.8uF 25V	0185-0002

(*Note: On Rev. A boards, C64 is on PC bottom.)

A2 BOARD FMM-2 Rev. A & B cont.

Reference Designation	Description	Part Number
CR1 thru CR3	DIODE: 1N4446	1900-0002
CR4	DIODE: IN753A	1900-0006
CR5	DIODE: 1N4446	1900-0002
CR6	DIODE: IN749A	1900-0018
CR7 thru CR14	DIODE: 1N4446	1900-0002
CR15,CR16	DIODE: 1N277 GERMANIUM	1900-0001
CR17	DIODE: 1N4446	1900-0002
CR18	DIODE: 1N277 GERMANIUM	1900-0001
CR19	DIODE: 1N4446	1900-0002
CR20,CR21	DIODE: 1N277 GERMANIUM	1900-0001
CR22	DIODE: 1N4446	1900-0002
CR23	DIODE: 1N277 GERMANIUM	1900-0001
CR24 thru CR26	DIODE: 1N4446	1900-0002
CR27	DIODE: 1N277 GERMANIUM	1900-0001
CR28 thru CR31	DIODE: 1N4446	1900-0002
CR32,CR33	DIODE: 1N4006	1900-0016
CR34	DIODE: 1N755A	1900-0023
CR35	DIODE: 1N4006	1900-0016
CR36	DIODE: 1N755A	1900-0023
P1 thru P5	PLUG: 3 PIN, PC MOUNT	0365-0030
--	JUMPER: 2 POSITION (USED WITH P1 thru P5)	0365-0028
FL1	FILTER: BELAR LPF	9120-0009
L1	INDUCTOR: BELAR	9140-0039
L2	INDUCTOR: BELAR	9140-0038
Q1	TRANSISTOR: 2N4401	1850-0028
Q2	TRANSISTOR: 2N4037	1850-0011
Q4 thru Q6	TRANSISTOR: 2N4401	1850-0028
R1	R: METAL FILM 100k 2% 1/4W	0751-1042
R2	R: METAL FILM 10k 2% 1/4W	0751-1032
R3	R: METAL FILM 2k 2% 1/4W	0751-2022
R4	R: METAL FILM 1k 2% 1/4W	0751-1022
R5	R: METAL FILM 47k 2% 1/4W	0751-4732
R6	R: METAL FILM 470k 2% 1/4W	0751-4742
R7	R: METAL FILM 47k 2% 1/4W	0751-4732
R8	R: FIXED CARBON 3M 5% 1/4W	0683-3055
R9	R: METAL FILM 47k 2% 1/4W	0751-4732
R10	R: METAL FILM 15k 2% 1/4W	0751-1532
R11	R: METAL FILM 2.2k 2% 1/4W	0751-2222
R12	R: METAL FILM 10k 2% 1/4W	0751-1032
R13	R: METAL FILM 1.1k 2% 1/4W	0751-1122
R14	R: METAL FILM 1.3k 2% 1/4W	0751-1322
R15	R: METAL FILM 1k 2% 1/4W	0751-1022
R16	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R17	R: METAL FILM 1k 2% 1/4W	0751-1022
R18	R: VAR COMP 1k, 10 TURN	2100-0023
R19	R: METAL FILM 7.50k 1%	0721-7501

A2 BOARD FMM-2 Rev. A & B cont.

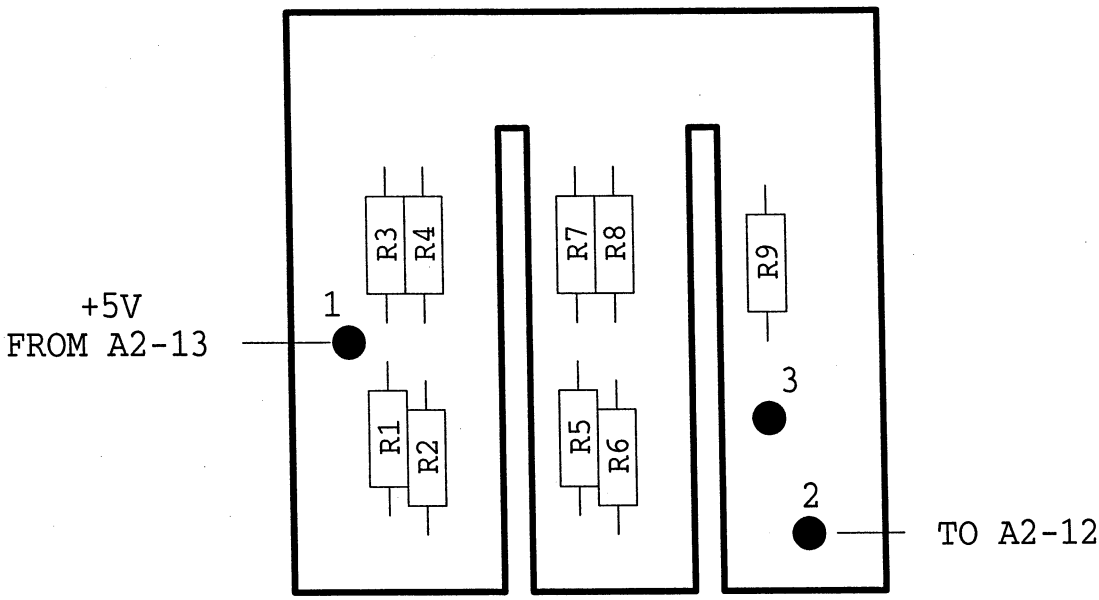
Reference Designation	Description	Part Number
R20	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R21	R: METAL FILM 10k 2% 1/4W	0751-1032
R22	R: METAL FILM 90.9k 1%	0721-9092
R23	R: METAL FILM 3.3k 2% 1/4W	0751-3322
R24	R: METAL FILM 10 2% 1/4W	0751-1002
R25	R: METAL FILM 3.3k 2% 1/4W	0751-3322
R26,R27	R: METAL FILM 1k 2% 1/4W	0751-1022
R28	R: WIRE WOUND 620 5% 2W	0811-0012
R29*	R: METAL FILM 866 1%	0721-8660
R30*	R: METAL FILM 1.00k 1%	0721-1001
	(*Note: R29 & R30 are on PC bottom.)	
R31	R: METAL FILM 4.87k 1%	0721-4871
R32	R: VAR COMP 2k, 10 TURN	2100-0031
R33	R: METAL FILM 3.92k 1% (Rev. A)	0721-3921
	R: METAL FILM 4.87k 1% (Rev. B)	0721-4871
R34	R: VAR COMP 1k, 10 TURN	2100-0023
R35	R: METAL FILM 12.7k 1% (Rev. A)	0721-1272
	R: METAL FILM 12.1k 1% (Rev. B)	0721-1212
R36	R: METAL FILM 7.50k 1%	0721-7501
R36A*	R: METAL FILM 75k 2% 1/4W	0751-7532
	(*Note: R36A is factory select, nominal value shown.)	
R37	R: METAL FILM 100 2% 1/4W	0751-1012
R38	R: METAL FILM 866 1%	0721-8660
R39,R40	R: METAL FILM 1.10k 1%	0721-1101
R41	R: METAL FILM 5.11k 1%	0721-5111
R42,R43	R: FIXED CARBON 3.9M 5% 1/4W	0683-3955
R44	R: METAL FILM 11.0k 1%	0721-1102
R45	R: METAL FILM 1.37k 1%	0721-1371
R46	R: METAL FILM 432 1%	0721-4320
R47	R: METAL FILM 12.1k 1%	0721-1212
R48	R: FIXED CARBON 1.5M 5% 1/4W	0683-1555
R49	R: VAR COMP 50k, 10 TURN	2100-0025
R50*	R: METAL FILM 10.0k 1%	0721-1002
	(*Note: R50 is used to set output at J4 & J5 to 1.5 Vrms.)	
R51	R: METAL FILM 2.10k 1%	0721-2101
R52	R: METAL FILM 75.0 1%	0721-75R0
R53	R: METAL FILM 2.2k 2% 1/4W	0751-2222
R54	R: METAL FILM 10k 2% 1/4W	0751-1032
R55	R: FIXED CARBON 1.5M 5% 1/4W	0683-1555
R56	R: METAL FILM 16k 2% 1/4W	0751-1632
R57	R: METAL FILM 27k 2% 1/4W	0751-2732
R58	R: METAL FILM 10k 2% 1/4W	0751-1032
R59	R: METAL FILM 27k 2% 1/4W	0751-2732
R60	R: METAL FILM 1.00k 1%	0721-1001
R61	R: METAL FILM 470k 2% 1/4W	0751-4742
R62	R: METAL FILM 270k 2% 1/4W	0751-2742
R63	R: METAL FILM 15.0k 1%	0721-1502
R64	R: METAL FILM 1.00k 1%	0721-1001
R65	R: METAL FILM 49.9k 1%	0721-4992
R66	R: METAL FILM 24.9k 1%	0721-2492
R67	R: METAL FILM 1.37k 1%	0721-1371
R68	R: METAL FILM 4.22k 1%	0721-4221

A2 BOARD FMM-2 Rev. A & B cont.

Reference Designation	Description	Part Number
R69 thru R71	R: METAL FILM 10k 2% 1/4W	0751-1032
R72	R: VAR COMP 2k, 10 TURN	2100-0031
R73	R: METAL FILM 9.09k 1%	0721-9091
R74	R: METAL FILM 12.7k 1%	0721-1272
R75	R: METAL FILM 13.0k 1%	0721-1302
R76	R: METAL FILM 29.4k 1%	0721-2942
R77	R: METAL FILM 9.1k 2% 1/4W	0751-9122
R78 thru R81	R: METAL FILM 2.2k 2% 1/4W	0751-2222
R82	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R83	R: METAL FILM 3.9k 2% 1/4W	0751-3922
R84,R85	R: METAL FILM 100 2% 1/4W	0751-1012
R86	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R87	R: METAL FILM 7.15k 1%	0721-7151
R88	R: VAR COMP 2k, 10 TURN	2100-0031
R89	R: METAL FILM 13.0k 1%	0721-1302
R90	R: METAL FILM 2.2k 2% 1/4W	0751-2222
R91	R: METAL FILM 100k 2% 1/4W	0751-1042
R92	R: METAL FILM 7.5k 2% 1/4W	0751-7522
R93	R: METAL FILM 27k 2% 1/4W	0751-2732
R94	R: FIXED CARBON 5.6M 5% 1/4W	0683-5655
R95	R: METAL FILM 39k 2% 1/4W	0751-3932
R96	R: METAL FILM 6.2k 2% 1/4W	0751-6222
R97	R: METAL FILM 18k 2% 1/4W	0751-1832
R98	R: METAL FILM 27k 2% 1/4W	0751-2732
R99	R: METAL FILM 820k 2% 1/4W	0751-8242
R100	R: METAL FILM 100k 2% 1/4W	0751-1042
R101	R: FIXED CARBON 22M 5% 1/4W	0683-2265
R102	R: METAL FILM 10k 2% 1/4W	0751-1032
R103	R: FIXED CARBON 2M 5% 1/4W	0683-2055
R104	R: FIXED CARBON 1.2M 5% 1/4W	0683-1255
R105	R: METAL FILM 10k 2% 1/4W	0751-1032
R106	R: METAL FILM 6.19k 1%	0721-6192
R107	R: VAR COMP 5k, 10 TURN	2100-0020
R108	R: METAL FILM 18.2k 1%	0721-1822
R109	R: METAL FILM 390 2% 1/4W	0751-3912
R110	R: VAR COMP 100, 10 TURN	2100-0022
R111	R: METAL FILM 649 1%	0721-6490
R112	R: METAL FILM 1.5k 2% 1/4W	0751-1522
R113	R: METAL FILM 820k 2% 1/4W	0751-8242
R114	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R115	R: FIXED CARBON 2.7M 5% 1/4W	0683-2755
R116	R: METAL FILM 10k 2% 1/4W	0751-1032
R117	R: FIXED CARBON 6.2M 5% 1/4W	0683-6255
R118	R: METAL FILM 10k 2% 1/4W	0751-1032
R119	R: FIXED CARBON 1.8M 5% 1/4W	0683-1855
R120	R: FIXED CARBON 1.2M 5% 1/4W	0683-1255
R121	R: METAL FILM 12k 2% 1/4W	0751-1232
R122	R: METAL FILM 160 2% 1/4W	0751-1612
R123	R: METAL FILM 12k 2% 1/4W	0751-1232
R124	R: METAL FILM 160 2% 1/4W	0751-1612
R125	R: FIXED CARBON 1.5M 5% 1/4W	0683-1555
R126	R: VAR COMP 100k, 10 TURN	2100-0030

A2 BOARD FMM-2 Rev. A & B cont.

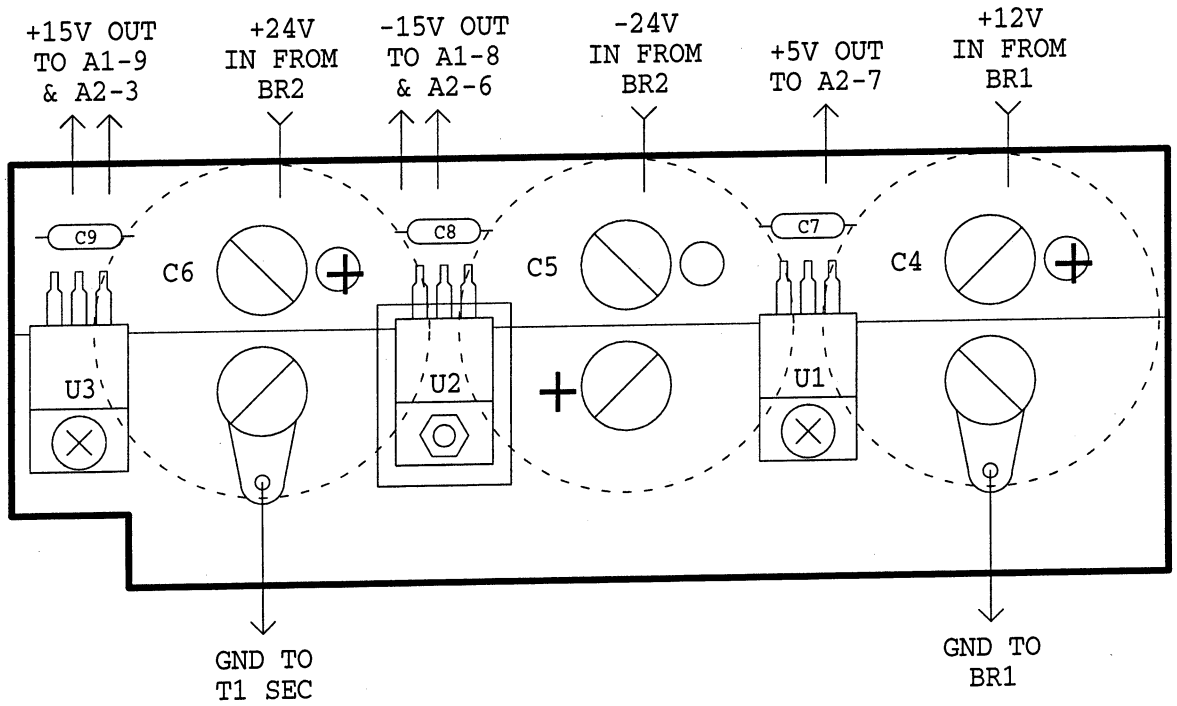
Reference Designation	Description	Part Number
R127	R: METAL FILM 120k 2% 1/4W	0751-1242
R128	R: METAL FILM 1.37k 1%	0721-1371
R129	R: METAL FILM 19.1k 1%	0721-1912
R130	R: METAL FILM 49.9k 1%	0721-4992
R131	R: METAL FILM 24.9k 1%	0721-2492
R132	R: METAL FILM 1.37k 1%	0721-1371
R133	R: METAL FILM 19.1k 1%	0721-1912
R134	R: METAL FILM 10.0k 1%	0721-1002
R135	R: METAL FILM 20.0k 1%	0721-2002
R136	R: METAL FILM 5.11k 1%	0721-5111
R137	R: METAL FILM 160 2% 1/4W	0751-1612
R138	R: METAL FILM 4.7k 2% 1/4W	0751-4722
R139	R: METAL FILM 910 2% 1/4W	0751-9112
R140	R: METAL FILM 560 2% 1/4W	0751-5612
S1	SWITCH: PUSHBUTTON (10 BUTTON)	3101-0015
U1	IC: CA3028	1826-0034
U2	IC: LM311	1826-0009
U3	IC: XO, 650kHz	0415-0065
U4	IC: 78L05CP	1826-0012
U5	IC: 74121	1821-0014
U6*	IC: DS0026	1826-0021
(*Note: On Rev. A boards, U6 is a 75372 IC, p/n 1823-0004)		
U7	IC: 4047B	1822-0017
U8	IC: UA723	1820-0012
U9,U10	IC: NE5534	1826-0025
U11	IC: TLO71	1826-0004
U12	IC: NE5534	1826-0025
U13	IC: LM311	1826-0009
U14	IC: TLO71	1826-0004
U15	IC: 4066B	1822-0018
U16	IC: TLO71	1826-0004
U17	IC: NE5532	1826-0037
U18	IC: SSM2142P	1827-0005
U19	IC: MC34081	1826-0041
U20,U21	IC: TLE2082	1826-0069
U22,U23	IC: LM311	1826-0009
U24	IC: 4538B	1822-0023
U25	IC: 78L05CP	1826-0012
U26	IC: 79L05CP	1826-0017
U27	IC: TLE2082	1826-0069
U28,U29	IC: LM311	1826-0009
U30	IC: 4538B	1822-0023
U31	IC: TLE2082	1826-0069
U32	IC: AD736	1827-0009
U33	IC: TLO71	1826-0004
U34	IC: 7805CT	1826-0014



FMM-2 A3 BOARD

SEE FMM-2 CHASSIS WIRING DRAWING FOR A3 BOARD SCHEMATIC

Reference Designation	Description	Part Number
R1	R: METAL FILM 100k 1%	0721-1003
R2	R: METAL FILM 49.9k 1%	0721-4992
R3	R: METAL FILM 24.9k 1%	0721-2492
R4	R: METAL FILM 12.4k 1%	0721-1242
R5	R: METAL FILM 10.0k 1%	0721-1002
R6	R: METAL FILM 4.99k 1%	0721-4991
R7	R: METAL FILM 2.49k 1%	0721-2491
R8	R: METAL FILM 1.24k 1%	0721-1241
R9	R: METAL FILM 1.00k 1%	0721-1001



FMM-2
A5 POWER SUPPLY BOARD
COMPONENT LAYOUT

(USED FROM SERIAL NUMBER 161259 TO 163359)

BELAR PWM-1 PEAK WEIGHTING MODULE
Operation Guide

The Belar PWM-1 Peak Weighting Module adds peak weighting to the Peak Mod and 100% Peak lights of your Belar FMM-2 FM Modulation Monitor. It will generally result in your peak lights lighting less frequently for a given modulation level. It does not affect the operation or reading of the modulation meter.

BYPASS The PWM-1 is completely bypassed. The monitor will function exactly as it would without the option installed.

3 CYCLES The monitor peak lights will ignore any peak shorter than 3 cycles (of a 10kHz tone burst).

5 CYCLES The monitor peak lights will ignore any peak shorter than 5 cycles (of a 10kHz tone burst).

9 CYCLES The monitor peak lights will ignore any peak shorter than 9 cycles (of a 10kHz tone burst).

15 CYCLES The monitor peak lights will ignore any peak shorter than 15 cycles (of a 10kHz tone burst).

20 CYCLES The monitor peak lights will ignore any peak shorter than 20 cycles (of a 10kHz tone burst).

By changing the peak weighting constants and noting the effect on your peak lights, you can better understand the composition of your total modulation. For example, if your program material is highly processed with little dynamic range (and you have no subcarriers), peak weighting will cause almost no change in your monitor readings. If your program has little processing, you will see more effect from the peak weighting.

Instructions for installing the BELAR PWM-1 PEAK WEIGHTING MODULE (Revision A) in your Belar FMM-2 FM Modulation Monitor (S/N 162190 & later)

Before proceeding, please:

- Read all the way through these instructions before beginning the actual installation.
- Ensure that your PWM-1 kit is complete. Contents include:
  PWM-1 circuit board (with rotary switch and ribbon cable attached)
  Knob for rotary switch
  Allen wrench for tightening set screws on knob
  4-40 X 1/4" pan head Phillips screws (4)
  #4 internal tooth lockwashers (4)
  PWM-1 foil label for back of unit (with switch mounting hole prepunched)
  Instruction book

Overview: The PWM-1 is installed in the back of the cover of your FMM-2. The installation procedure involves removing the cover, applying the foil label, installing the switch (with attached circuit board), making the electrical connections, and reinstalling the cover.

Tools required:

small Phillips screwdriver
IC removal tool (or small flat screwdriver)
3/8" open end wrench (or small adjustable open-end wrench)

Procedure:

1 Unplug all cords from the FMM-2, and remove it from the equipment rack.

2 Remove the FMM-2 top cover.

3 Clean area on cover where the label will be installed with alcohol or similar solvent to make sure that the label will adhere properly. Carefully peel the label backing away from bottom of label, and fold it over so the prepunched mounting hole is exposed. Locate the label on the cover so that the holes in the cover and the label line up and the bottom edge of the label is parallel to the top of the cover, then carefully press the bottom of the label against the panel.

4 Slowly peel label backing from the bottom up, while pressing label against panel. This will avoid trapping air bubbles under label.

5 Roll label flat with a rubber roller, or rub the label backing over the surface of the label to flatten.

6 Remove the nut and lockwasher from the PWM-1 rotary switch, and the four #4 screws and lockwashers from the mounting standoffs.

7 Install the PWM-1 module on the inside rear of the FMM-2 top cover, with the black wire on the PWM-1 module toward the bottom of the cover. Install the four mounting screws and lock washers, then tighten. Mount the switch lockwasher and nut. Do not overtighten the switch nut since this could damage the switch.

8 Install the knob. The knob pointer should be opposite the flat on the switch shaft. Tighten the set screws on the knob with the Allen wrench supplied. Tighten the set screw which contacts the flat on the shaft first.

9 Remove integrated circuit U27 (MC34082 or TLE2082) from the FMM-2 A2 board. See diagram for U27 location. Note the position of pin 1.

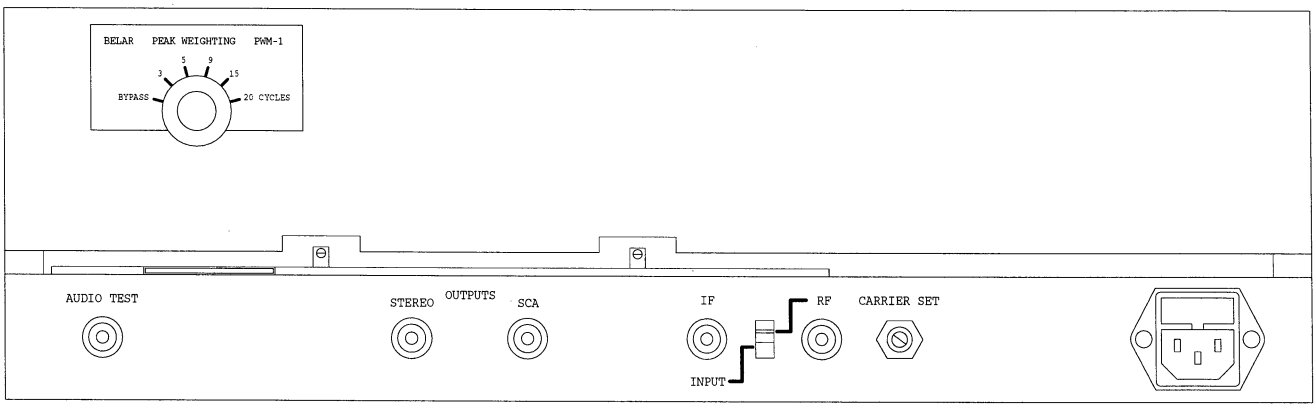
10 Lay the FMM-2 top cover just behind the unit with the PWM-1 knob facing down. Rest the cover on the A2 board fingers.

11 Insert the 8 pin DIP plug from the module into U27's socket on the FMM-2 A2 board. The notch on the DIP plug denotes pin 1. This pin should be inserted closest to the dot on the A2 board next to U27's socket. If the DIP plug is inserted properly, the flat cable should exit the DIP plug on the side of the socket toward the unit power supply. Fold the flat cable across the top of the DIP plug.

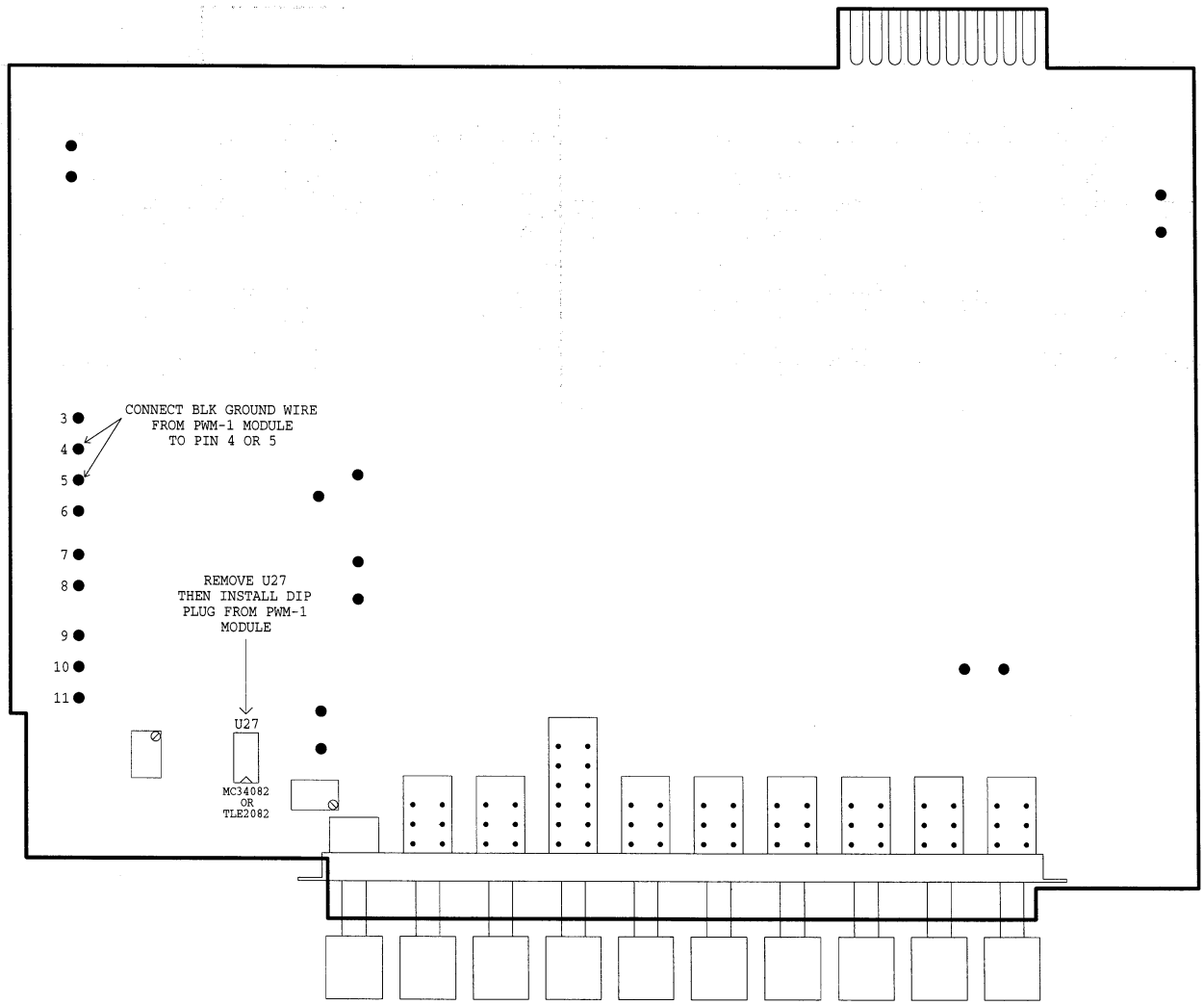
12 Connect the black ground wire from the module to Pin 4 or Pin 5 (whichever pin is not used) on the FMM-2 A2 board. See diagram for pin 4 and 5 location.

13 Carefully rotate the top cover into position and secure it with its mounting screws.

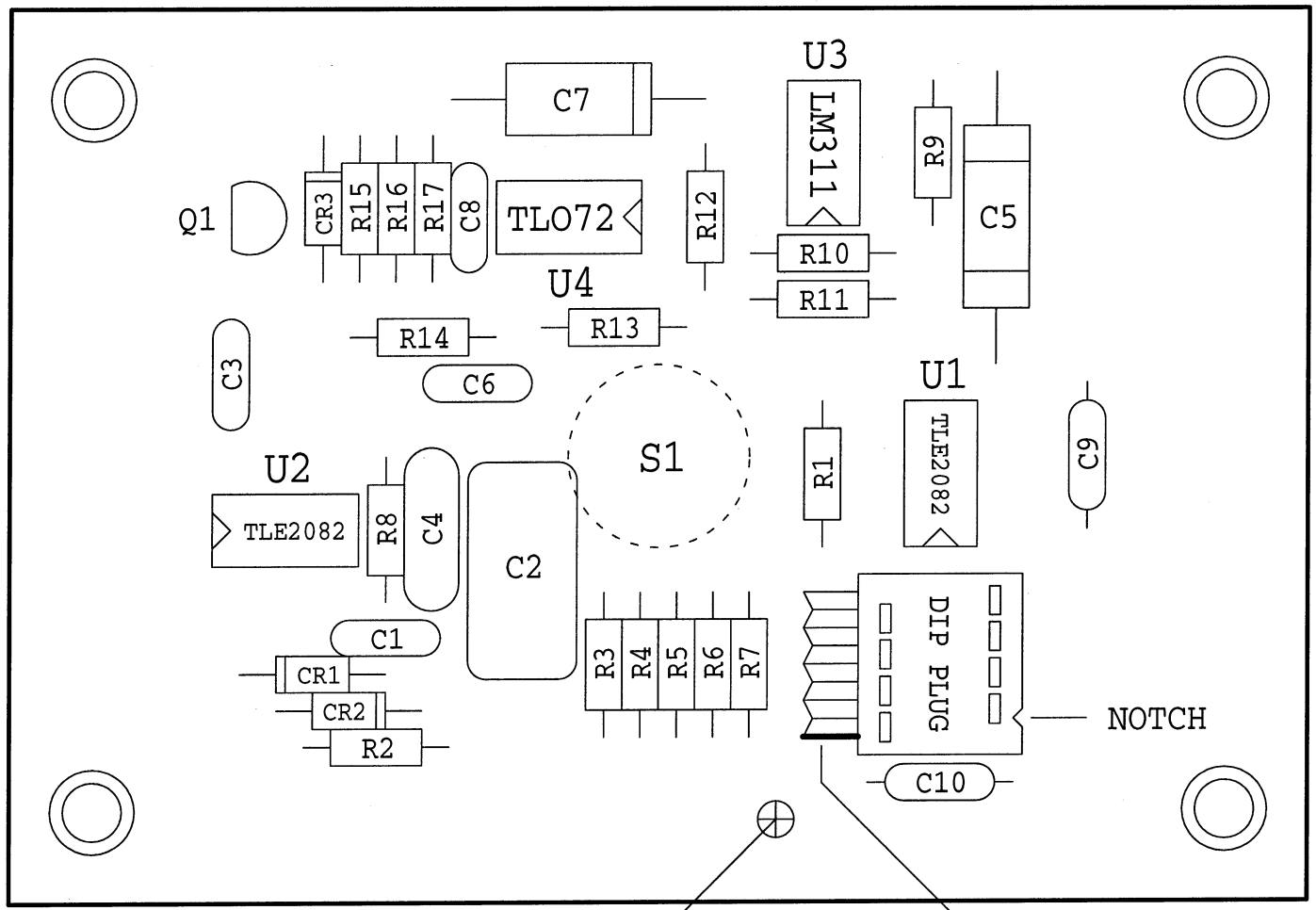
14 Reinstall the FMM-2, and reconnect all cords. This completes the module installation.



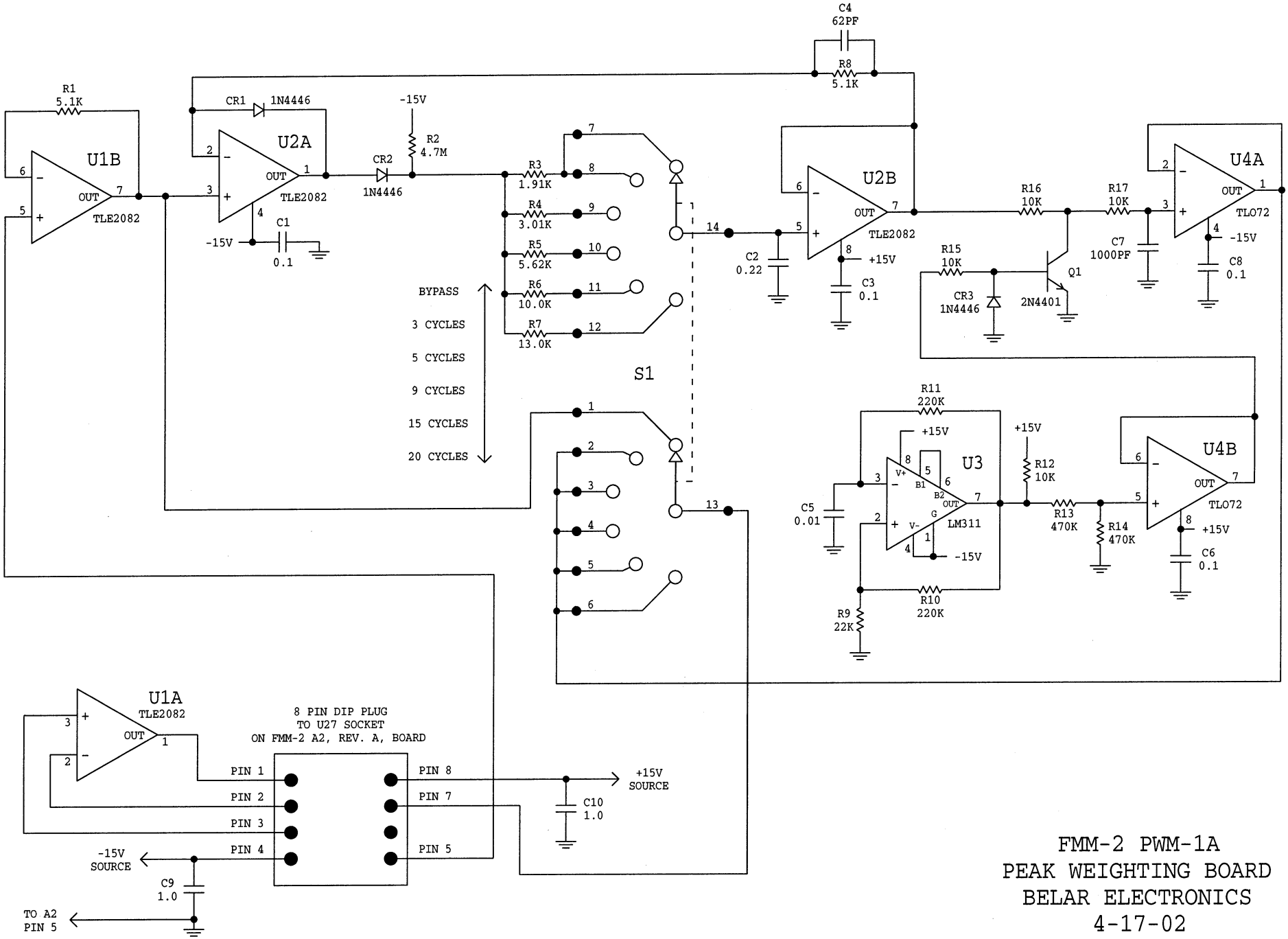
FMM-2 CHASSIS REAR VIEW
WITH PWM-1 INSTALLED
BELAR ELECTRONICS



PWM-1 MODULE TO FMM-2 A2 BOARD
CONNECTION POINTS
(BOTH REV. A)
BELAR ELECTRONICS



PWM-1A BOARD
COMPONENT LAYOUT
BELAR ELECTRONICS



FMM-2 PWM-1A
PEAK WEIGHTING BOARD
BELAR ELECTRONICS
4-17-02

PWM-1A BOARD FMM-2
(For FMM-2s with the Rev. A A2 board.)

Reference Designation	Description	Part Number
C1	C: FIXED CERAMIC 0.1uF 50V	0151-0015
C2*	C: FIXED FILM 0.22 uF 10% 100V *C2 is factory selected	0122-2241
C3	C: FIXED CERAMIC 0.1uF 50V	0151-0015
C4	C: FIXED MICA 62pF 5%	0140-6205
C5	C: FIXED FILM 0.01 uF 10% 200V	0120-1031
C6	C: FIXED CERAMIC 0.1uF 50V	0151-0015
C7	C: FIXED POLY 1000pF 2.5% 160V	0130-1022
C8	C: FIXED CERAMIC 0.1uF 50V	0151-0015
C9,C10	C: FIXED CERAMIC 1.0uF 50V	0151-0008
CR1 thru CR3	DIODE: 1N4446	1900-0002
Q1	TRANSISTOR: 2N4401	1850-0028
R1	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R2	R: FIXED CARBON 4.7M 5% 1/4W	0683-4755
R3	R: METAL FILM 1.91k 1%	0721-1911
R4	R: METAL FILM 3.01k 1%	0721-3011
R5	R: METAL FILM 5.62k 1%	0721-5621
R6	R: METAL FILM 10.0k 1%	0721-1002
R7	R: METAL FILM 13.0k 1%	0721-1302
R8	R: METAL FILM 5.1k 2% 1/4W	0751-5122
R9	R: METAL FILM 22k 2% 1/4W	0751-2232
R10,R11	R: METAL FILM 220k 2% 1/4W	0751-2242
R12	R: METAL FILM 10k 2% 1/4W	0751-1032
R13,R14	R: METAL FILM 470k 2% 1/4W	0751-4742
R15 thru R17	R: METAL FILM 10k 2% 1/4W	0751-1032
S1	SWITCH: ROTARY - 2 POLE, 6 POS.	3100-0003
--	KNOB: 0F3B	0370-0005
U1,U2*	IC: TLE2082	1826-0069
	*(Previously U1 and U2 were the MC34082 IC. These IC's are interchangeable.)	
U3	IC: LM311	1826-0009
U4	IC: TLO72	1826-0038