Model FMM-2
FM MODULATION MONITOR

Guide to Operations

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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.

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, via air freight. 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 vacuum-tube power supplies, 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).

The Model FMM-2 can be operated from either a 105 to 125 Vac or 210 to 250 Vac single phase, 50 to 60 Hz power source. Make sure the unit is set for the proper voltage as follows:

Units with serial number 161719 and lower:
Unplug the line cord. Slide the switch (S1) to 115V or 230V position. Ensure that the fuse (F1) is the proper current rating for selected voltage (½A 250V for 115Vac, ¼A 250V for 230Vac). Plug the line cord back in.

Units with serial number 161720 and higher:
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, install the proper fuse (½A 250V for 115Vac, ¼A 250V for 230Vac), close the fuse door, and 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 meters read 0%. If not, use a small screwdriver to turn the meter adjust screws (below the meters on the front panel) so that they read 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 switch 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 by substituting 2600 pF ±2½% polystyrene capacitors for the 3900 pF capacitors (C27 & C37) located on the A2 circuit board.

C27 controls the audio output de-emphasis and C37 controls the de-emphasis in the noise metering amplifier.

Frequency Change

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).

4 Maintenance

4-1 Field Calibration Procedure

1. 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 U5. With the *Pulse Width* potentiometer (R6), 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 about 75 kHz peak deviation. Adjust the *Meter Balance* potentiometer (R76) 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 CALibrate mode and adjust the *Calibrate* potentiometer (R28) 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 U8. Adjust the *Offset* potentiometer (R38) 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 (R92) 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 (R89) 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 (R119) 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 (R117) 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. U1 supplies regulated +5V to U2, the input signal limiter and U3, 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 crystal oscillator transistor Q1.

During normal operation, the monostable, U3, 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, U5. Approximately +7.35 volts is supplied to U5 by regulator U6. 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 U7. The average dc value of the pulse train is canceled in U7 by applying a positive voltage from U6 to the non-inverting input of U7. U7 drives a phase equalizer and, in turn, non-inverting amplifier U8, which provides full level for the composite baseband output (the STEREO and SCA outputs on the rear panel).

In the CALibrate mode, U4, 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 crystal oscillator 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 U8 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 U8 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 crystal oscillator. (Diodes are employed on the main board to switch the discriminator between the IF and oscillator inputs.)

Output. U9 buffers the selected output of U8 and feeds the detected signal to the other output and metering circuitry. U10 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 U11 and non-inverting amplifier U12 provide a +10 dBm, 600Ω, balanced, and de-emphasized output for aural monitoring.

Metering. U9 also drives non-inverting amplifier U13 and inverting amplifier U14 which feed the metering, flasher, and muting circuits. The outputs of U13 and U14 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. U15, U16, and U17, working in conjunction with U13 and U14, comprise an active full-wave peak rectifying circuit. If the feedback paths of U15 and U16 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 U17, the amplitude of the larger of the inputs to U15 and U16 appears at the output of U17. Since U13 and U14 provide signals of equal amplitude and opposite polarity, the complete circuit acts as a full-wave rectifier. The output of U17 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 (R59, R60 and C30) allows coupling of external meters to U17 as well. Meter ballistics in the SEMI-peak mode are controlled by an R-C network (C31, R67) at the U15-U16 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 U13 and U14, (possibly controlled by the setting of the PLUS or MINUS switches) falls below the output voltage of U17, the output of comparator U18 falls, triggering a non-retriggerable monostable in U19. The output of the monostable goes low for 150 milliseconds, turning Q6 off and breaking the discharge path through the 5.6 MΩ resistor to the metering capacitor. Once the 150 milliseconds passes, with Q6 now on, metering ballistics remain the same as those in SEMI-peak until the next peak is reached.

Flashers. The outputs of U13 and U14 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 U23. The output of U23 is applied to one input of U26, the comparator for the adjustable PEAK MODulation flasher, and one input of U28, the comparator for the 100% flasher. The trigger reference voltage for the PEAK MOD flasher is set by U25 and U24, in conjunction with the thumbwheel switch. U25 provides a regulated +5V which is applied the inverting input of amplifier U24 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 U24 is increased, resulting in a more negative reference voltage applied to U26. When the modulation-induced negative excursion swings below the negative reference from U24, the output of U26 goes low, triggering a retriggerable monostable in U29. 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 U27. This voltage is applied to the inverting input of U28. Again, when the modulation-induced negative excursion swings below this reference voltage, the output of U28 goes low, triggering a second retriggerable monostable in U29. This in turn, via Q4, lights the 100% LED for approximately 120 milliseconds.

Average Noise Metering. U30, U31, and U32 and associated circuitry comprise a de-emphasized, full-wave averaging voltmeter with 50 dB amplification for making FM and AM noise measurements. U30 is a de-emphasis amplifier with a low-frequency gain of approximately 26 dB. U31 and U32 are the active elements of a full-wave rectifying circuit with gain. Since the rectifying diodes are in a feedback loop, the effect of diode cut-in voltage is minimized. 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 U17 and connect it to the output of U32. The input to U30 is appropriately switched to the output of U8 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 U13 and U14 are combined ahead of the polarity switching resistors through diodes and applied to the inverting input of U20. When the more positive of their two outputs exceeds the threshold set by the voltage divider at the non-inverting input, the output of U20 goes low, firing a retriggerable monostable in U19. 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 U21. Two of these switches are connected in parallel to ground and clamp the output of U9 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 U19. The high at pin 6 of U19 also serves to turn on Q7, discharging the metering capacitor. At the same time, the $\overline{Q}$ output at pin 7 of U19 clears the sample-hold monostable, turning on Q6 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 U22. When the output voltage exceeds the reference voltage applied to the inverting input from a voltage divider, the output of U22 rises. This turns on an analog switch in U21, 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.*

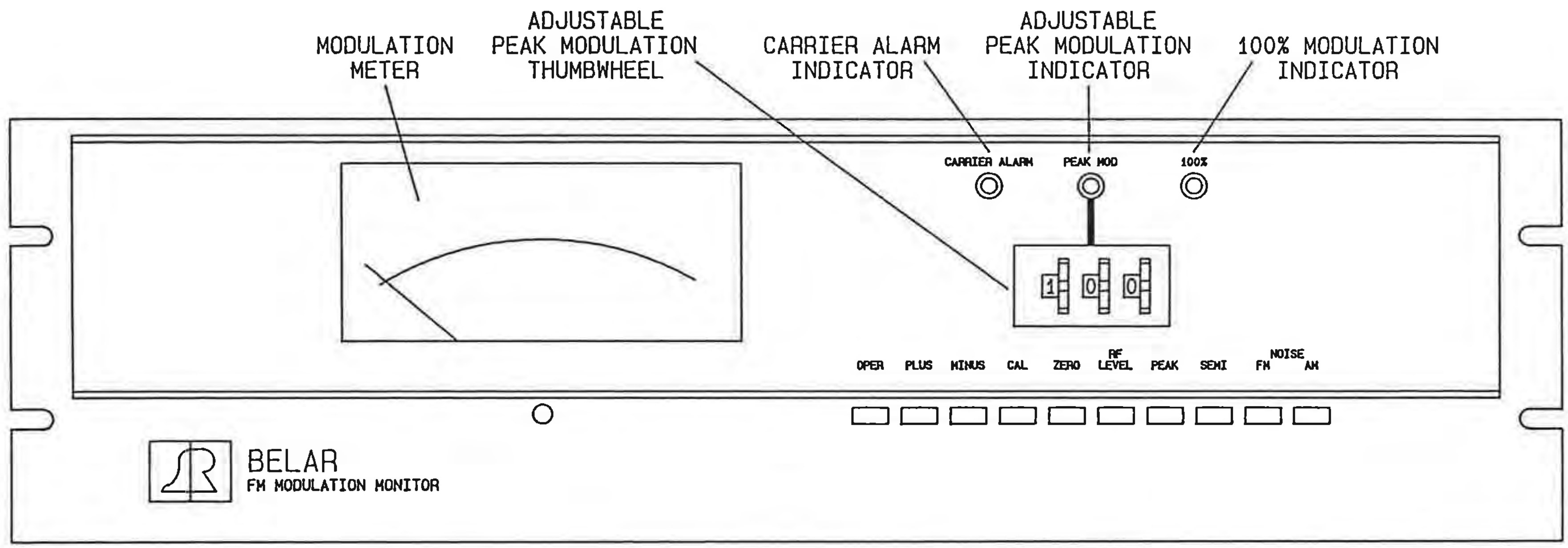
Orders may also be taken over the telephone. Parts orders can be put on your VISA, MasterCard, or American Express card, or we can ship them COD.

REFERENCE DESIGNATORS

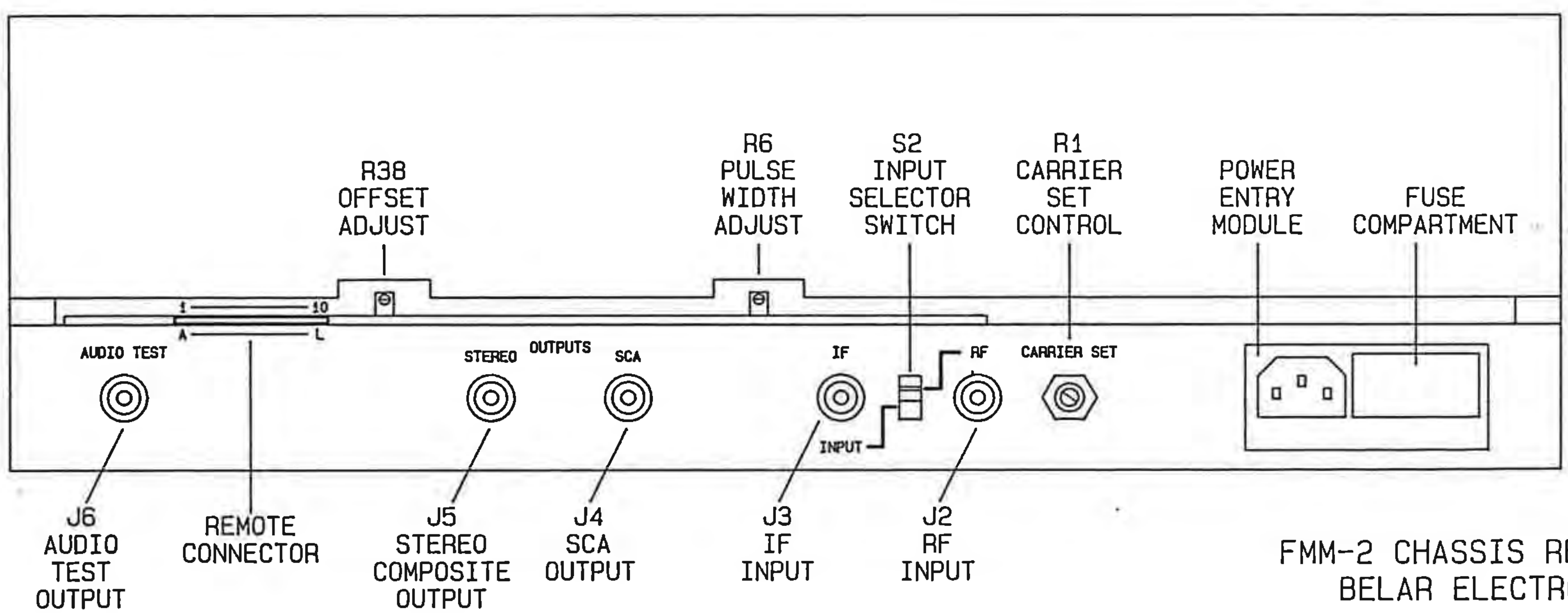
A	= assembly	J	= jack	S	= switch
BR	= diode bridge	L	= inductor	T	= transformer
C	= capacitor	M	= meter	TB	= terminal block
CR	= diode or LED	P	= plug	U	= integrated circuit
DS	= display or lamp	Q	= transistor	W	= cable
F	= fuse	R	= resistor	X	= socket
FL	= filter	RL	= relay	Y	= crystal
HDR	= header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



FMM-2 CHASSIS REAR VIEW
BELAR ELECTRONICS

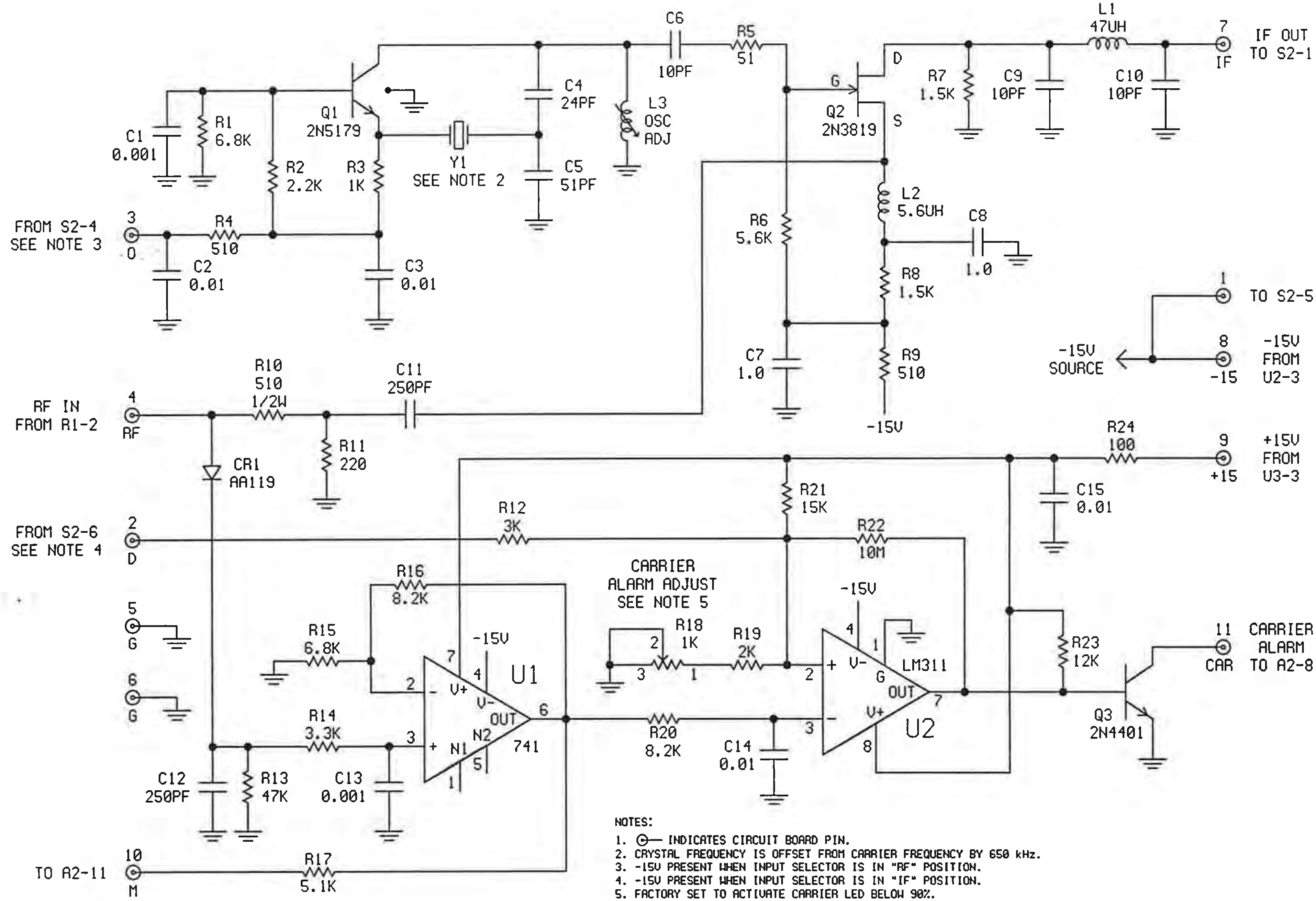
FMM-2 PARTS LISTS

MAIN CHASSIS

Reference Designation	Description		Part Number
BR1,BR2	DIODE: BRIDGE KBPC602 GI		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 3500uF 40V	(NOTE 1)	0180-0026
C7 thru C9	C: FIXED CERAMIC 0.1uF 50V	(NOTE 1)	0151-0006
CR1	LED: RED MV5053		1910-0001
CR2	LED: YELLOW MV5353		1910-0002
CR3	LED: RED MV5053		1910-0001
DS1	LAMP: 1847		2140-0005
--	SOCKET: LAMP		1450-0012
F1	FUSE: AGC 1/2A 250V (115 Vac line voltage)		2110-0001
	AGC 1/4A 250V (230 Vac Line voltage)		2110-0002
--	FUSEHOLDER:	(NOTE 2)	2110-0003
J1	JACK: POWER	(NOTE 2)	0360-0010
J2 thru J6	JACK: BNC		0360-0005
M1	METER: MOD 0-133%		1120-0012
R1	R: VAR COMP 100 ohm 2W		2100-0010
R2	R: FIXED CARBON 100 ohm 10% 1W		0690-1011
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		9100-0010
U1	IC: 7805C		1826-0014
U2	IC: 7915C		1826-0033
U3	IC: 7815C		1826-0031
--	LINE CORD		8120-0002

NOTE 1: Prior to serial number 161259 - C4 thru C6 were 1000uF 50v (0180-0002) and C7 thru C9 were not used.

NOTE 2: Beginning serial number 161720, these parts are replaced by the 6J4 power entry module (0360-0020).



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

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
CR1	DIODE: AA119	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	R: METAL FILM 510 2% 1/4W	0751-5112
R10	R: METAL FILM 510 2% 1/2W	0771-5112
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	

FMM-2 A2 BOARD
PART LOCATIONS

Desig	Loc	Desig	Loc	Desig	Loc	Desig	Loc	Desig	Loc
C1	A1	C50	D8	Q4	D3	R45	B9	R94	E2
C2	A2	C51	E8	Q5	E3	R46	B8	R95	E2
C3	A2	C52	B2	Q6	E7	R47	B9	R96	E2
C4	B2	C53	C3	Q7	D7	R48	B9	R97	D2
C5	B3	C54*	E5			R49	B8	R98	D3
C6	A3			R1	B1	R50	C8	R99	D3
C7#	B1	CR1	B1	R2	A2	R51	C9	R100	E3
C8#	C1	CR2	B2	R3	C2	R52	B8	R101	E3
C9#	C2	CR3	B1	R4	B2	R53	B8	R102	F9
C10#	B2	CR4	B3	R5	B2	R54	C9	R103	F9
C11#	C2	CR5	C4	R6	A2	R55	C8	R104	F8
C12	A4	CR6	D4	R7	A3	R56	C8	R105	E9
C13	B4	CR7	D4	R8	B3	R57	C9	R106	E9
C14	B4	CR8	D7	R9	B2	R58	C9	R107	E8
C15	B5	CR9	D4	R10	B1	R59	D8	R108	E8
C16	C7	CR10	D5	R11#	B1	R60	D8	R109	D9
C17	B7	CR11	D7	R12#	C1	R61	D7	R110	D9
C18	A7	CR12	D5	R13#	C2	R62	D8	R111	D8
C19	A7	CR13	E5	R14#	B1	R63	E8	R112	D8
C20	F3	CR14	D5	R15#	C1	R64	D4	R113	D8
C21	F4	CR15	E4	R16	C4	R65	E7	R114	D9
C22	C5	CR16	D4	R17	C3	R66	D4	R115	D9
C23	C3	CR17	D4	R18	B4	R67	D8	R116	C9
C24	A9	CR18	D5	R19	A4	R68	D5	R117	F8
C25	A9	CR19	E5	R20	A4	R69	D5	R118	E8
C26	B9	CR20	E5	R21	A4	R70	D6	R119	F8
C27	C8	CR21	E2	R22	B4	R71	E5	R120	E7
C28	C9	CR22	D2	R23	B4	R72	D7	R121	E7
C29	C8	CR23	D9	R24	B5	R73	E4	R122	E7
C30	D8	CR24	D9	R25*	B5	R74	E4	R123	E8
C31	C5	CR25	E7	R26*	B6	R75	E4	R124	E7
C32	F2	CR26	E7	R27	B6	R76	E4	R125	F7
C33	F2	CR27	E6	R28	B6	R77	E5	R126	F6
C34	E2	CR28	E6	R29	--	R78	E4	R127	E5
C35	D3	CR29	D6	R30	B7	R79	F4	R128	E5
C36	F9	CR30	E6	R31	C6	R80	E5	R129	E5
C37	F8	CR31	D1	R32	B7	R81	E5	R130	E6
C38	E9	CR32	C1	R33	B8	R82	E4	R131	E6
C39	E9	CR33	D8	R34	B8	R83	E3	R132	D6
C40	F7	CR34	E8	R35	F4	R84	E2	R133	D6
C41	E6			R36	F3	R85	E2	R134	E6
C42	E6	FL1	B5	R37	F4	R86	E2	R135	D8
C43	D7			R38	A6	R87	E2	R136	E8
C44	D1	L1	B7	R39	B6	R88	F3	R137	D3
C45	C1	L2	A7	R40	C5	R89	F3	R138	D3
C46	D2			R41	C3	R90	E3	R139	--
C47	C2	Q1#	C2	R42	B4	R91	F2	R140*	E5
C48	D8	Q2	B3	R43	D3	R92	F2		
C49	E8	Q3	A5	R44	A8	R93	F2		

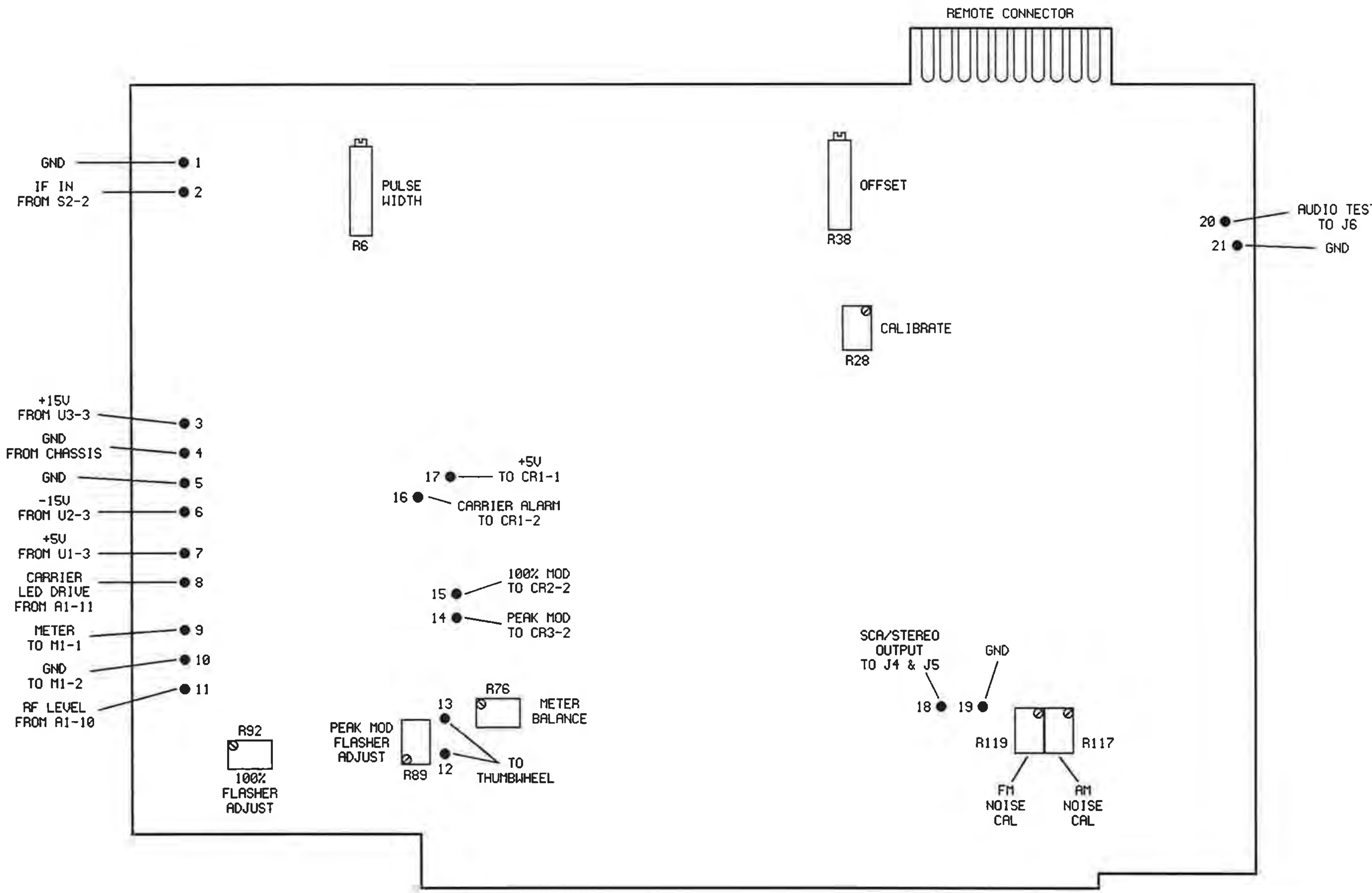
*R25,26,140 & C54 ARE ON BOTTOM OF PCB

-- R29 & R139 ARE NOT USED

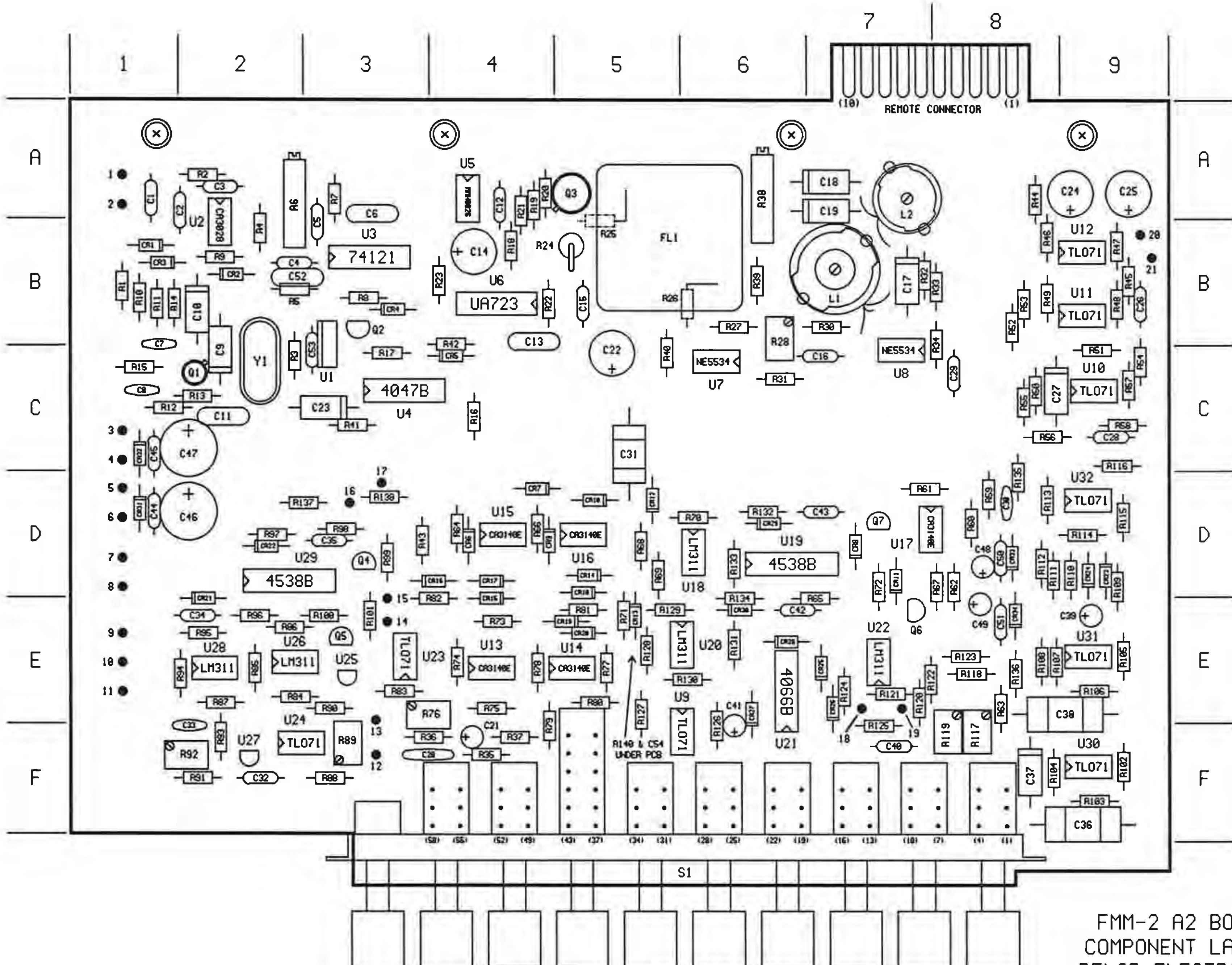
FMM-2 A2 BOARD
PART LOCATIONS
CONT.

Desig/Loc		Desig/Loc	
		pins	
S1	F5	1	A1
		2	A1
U1	C3	3	C1
U2	B2	4	C1
U3	B3	5	D1
U4	C3	6	D1
U5	A4	7	D1
U6	B4	8	D1
U7	C6	9	E1
U8	C7	10	E1
U9	F6	11	E1
U10	C9	12	F3
U11	B9	13	E3
U12	B9	14	E3
U13	E4	15	E3
U14	E5	16	D3
U15	D4	17	D3
U16	D5	18	E7
U17	D7	19	E7
U18	D6	20	B9
U19	D6	21	B9
U20	E6		
U21	E6		
U22	E7		
U23	E3		
U24	F2		
U25	E3		
U26	E2		
U27	F2		
U28	E2		
U29	D2		
U30	F9		
U31	E9		
U32	D9		
Y1#	C2		

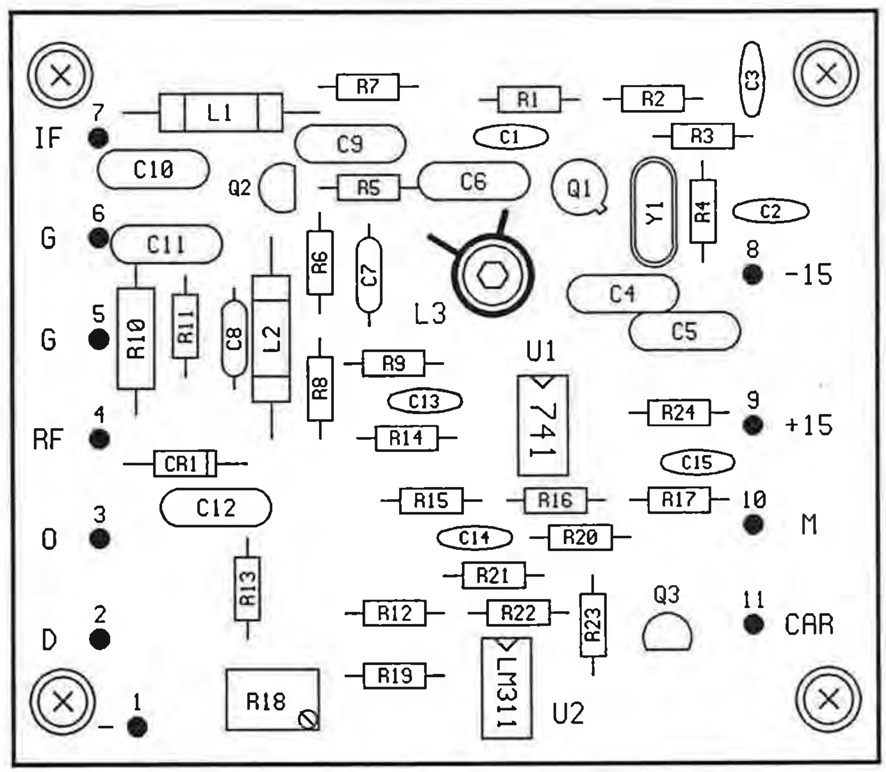
#BEGINNING SERIAL NUMBER 162080: C7 thru C11, Q1, R11 thru R15 AND Y1 ARE REPLACED BY THE A2-1 BOARD.



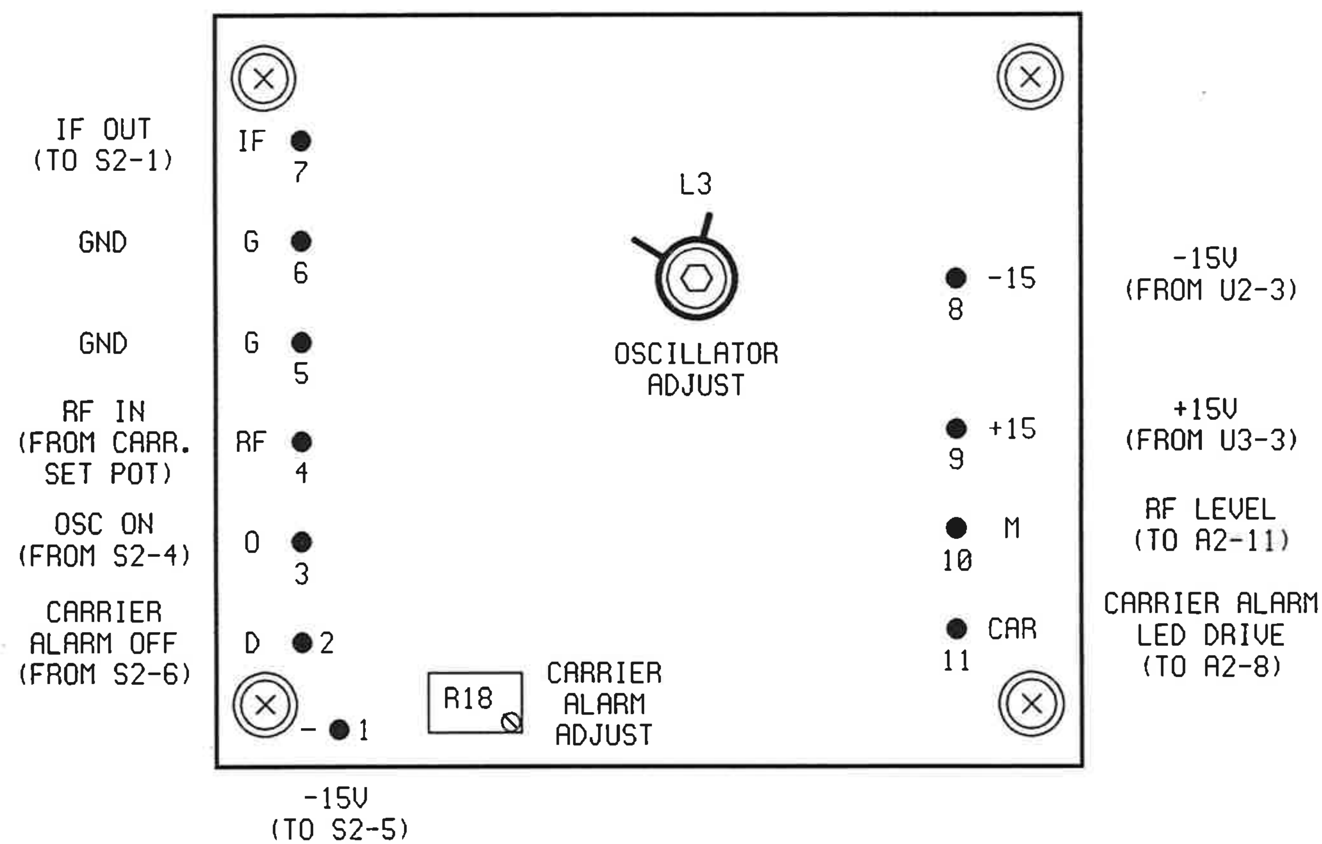
FMM-2 A2 BOARD
CONNECTIONS & ADJUSTMENTS
BELAR ELECTRONICS



FMM-2 A2 BOARD
COMPONENT LAYOUT
BELAR ELECTRONICS



FMM-2 A1 BOARD
COMPONENT LAYOUT
BELAR ELECTRONICS



FMM-2 A1 BOARD
CONNECTIONS & ADJUSTMENTS
BELAR ELECTRONICS

A2 BOARD FMM-2

Reference Designation	Description	Part Number
C1 thru C4	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C5	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C6	C: FIXED MICA 75pF 5%	0140-7505
C7,C8 (note 1)	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C9 (note 1)	C: FIXED POLY 1000pF 2.5% 160V	0130-1022
C10 (note 1)	C: FIXED POLY 510pF 2.5% 160V	0130-5112
C11 (note 1)	C: FIXED MICA 36pF 5%	0140-3605
C12	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C13	C: FIXED MICA 22pF 5%	0140-2205
C14	C: FIXED ELEC 47uF 50V	0180-0017
C15	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C16	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C17	C: FIXED POLY 270pF 2.5% 160V	0130-2712
C18	C: FIXED POLY 3900pF 2.5% 160V	0130-3922
C19	C: FIXED POLY 820pF 2.5% 160V	0130-8212
C20	C: FIXED CERAMIC 0.05uF 75V	0151-0005
C21	C: FIXED TANT 15uF 15V	0185-0003
C22	C: FIXED ELEC 47uF 50V	0180-0017
C23	C: FIXED POLY 1000pF 2.5% 160V	0130-1022
C24,C25	C: FIXED ELEC 100uF 35V	0180-0018
C26	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C27	C: FIXED POLY 3900pF 2.5% 160V	0130-3922
C28,C29	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C30	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C31	C: FIXED FILM 0.047uF 10% 200V	0120-4731
C32	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C33	C: FIXED CERAMIC 0.01uF 100V	0151-0003
C34	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C35	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C36	C: FIXED FILM 0.22uF 10% 80V	0120-2241
C37	C: FIXED POLY 3900pF 2.5% 160V	0130-3922
C38	C: FIXED FILM 0.22uF 10% 80V	0120-2241
C39	C: FIXED TANT 15uF 15V	0185-0003
C40	C: FIXED CERAMIC 1.0uF 50V	0151-0008
C41	C: FIXED TANT 6.8uF 25V	0185-0002
C42 thru C45	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C46,C47	C: FIXED ELEC 330uF 20V	0180-0022
C48,C49	C: FIXED TANT 6.8uF 25V	0185-0002
C50,C51	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C52	C: FIXED MICA 75pF 5%	0140-7505
C53	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C54	C: FIXED CERAMIC 0.001uF 1kV	0151-0002
CR1	DIODE: 1N4446	1900-0002
CR2	DIODE: IN753A	1900-0006
CR3,CR4	DIODE: 1N4446	1900-0002
CR5	DIODE: IN749A	1900-0018
CR6	DIODE: AA119	1900-0001
CR7,CR8	DIODE: 1N4446	1900-0002
CR9	DIODE: AA119	1900-0001

A2 BOARD FMM-2 CONT.

Reference Designation	Description	Part Number
CR10,CR11	DIODE: 1N4446	1900-0002
CR12	DIODE: AA119	1900-0001
CR13	DIODE: 1N4446	1900-0002
CR14,CR15	DIODE: AA119	1900-0001
CR16	DIODE: 1N4446	1900-0002
CR17,CR18	DIODE: AA119	1900-0001
CR19 thru CR22	DIODE: 1N4446	1900-0002
CR23,CR24	DIODE: AA119	1900-0001
CR25 thru CR30	DIODE: 1N4446	1900-0002
CR31,CR32	DIODE: 1N4006	1900-0016
CR33,CR34	DIODE: 1N755A	1900-0023
FL1	FILTER: BELAR LPF	9120-0009
L1	INDUCTOR: BELAR 65T	9140-0039
L2	INDUCTOR: BELAR 37T	9140-0038
Q1 (note 1)	TRANSISTOR: 2N914	1850-0006
Q2	TRANSISTOR: 2N4401	1850-0028
Q3	TRANSISTOR: 2N4037	1850-0011
Q4 thru Q7	TRANSISTOR: 2N4401	1850-0028
R1	R: FIXED CARBON 10k 5% 1/4W	0683-1035
R2	R: FIXED CARBON 2k 5% 1/4W	0683-2025
R3	R: FIXED CARBON 1k 5% 1/4W	0683-1025
R4	R: FIXED CARBON 1.1k 5% 1/4W	0683-1125
R5	R: FIXED CARBON 1.3k 5% 1/4W	0683-1325
R6	R: VAR COMP 1k, 10 TURN	2100-0023
R7	R: METAL FILM 7.50k 1%	0721-7501
R8	R: FIXED CARBON 1k 5% 1/4W	0683-1025
R9	R: FIXED CARBON 15k 5% 1/4W	0683-1535
R10	R: FIXED CARBON 10k 5% 1/4W	0683-1035
R11 (note 1)	R: FIXED CARBON 2.2k 5% 1/4W	0683-2225
R12 (note 1)	R: FIXED CARBON 510 5% 1/4W	0683-5115
R13 (note 1)	R: FIXED CARBON 39k 5% 1/4W	0683-3935
R14 (note 1)	R: FIXED CARBON 6.2k 5% 1/4W	0683-6225
R15 (note 1)	R: FIXED CARBON 39k 5% 1/4W	0683-3935
R16	R: FIXED CARBON 4.7k 5% 1/4W	0683-4725
R17	R: FIXED CARBON 1k 5% 1/4W	0683-1025
R18	R: FIXED CARBON 10 5% 1/4W	0683-1005
R19,R20	R: FIXED CARBON 1k 5% 1/4W	0683-1025
R21	R: METAL FILM 12.1k 1%	0721-1212
R22,R23	R: FIXED CARBON 3.3k 5% 1/4W	0683-3325
R24	R: WIRE WOUND 620 5% 2W	0811-0012
R25	R: METAL FILM 866 1%	0721-8660
R26	R: METAL FILM 1.00k 1%	0721-1001
R27	R: METAL FILM 6.19k 1%	0721-6191

A2 BOARD FMM-2 CONT.

Reference Designation	Description	Part Number
R28	R: VAR COMP 1k, 10 TURN	2100-0021
R29	not used	
R30	R: METAL FILM 866 1%	0721-8660
R31	R: FIXED CARBON 100 5% 1/4W	0683-1015
R32	R: METAL FILM 1.00k 1%	0721-1001
R33	R: METAL FILM 1.10k 1%	0721-1101
R34	R: METAL FILM 5.11k 1%	0721-5111
R35	R: METAL FILM 1.37k 1%	0721-1371
R36	R: METAL FILM 432 1%	0721-4320
R37	R: METAL FILM 12.1k 1%	0721-1212
R38	R: VAR COMP 1k, 10 TURN	2100-0023
R39	R: METAL FILM 5.11k 1%	0721-5111
R40	R: METAL FILM 10.0k 1%	0721-1002
R41	R: METAL FILM 90.9k 1%	0721-9092
R42	R: FIXED CARBON 10k 5% 1/4W	0683-1035
R43	R: FIXED CARBON 5.1k 5% 1/4W	0683-5125
R44,R45	R: FIXED CARBON 300 5% 1/4W	0683-3015
R46	R: FIXED CARBON 5.1k 5% 1/4W	0683-5125
R47 thru R49	R: METAL FILM 10.0k 1%	0721-1002
R50	R: METAL FILM 20.0k 1%	0721-2002
R51	R: FIXED CARBON 6.8k 5% 1/4W	0683-6825
R52 thru R54	R: FIXED CARBON 10k 5% 1/4W	0683-1035
R55	R: METAL FILM 19.1k 1%	0721-1912
R56	R: METAL FILM 1.00k 1%	0721-1001
R57	R: METAL FILM 4.32k 1%	0721-4321
R58	R: METAL FILM 19.1k 1%	0721-1912
R59,R60	R: FIXED CARBON 100 5% 1/4W	0683-1015
R61	R: FIXED CARBON 3.9k 5% 1/4W	0683-3925
R62	R: METAL FILM 8.25k 1%	0721-8251
R63	R: METAL FILM 15.0k 1%	0721-1502
R64	R: FIXED CARBON 5.1k 5% 1/4W	0683-5125
R65	R: FIXED CARBON 7.5k 5% 1/4W	0683-7525
R66	R: FIXED CARBON 5.1k 5% 1/4W	0683-5125
R67	R: FIXED CARBON 5.6M 5% 1/4W	0683-5655
R68	R: FIXED CARBON 2.2k 5% 1/4W	0683-2225
R69	R: FIXED CARBON 100k 5% 1/4W	0683-1045
R70	R: FIXED CARBON 22M 5% 1/4W	0683-2265
R71	R: FIXED CARBON 100k 5% 1/4W	0683-1045
R72	R: FIXED CARBON 27k 5% 1/4W	0683-2735
R73	R: FIXED CARBON 2.2k 5% 1/4W	0683-2225
R74,R75	R: METAL FILM 19.1k 1%	0721-1912
R76	R: VAR COMP 5k, 10 TURN	2100-0020
R77	R: FIXED CARBON 39k 5% 1/4W	0683-3935
R78	R: METAL FILM 24.9k 1%	0721-2492
R79	R: METAL FILM 13.0k 1%	0721-1302
R80	R: FIXED CARBON 9.1k 5% 1/4W	0683-9125
R81	R: FIXED CARBON 2.2k 5% 1/4W	0683-2225
R82	R: FIXED CARBON 820k 5% 1/4W	0683-8245
R83	R: FIXED CARBON 4.7k 5% 1/4W	0683-4725

A2 BOARD FMM-2 CONT.

Reference Designation	Description	Part Number
R84	R: FIXED CARBON 1.5k 5% 1/4W	0683-1525
R85	R: FIXED CARBON 2.7M 5% 1/4W	0683-2755
R86	R: FIXED CARBON 10k 5% 1/4W	0683-1035
R87	R: FIXED CARBON 6.2k 5% 1/4W	0683-6225
R88	R: FIXED CARBON 390 5% 1/4W	0683-3915
R89	R: VAR COMP 100, 10 TURN	2100-0022
R90	R: METAL FILM 649 1%	0721-6490
R91	R: METAL FILM 18.2k 1%	0721-1822
R92	R: VAR COMP 5k, 10 TURN	2100-0020
R93	R: METAL FILM 6.19k 1%	0721-6191
R94	R: FIXED CARBON 6.2M 5% 1/4W	0683-6255
R95	R: FIXED CARBON 10k 5% 1/4W	0683-1035
R96	R: FIXED CARBON 3M 5% 1/4W	0683-3055
R97	R: FIXED CARBON 1.2M 5% 1/4W	0683-1255
R98	R: FIXED CARBON 12k 5% 1/4W	0683-1235
R99	R: FIXED CARBON 160 5% 1/4W	0683-1615
R100	R: FIXED CARBON 12k 5% 1/4W	0683-1235
R101	R: FIXED CARBON 160 5% 1/4W	0683-1615
R102	R: FIXED CARBON 120k 5% 1/4W	0683-1245
R103	R: METAL FILM 1.00k 1%	0721-1001
R104	R: METAL FILM 19.1k 1%	0721-1912
R105	R: FIXED CARBON 120k 5% 1/4W	0683-1245
R106	R: METAL FILM 10.0k 1%	0721-1002
R107	R: FIXED CARBON 820k 5% 1/4W	0683-8245
R108	R: METAL FILM 9.09k 1%	0721-9091
R109	R: METAL FILM 221 1%	0721-2210
R110,R111	R: METAL FILM 2.21k 1%	0721-2211
R112	R: METAL FILM 90.9k 1%	0721-9092
R113	R: METAL FILM 100k 1%	0721-1003
R114	R: METAL FILM 90.9k 1%	0721-9092
R115	R: METAL FILM 100k 1%	0721-1003
R116	R: METAL FILM 2.21k 1%	0721-2211
R117	R: VAR COMP 50k, 10 TURN	2100-0025
R118	R: FIXED CARBON 1.5M 5% 1/4W	0683-1555
R119	R: VAR COMP 50k, 10 TURN	2100-0025
R120	R: FIXED CARBON 10k 5% 1/4W	0683-1035
R121	R: FIXED CARBON 1.5M 5% 1/4W	0683-1555
R122	R: FIXED CARBON 16k 5% 1/4W	0683-1635
R123	R: FIXED CARBON 27k 5% 1/4W	0683-2735
R124	R: FIXED CARBON 10k 5% 1/4W	0683-1035
R125	R: FIXED CARBON 1k 5% 1/4W	0683-1025
R126	R: METAL FILM 1.00k 1%	0721-1001
R127,R128	R: FIXED CARBON 27k 5% 1/4W	0683-2735
R129	R: FIXED CARBON 18k 5% 1/4W	0683-1835
R130	R: FIXED CARBON 820k 5% 1/4W	0683-8245
R131	R: FIXED CARBON 10k 5% 1/4W	0683-1035
R132	R: FIXED CARBON 1.5M 5% 1/4W	0683-1555
R133	R: FIXED CARBON 10k 5% 1/4W	0683-1035

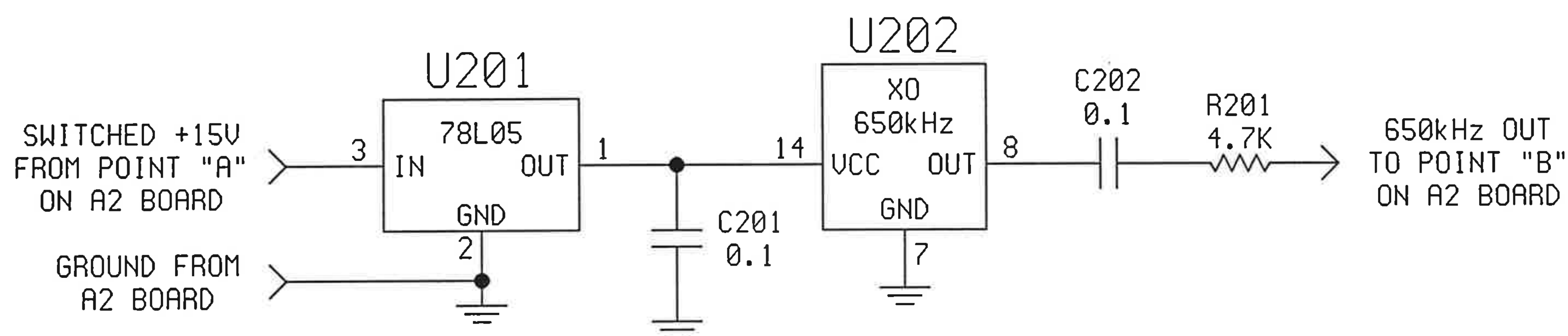
A2 BOARD FMM-2

Reference Designation	Description	Part Number
R134	R: FIXED CARBON 2.7M 5% 1/4W	0683-2755
R135	R: FIXED CARBON 560 5% 1/4W	0683-5615
R136	R: FIXED CARBON 910 5% 1/4W	0683-9115
R137	R: FIXED CARBON 4.7k 5% 1/4W	0683-4725
R138	R: FIXED CARBON 160 5% 1/4W	0683-1615
R139	not used	
R140	R: FIXED CARBON 6.2k 5% 1/4W	0683-6225
S1	SWITCH: PUSHBUTTON (10 BUTTON)	3101-0015
U1	IC: 7805C	1826-0014
U2	IC: CA3028	1826-0034
U3	IC: 74121	1821-0014
U4	IC: 4047	1822-0017
U5	IC: MMH0026	1826-0021
U6	IC: UA723	1820-0012
U7,U8	IC: NE5534	1826-0025
U9 thru U12	IC: TL071	1826-0004
U13 thru U17	IC: CA3140E	1826-0001
U18	IC: LM311	1826-0009
U19	IC: 4538	1822-0023
U20	IC: LM311	1826-0009
U21	IC: 4066	1822-0018
U22	IC: LM311	1826-0009
U23,U24	IC: TL071	1826-0004
U25	IC: 78L05CP	1826-0012
U26	IC: LM311	1826-0009
U27	IC: 79L05CP	1826-0017
U28	IC: LM311	1826-0009
U29	IC: 4538	1822-0023
U30 thru U32	IC: TL071	1826-0004
Y1 (note 1)	XTAL: 650 kHz	0410-0003

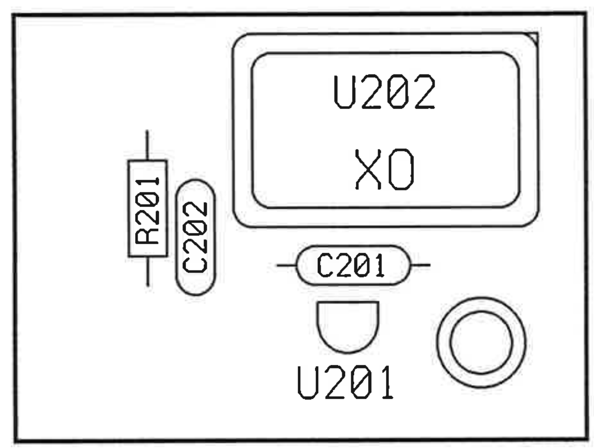
note 1: Beginning serial number 162080: C7 thru C11, Q1, R11 thru R15 and Y1 are replaced by the A2-1 650kHz XO board.

FMM-2 A2-1 BOARD

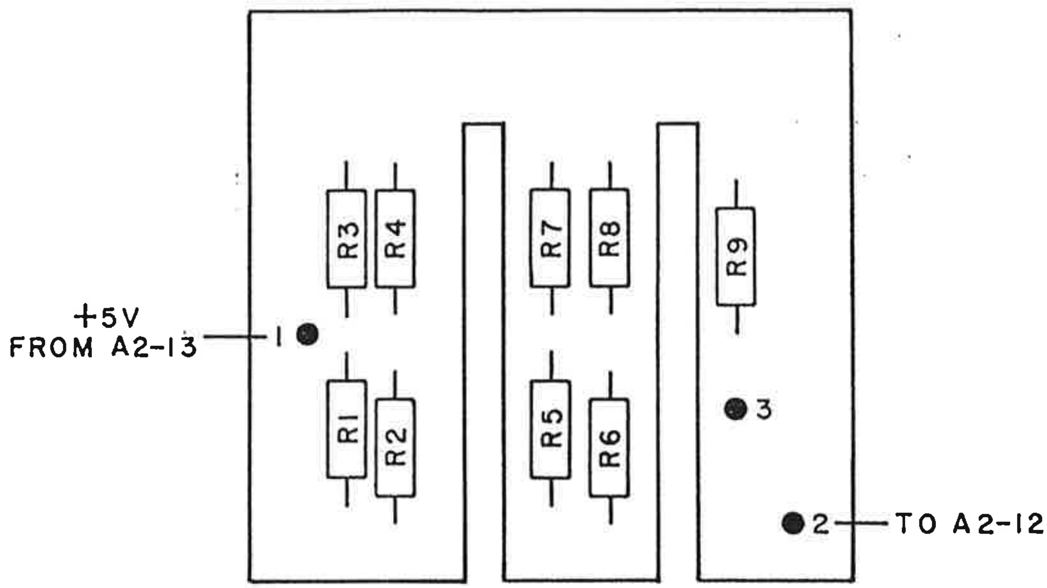
C201	C: FIXED CERAMIC 0.1uF 50V	0151-0006
C202	C: FIXED CERAMIC 0.1uF 50V	0151-0015
R201	R: FIXED CARBON 4.7k 5% 1/4W	0683-4725
U201	IC: 78L05CP	1826-0012
U202	XO: 650kHz	0415-0065



FMM-2 A2-1
650kHz XO BOARD
BELAR ELECTRONICS



FMM-2 A2-1 BOARD
COMPONENT LAYOUT
BELAR ELECTRONICS

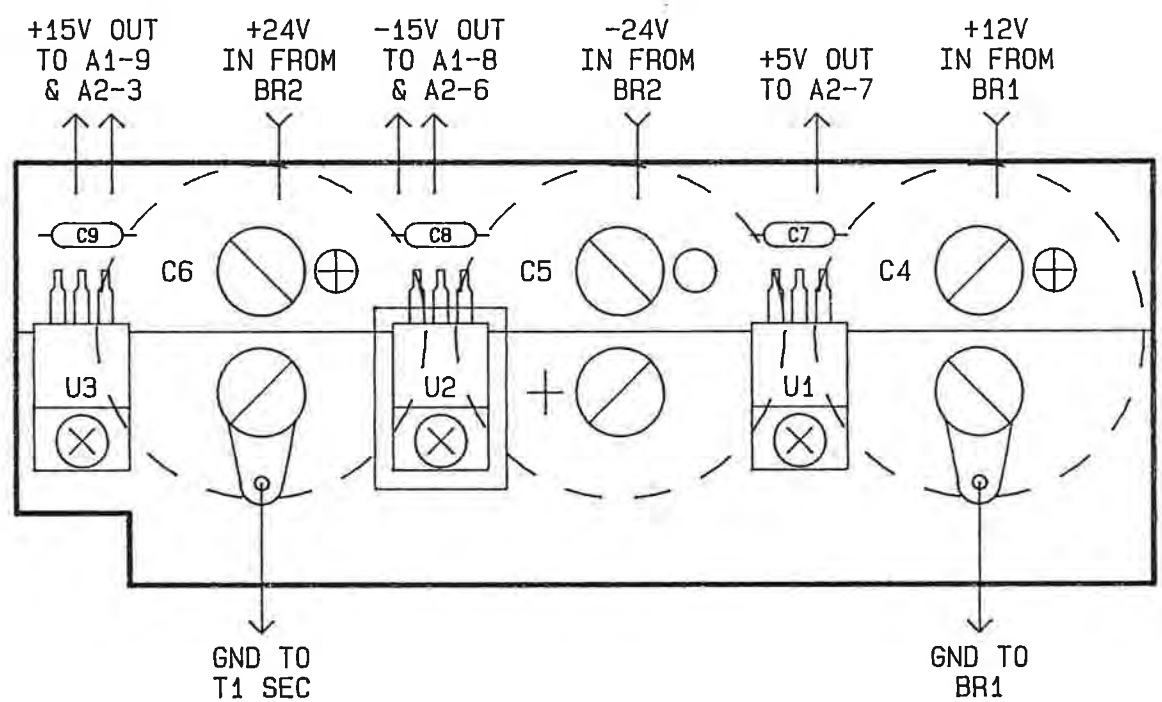


FMM-2 A3 BOARD
DETAIL

See FMM-2 Chassis Wiring Drawing for A3 board schematic.

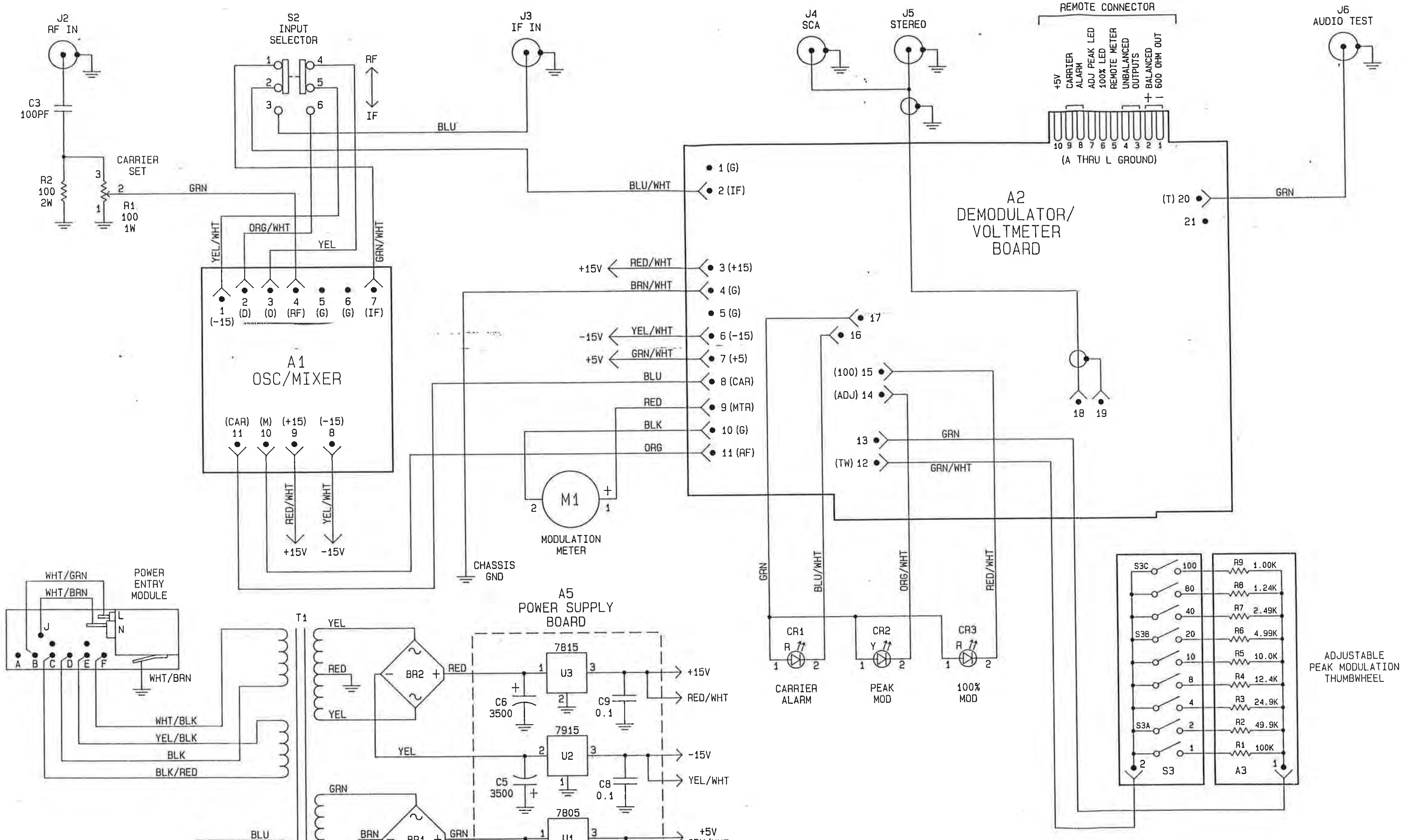
A3 BOARD

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

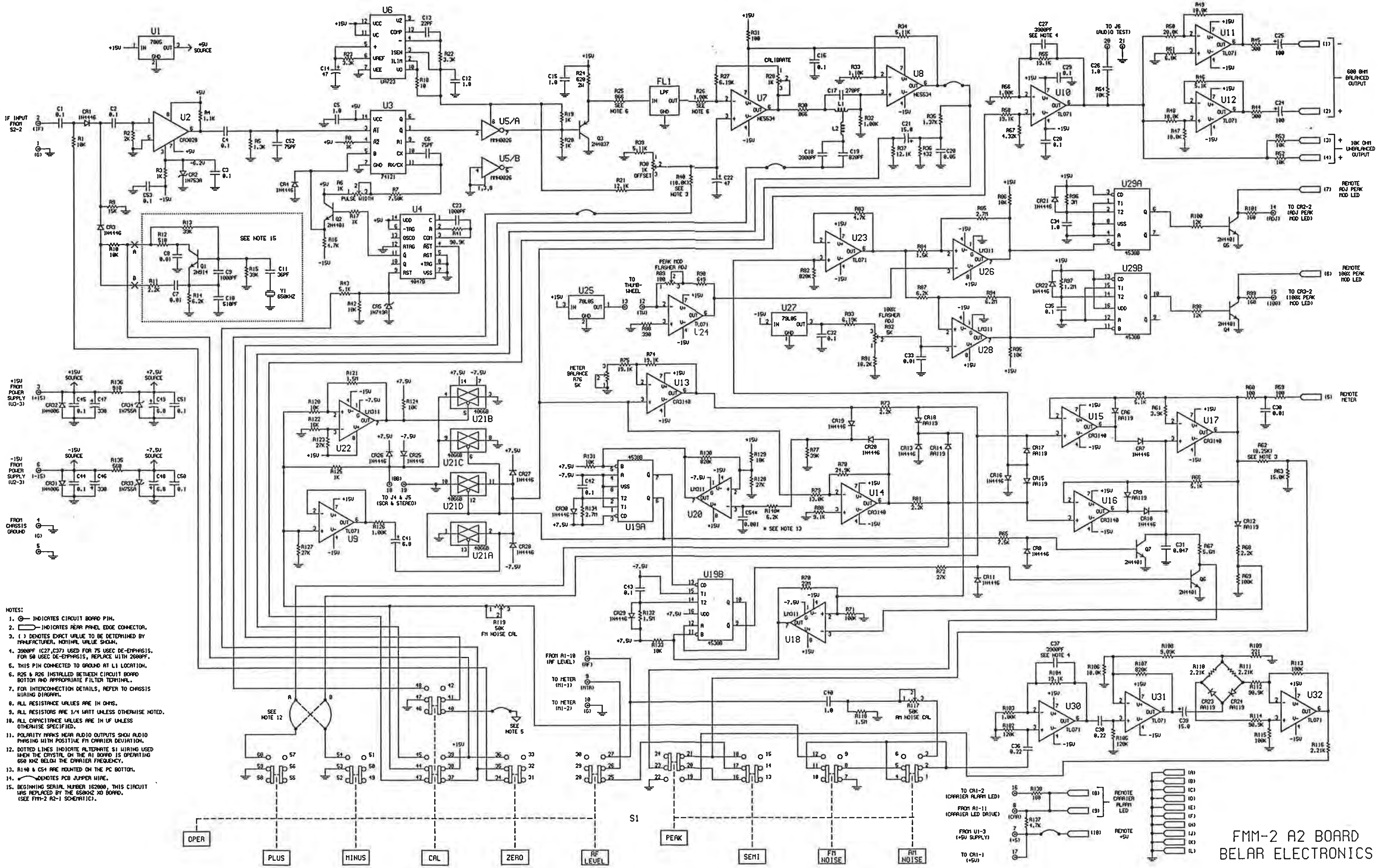


(USED BEGINNING SERIAL NUMBER 161259)

FMM-2
A5 POWER SUPPLY BOARD
COMPONENT LAYOUT



FMM-2 CHASSIS WIRING
BELAR ELECTRONICS



NOTES:

1. —INDICATES CIRCUIT BOARD PIN.
2. —INDICATES REAR PANEL EDGE CONNECTOR.
3. ( ) DENOTES EXACT VALUE TO BE DETERMINED BY MANUFACTURER. NOMINAL VALUE SHOWN.
4. 3900PF (C27,C37) USED FOR 75 USEC DE-EMPHASIS. FOR 50 USEC DE-EMPHASIS, REPLACE WITH 2600PF.
5. THIS PIN CONNECTED TO GROUND AT L1 LOCATION.
6. R25 & R26 INSTALLED BETWEEN CIRCUIT BOARD BOTTOM AND APPROPRIATE FILTER TERMINAL.
7. FOR INTERCONNECTION DETAILS, REFER TO CHASSIS WIRING DIAGRAM.
8. ALL RESISTANCE VALUES ARE IN OHMS.
9. ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE NOTED.
10. ALL CAPACITANCE VALUES ARE IN UF UNLESS OTHERWISE SPECIFIED.
11. POLARITY MARKS NEAR AUDIO OUTPUTS SHOW AUDIO PHASING WITH POSITIVE FM CARRIER DEVIATION.
12. DOTTED LINES INDICATE ALTERNATE S1 WIRING USED WHEN THE CRYSTAL ON THE A1 BOARD IS OPERATING 650 KHZ BELOW THE CARRIER FREQUENCY.
13. R140 & C54 ARE MOUNTED ON THE PC BOTTOM.
14. —DENOTES PCB JUMPER WIRE.
15. BEGINNING SERIAL NUMBER 162000, THIS CIRCUIT WAS REPLACED BY THE 650KHZ XO BOARD. (SEE FMM-2 A2-1 SCHEMATIC).

FMM-2 A2 BOARD
BELAR ELECTRONICS