Model AMM- I
AM FREQUENCY MONITOR

Guide to Operations

10/00

BELAR ELECTRONICS LABORATORY, INC.
119 LANCASTER AVENUE • P.O. BOX 76 • DEVON, PA 19333-0076 USA
VOICE(610) 687-5550 • FAX (610) 687-2686
WEB: http://www.belar.com/ • e-mail: sales@belar.com • service@belar.com • parts@belar.com

SECTION 1

GENERAL INFORMATION

1–1 GENERAL DESCRIPTION

The Belar AMM–1 AM Frequency and Modulation Monitor (FCC Type Approval Number3-176), Figure 1–1, is an all solid state AM monitor designed to meet the Federal Communications Commission requirements for measuring the center frequency and total modulation characteristics of AM transmitters. A switch is provided to measure either positive or negative polarities on the modulation meter and normal peak indicator. A separate peak indicator is included to indicate negative peaks in excess of 99%. The AMM–1 incorporates a modulation calibrator as well as ±19.5 Hz frequency calibrators to insure the accuracy of the readings at any time.

1–2 PHYSICAL DESCRIPTION

The AMM–1, Figure 1–2, is constructed on a standard 5¼ x 19 inch rack mount. Seldom used controls and test points are located under the hinged front cover bar. Factory adjustments are located within the unit. The AC power input, RF inputs, and monitor outputs are located at the rear of the AMM–1 chassis on individual connectors and rear terminal block as shown in Figure 1–3. The AMM–1 is completely solid state utilizing all silicon transistors and integrated circuits for long, trouble-free life. The individual circuits are constructed on military grade, glass-epoxy, plated printed circuit boards. High reliability industrial and military grade components are used throughout.

1–3 ELECTRICAL DESCRIPTION

The AMM–1 is a solid state, low sensitivity AM receiver that incorporates a highly linear AM detector that demodulates the AM envelope and a digital frequency counter circuit with a digital to analog converter that measures center frequency deviation. Various metering and testing provisions are contained within the monitor to measure transmitter output characteristics. These provisions include a center frequency deviation meter; a carrier level meter; a peak reading modulation meter, switchable to either positive or negative modulation polarity; a peak modulation light, switched with the modulation meter to either positive or negative modulation polarity; a peak modulation light that responds when the negative modulation exceeds 99%; a modulation calibrator to standardize the modulation level; ±19.5Hz off frequency calibrators to standardize the digital to analog converter; a clock count to insure that the logic circuits in the frequency counter are functioning. Outputs obtained from the monitor include an output for aural monitoring, a distortion meter test output, a transistor driver for carrier off alarm. FCC Type Approved remote metering of the AMM–1 may be externally provided for the center frequency deviation meter, carrier level meter, modulation meter, normal peak light, and 100% negative peak light.

1–4 ELECTRICAL SPECIFICATIONS

MODULATION

RF Input Frequency	260 kHz – 1610 kHz
RF Sensitivity (Modulation Input)	5 – 10 volts RMS
RF Input Impedance	1000 ohms (May be bridged for lower impedance)
Modulation Meter Range	133%
Carrier Level Meter Range	80% – 110%
Peak Modulation Indicator	50 – 120% Positive 50 – 100% Negative
Modulation Metering Circuit	Complies with Par. 73.500
Frequency Response	0.5 dB 30 Hz - 10 kHz
100% Negative Flasher	100% Negative – Indicates carrier off independent of any calibration procedure
Remote Metering	All meters and lamps may be remotely metered
Distortion	0.25% max. at 95% mod or less 0.5% max. at 100% mod
Signal-to-Noise Radio	75 db
Outputs	+10 dbm, 600 ohm aural monitoring output 5 V RMS, 10 K ohm distortion meter output
Remote Metering	All meters may be remotely metered–5000 ohms external loop resistance

FREQUENCY

RF Input Frequency	540 kHz – 1600 kHz
RF Sensitivity (Freq. Input)	100 mv RMS
RF Input Impedance	1000 ohms (may be bridged for lower impedance)
Frequency Meter Range	30 Hz
Oscillator Stability	Within 5 PPM – 10 to 35 C (temp, humidity, power supply and aging)
Alarm	28 V signal at ± 20 Hz (± 16 Hz opt.) or loss of input
Remote Metering	All meters may be remotely metered–5000 ohms external loop resistance

1–5 MECHANICAL SPECIFICATIONS

Dimensions	5¼ x 19 x 11 7/8 inches overall
Detailed Dimensions	Figure 1–4
Net Weight	15 pounds
Shipping Weight	19 pounds

1–6 INSTRUMENT IDENTIFICATION

The instrument is identified by the model number and a six digit serial number. The model number and serial number appear on a plate located on the rear panel, Figure 1–3. All correspondence to your Belar representative or to the Belar factory in regard to the instrument should reference the model number and complete serial number.

1–7 ACCESSORIES

The Belar AMM–1 AM Frequency and Modulation Monitor may be used for remote monitoring of an AM transmitter with either the Belar MP–5 Remote Meter and Flasher Panel or the Belar RFA–2 AM RF Amplifier. The MP–5 Remote Meter and Flasher Panel contains a center frequency deviation meter, a carrier level meter, and a modulation meter, all designed for approximately 5000 ohms loop resistance. The MP–5 also includes the normal peak light and 100% negative peak light. The RFA–2 AM RF Amplifier provides pre-amplification and selectivity to permit direct off-air monitoring with the AMM–1.

SECTION 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.

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 of 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 AMM–1 AM Frequency and Modulation Monitor is designed to be mounted in a standard 19-inch rack mount. When the monitor is mounted above high heat generation equipment such as vacuum-tube power supplies, consideration should be given to cooling requirements which allow a free movement of cooler air around the AMM–1. In no instance should the ambient chassis temperature be allowed to rise above 50 degrees C (122 degrees F). Mount the AMM–1 to the rack mount using four No. 10 screws and four No. 10 countersunk finishing washers.

The Model AMM–1 requires a 105 to 125 VAC single phase, 50 to 60 Hz power sources. Attach the three wire, grounded 115 VAC grounded receptacle.

CAUTION: BEFORE APPLYING ANY RF INPUT, TURN CARRIER LEVEL CONTROL MAXIMUM COUNTER-CLOCKWISE.

If a modulated carrier is to be sampled, interconnect J2 and J3 with the cable supplied. Connect a coaxial cable (RG–58 or RG–59) between the monitor probe on the transmitter (or RF amplifier) and J1 (MOD RF IN) at the rear of the main chassis.

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

If separate modulated and unmodulated carriers are to be used from the transmitter, connect a coaxial cable (RG–58 or RG–59) between the unmodulated carrier monitor probe of the transmitter and J3 (FREQ RF IN). Connect a coaxial cable (RG–58 or RG–59) between the modulated carrier monitor probe of the transmitter and J1 (MOD RF IN). Again observe the caution with excessive RF level. Connect a jumper wire between TB1–10 and TB1–12 so that the 100% negative light remains on when there is a loss of signal to the frequency counter.

If desired, connect external aural monitoring amplifier to terminals 1 and 2 on TB1. Note that this is an unbalanced 600 ohm output with terminal 1 grounded. A remote center frequency deviation meter, carrier level meter, and modulation meter may be connected to terminals 7 and 8, 3 and 4, and 6 and 5 respectively, if desired. Observe the proper polaritites (terminals 3, 6, and 7 are positive). Note that terminals 3 and 7 are grounded but the pair for the modulation meter is above ground. Also note that the external loop resistance, not including meters, must be approximately 5000 ohms. These meters must be obtained from Belar Electronics Laboratory, Inc. in order to comply with FCC regulations on remote metering. A remote peak modulation lamp may be connected to terminals 9 and 11 on TB1. A remote 100% negative lamp may be connected to terminals 10 and 11 on TB1. A lamp may be also connected to terminals 11 and 12 on TB1 to indicate when the carrier is off frequency or loss of signal to the frequency counter circuit. The remote meters and two lamps are contained in the MP–5 Remote Meter and Flasher Panel.

SECTION 3

OPERATION

3—1 INITIAL OPERATION

The following procedure should be followed when placing the unit into initial operation. Refer to Figure 3—1 for control locations:

1. Before turning the unit on, depress the ZERO switch and release the REMOTE METERS switch.

2. Depress POWER switch and allow a 15-minute warmup.

3. Adjust FREQ ZERO control to zero FREQ DEVIATION meter.

4. Adjust MOD ZERO control to zero MODULATION METER.

5. Depress —19.5 switch — FREQ DEVIATION meter should read —19.5 Hz. Depress 19.5 switch — FREQ DEVIATION meter should read 19.5 Hz.

NOTE: Since the AMM-1 is a digital counter with approx. a 2 second gate time, a waiting period of a few seconds may be necessary to allow the counter to obtain a valid count.

6. Depress MOD CAL switch — CARRIER LEVEL meter & MODULATION meter should indicate. Adjust CARRIER LEVEL control to make the CARRIER LEVEL meter indicate 100%. The MODULATION meter should also indicate 100% at this time. This verifies the calibration of the Modulation Monitor. After this check, turn the CARRIER LEVEL control full CCW.

7. Connect a modulated RF signal (5—10 volts RMS) to J1 MOD. RF IN jack at rear of unit. Depress (—) OPER or (+) OPER switch depending on which modulation polarity is to be measured. Adjust CARRIER LEVEL control until CARRIER LEVEL meter indicates 100%. Adjust PEAK FLASHER control to level desired. The 100% NEG lamp will flash on 100% negative peaks regardless of any control settings. NOTE: DO NOT EXCEED 10V RMS OF RF INTO THE MONITOR.

8. If unmodulated RF is available for the Frequency Monitor (100 mv — 5V RMS) connect to J3 FREQ RF IN jack at rear of unit. If unmodulated RF is not available, connect a short jumper from J2 LIMITER OUT jack to J3 FREQ RF IN jack.

NOTE: With the latter connection, if the transmitter is modulated more than 100% negative, the FREQ DEVIATION meter will indicate a frequency error. This is because the monitor is a digital counter and some cycles of RF are lost if the transmitter is overmodulated.

9. The frequency monitor is adjusted at the factory to read correctly for all Standard Broadcast frequencies. In the event the monitor should require recalibration, the following procedure should be used:

a. Determine the transmitter frequency using an external frequency measurement service.

b. Use a small screwdriver to adjust the clock oscillator trimmer C20, accessible through the hole in the front panel. Turning the trimmer CW will move the FREQ DEVIATION meter toward plus deviation.

NOTE: Allow a few seconds after each movement of the trimmer so that the counter may obtain a complete count at the new clock frequency.

10. An external alarm may be connected between terminals 11 & 12 on the rear panel. 28 VDC is applied across these terminals when the measured frequency deviates more than 20 Hz (16 Hz optional) from the assigned frequency or if the input is lost to the FREQ RF IN jack J3. Alternately, a jumper may be connected between terminals 10 and 12 in which case the 100% NEG lamp will also indicate the frequency alarm.

11. If REMOTE metering is connected, depress the REMOTE METERS switch.

SECTION 4

PRINCIPLES OF OPERATION

4–1 MODULATION MONITOR

The modulated RF carrier is fed to J1 MOD RF IN located on the rear of the monitor. From there the signal is applied to a diode detector (A2CR1 and A2CR2) through the CARRIER LEVEL control. Transistor A2Q1 is a constant current source that provides sufficient forward bias to operate the detector diodes in the linear region. Switch S6 selects the output of the positive or negative detector. The detected output is filtered by the low pass filter consisting of A2C1 or 2, A2L1, A2C3, A2L2 and A2C4.

The DC output of the detector is fed via A2R4 and A2R5 to the CARRIER LEVEL meter. A2R7 controls the level of the audio fed to the buffer amplifier consisting of A2Q2 and A2Q3. A2CR5, A2C7 and A2R12 comprise a peak detector and FET A2Q4 and A2Q5 form a DC amplifier which drives the modulation meter. The output of A2Q3 is also fed thru A2R11 to a Schmitt Trigger consisting of A2Q10 and A2Q11. The PEAK MODULATION control sets the level at which the Schmitt fires. When the Schmitt fires, it triggers the monostable multivibrator consisting of A2Q12 and A2Q14. This produces a pulse approximately 200 – 300 msec long which flashes the PEAK lamp through lamp driver A2Q13. Transistor A2Q6, A2Q7, A2Q8 and A2Q9 form a low distortion amplifier capable of driving monitor amplifiers, distortion analyzers, etc.

The modulated RF carrier is also fed through a limiter consisting of A2R48, A2CR10 and A2CR11 to A2IC1 which supplies approx. 35 dB gain. This output is fed to the clocking input of a flip flop. (l/2 of A2IC2). The output of this flip flop is a square wave at one half the carrier frequency. This signal is fed through a lowpass filter consisting of A2C25, A2L3 and A2C26 to switch A2Q15. If the carrier is lost for more than approximately 8–10 usec, A2Q15 sets the other flip flop in A2IC2. This turns on the 100% NEG lamp through the lamp driver consisting of A2Q16 and A2Q18. This also allows A2C28 to charge through A2R63. When the voltage on A2C28 exceeds the trigger point of UJT A2Q17, (Approx. 200 msec) the UJT fires discharging A2C28 and resetting the flip flop thus shutting the 100% NEG lamp off.

Transistor A2Q19, A2Q20 and A2Q21 form a Wien Bridge oscillator operating at approximately 1 KHz. When the MOD CAL switch is depressed, the output of this oscillator is applied across the CARRIER LEVEL control. Another contact on the MOD CAL switch connects C4 and R6 to the positive detector (A2CRs). The action of C4, R6, and the positive detector C1 amps the 1 KHz signal at the junction of A2CR1 and A2CR2 to the DC voltage existing at that point. This allows the entire 1 KHz signal to be passed by the negative detector A2CR1 and therefore becomes a reference for checking the accuracy of the CARRIER LEVEL meter against the MODULATION meter.

4–2 FREQUENCY MONITOR

The output of a stable, crystal controlled oscillator operating at 2.048000 MHz (A4Q1 & A4IC1) is fed to a time base count down chain consisting of 23 Flip Flops. (A3 IC1 thru A3IC12) The output of this chain is a pulse that is high for 2.048 seconds. The RF carrier to be measured is connected to FREQ RF IN jack J3 on the rear of the unit. From there it is fed to a limiter and amplifier consisting of A4R12, A4CR3 and 4 and A4IC2. The output of A4IC2 is then gated with the 2.048 second gate pulse in a NOR gate (p/o A3IC13). The gated RF is then fed to a 10 flip flop ripple counter consisting of A3IC16 through A31C20. The Ripple counter returns to its preset condition every 1,024 pulses. This causes the counter to return to its preset condition after counting any frequency exactly divisible by 500 for 2.048 seconds. Since the counter is preset to 32, and its maximum count is 512, any remainder from 32 to 288 will indicate a plus deviation and any remainder from 288 to 32 will indicate a minus deviation.

After the counter stops counting, a transfer pulse is generated which transfers the information in the counter to a 10 flip flop storage register consisting of A3IC21 through A3IC25. This allows the information to be displayed while the counter is accumulating a new count. After the information is transfered to the register, a preset pulse resets the counter to 32 then the gate opens allowing the counter to accumulate the new count. The storage register outputs are fed to the digital-analog converter, the high and low limit decoders, and the alarm decoders. The outputs of the first seven flip flops are supplied to the digital-analog converter. As long as the remainder is between 0 and 64, these outputs cause the meter to indicate the frequency error. If the count is between 64 and 288, a high limit signal is decoded causing the meter to pin in the plus direction. If the count is between 288 and 0, a low limit signal is decoded causing the meter to pin in the minus direction. An alarm signal is decoded from 52 through 12 (±20Hz) or at 48 through 16 (±16 Hz). An additional alarm is generated if the RF input to the Frequency Monitor is lost. A flip flop (P/0 A3IC12) is set to the alarm condition by the leading edge of the gate pulse. If the Ripple counter accumulates any count, the switching of the 10th flip flop in the counter resets the alarm flip flop. If the counter does not receive an input, the flip flop remains in the alarm condition.

Test functions are provided to check the logic. The ZERO switch allows the counter to count the clock oscillator. If the logic is operating correctly, the counter will return to the preset state and indicate a zero on the FREQ DEV meter. If the –19.5 switch is depressed, the counter counts the clock and the signal paths from counter to storage register are modified so that for a 32 in the counter, a 12 is transferred to the storage register causing the FREQ. DEV meter to indicate –19.5 Hz. If the +19.5 switch is depressed, a 52 is transferred to the register causing the meter to indicate + 19.5 Hz.

NOTE: Since a count of 512 Hz = 500 Hz, a count of 20 equals 19.5 Hz.

TEMPORARY CALIBRATION SEQUENCE FOR AMM-1

(Operation has been checked and all prescribed parts replacements and unit indications have been completed.)

1. Mechanically zero meters

2. Turn unit on

3. Place unit in positive modulation mode. Remove wire from pin 13 of modulation board and measure resistance between wire and chassis. Remove wire from pin #7 of modulation board and measure resistance between pin #7 and ground. Adjust R5 so this resistance is the same as the first reading. Reattach wires to pins.

4. Electrically zero modulation meter

5. With unmodulated carrier, check to see that modulation meter remains at zero in both negative and positive monitoring positions. Unbalance would indicate that C5 is leaky or that the carrier is asymmetrical.

6. Apply a 100% modulated signal to the monitor and set the carrier level. Adjust R7 for proper meter indication.

7. Reduce modulation to 95% and check for equal indication in positive and negative modes. Indication should be within 1%.

8. Press "Calibrate" and abserve output of calibration oscillator at pin 6 of modulation board. Adjust R70 to obtain a waveform that is slightly chipped on the bottom. Adjust the value of R6 on the front panel switch assembly so that simultaneous readings of 100% can be obtained on the modulation and carrier level meters by adjusting R1, the carrier level control. Final value for R5 should be around 2.2kΩ. R70 may have to be

changed to insure sufficient output margin for the oscillator (110%). There will be interaction between the adjustments in this step.

9. Set peak flasher control using a modulated waveform. Absolute setting is determined by knob mounting. Span is controlled by R11. Set the flasher at 100%. Check linearity at 50%.

10. Set negative flasher control R57 to 3/4 full clockwise. Check flasher operation by reducing carrier level of modulated waveform.

11. Check audio distortion, frequency response, and signal to noise ratio. Distortion should be less than .4%. Three-decibel points should be at about 5 Hz and 25 KHz. Signal-to-noise ratio should be $\geq$65db.

12. Check that meter indications remain the same with external 5.1kΩ resistors attached. Modulation meter should drop 6% with 7.5kΩ resistor attached.

Follow sequence on page 12 of BW50 manual for frequency calibration. If adjustments are made to the crystal frequency, set C1 (on board) so that C20 is approximately centered when adjustment is complete.

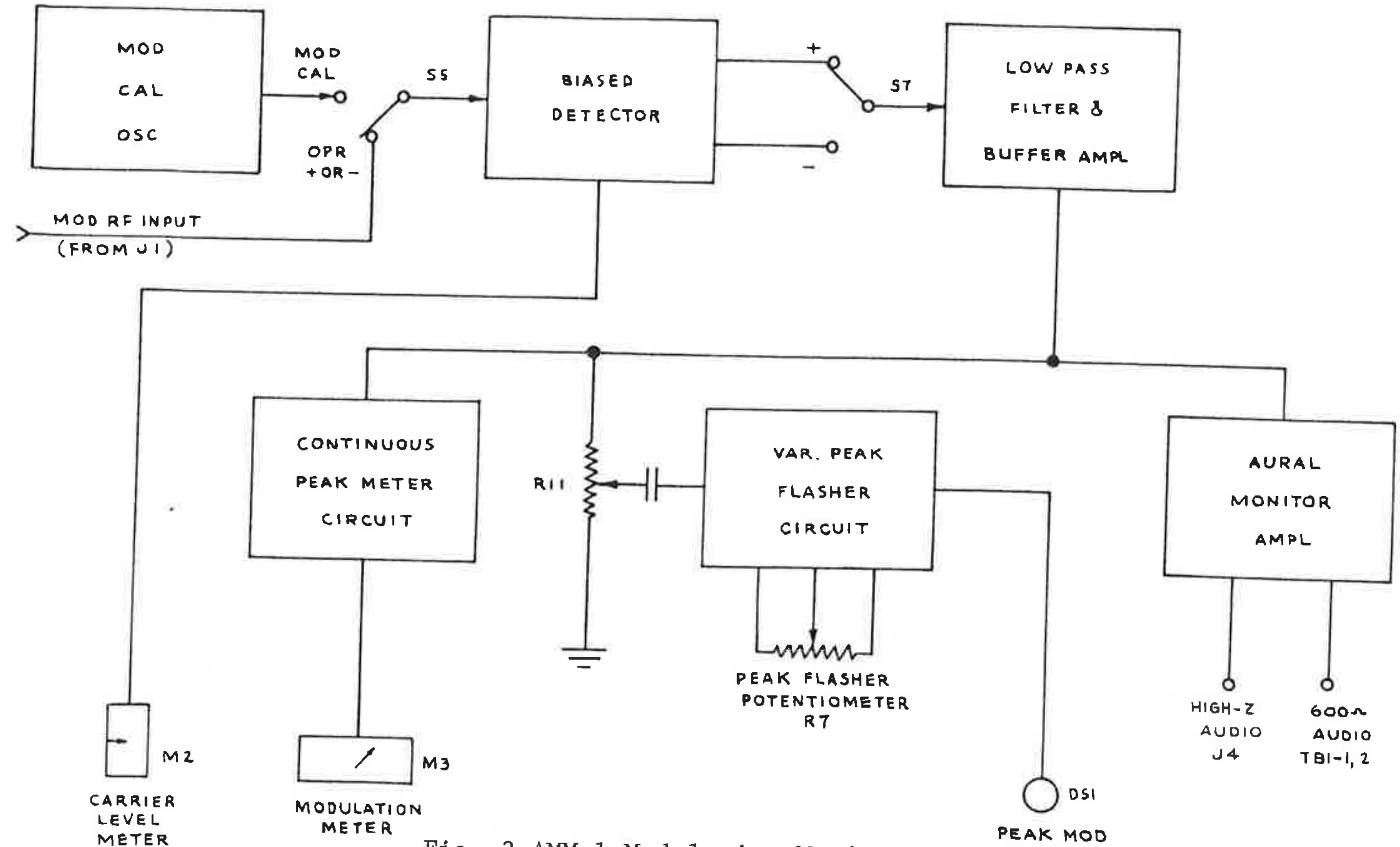


Fig. 3 AMM-1 Modulation Monitor Block Diagram.

100% Negative Modulation Indicator

This circuit controls a red front panel flasher and a rear panel alarm terminal, regardless of the position of the front panel function switches or calibration potentiometers. Although this circuit is located on the Modulation Measurement assembly, it is electrically and functionally independent.

Modulated RF carrier from the MOD RF IN jack, J1 (Fig. 13), is limited by R48, CR10 and CR11 (Fig. 14) and amplified by U1 with a gain of approximately 35 dB. The limited RF is biased by R56 and R57, and applied to the clocking input of flip-flop U2A. Adjustment of this bias, by R57, sets the sensitivity threshold of the 100% Negative Modulation Indicator. Output of the flip-flop is a squarewave at one-half carrier frequency. This squarewave is lowpass filtered by C25, L3, C26, and used to hold transistor switch, Q15, in a normally closed condition.

Should a negative peak occur, momentary loss of carrier causes the transistor switch to open, allowing the voltage level to rise at the Direct Set input of a second flip-flop U2B. If the peak exceeds approximately 8-10 usec, this flip-flop will be set, turning off transistor Q16. When Q16 is off, lamp driver Q18 is turned on, and capacitor C28 exceeds the trigger point of UJT Q17 (approximately 200 msec), the UJT fires, discharging C28 and causing flip-flop U2B to reset, thus shutting off the 100% Negative Modulation Indicator.

NOTE: In extended absence of carrier, as when the transmitter is off or no signal is applied to MOD RF IN jack, J1, the state of flip-flop U2A is indeterminate. Under such conditions the 100% NEGATIVE FLASHER DS2 may

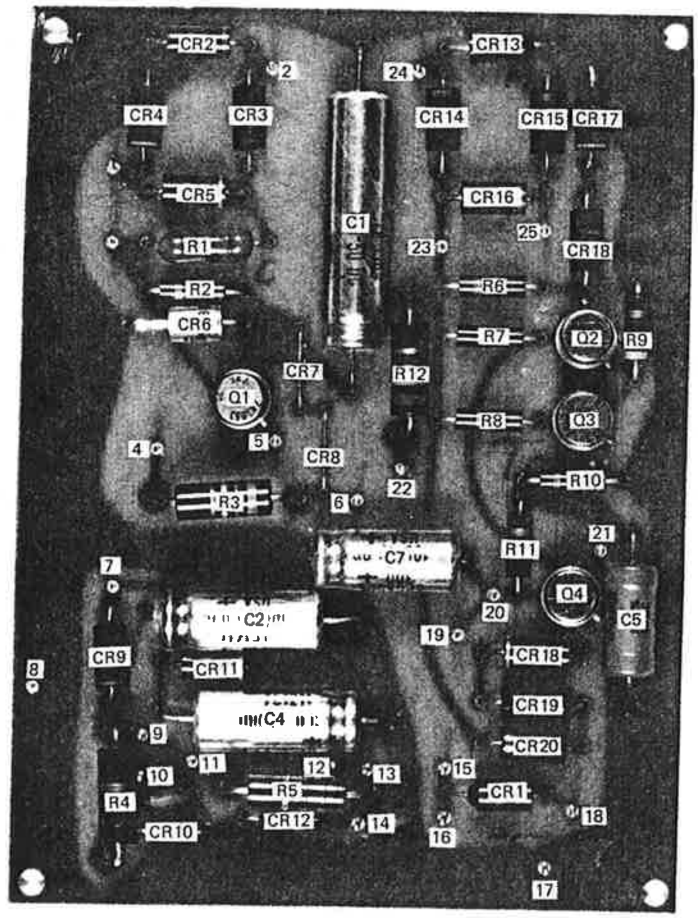


Fig. 4. AMM-1 Power Supply Components.

normally be either on or off. A separate "carrier off" alarm is provided as a part of the Frequency Monitor (Counter and Logic Assembly).

FREQUENCY MEASUREMENT

The RCA Frequency Monitor (Counter and Logic Assembly) uses a highly accurate all-digital direct counting technique to determine frequency deviation. This technique minimizes the effect of critical circuit parameters upon the accuracy of measurement and eliminates the oven-stabilized crystal required by conventional heterodyne monitors.

Frequency measurements may be made by counting cycles of the carrier for a known time period. The frequency is thus determined as: f=N/T, where N is the number of cycles counted in time period T. Similarly, frequency deviation, or the difference of an actual frequency from its assigned value, is represented by: $\Delta f = \Delta N/T$, where Δf is the frequency difference represented by a difference ΔN, in the number of cycles counted in the base period T. For 1/2 Hz resolution, a base period of at least two seconds is required. To provide a decimal frequency deviation display while using a straight binary frequency counter, a scale factor is introduced into the time base.

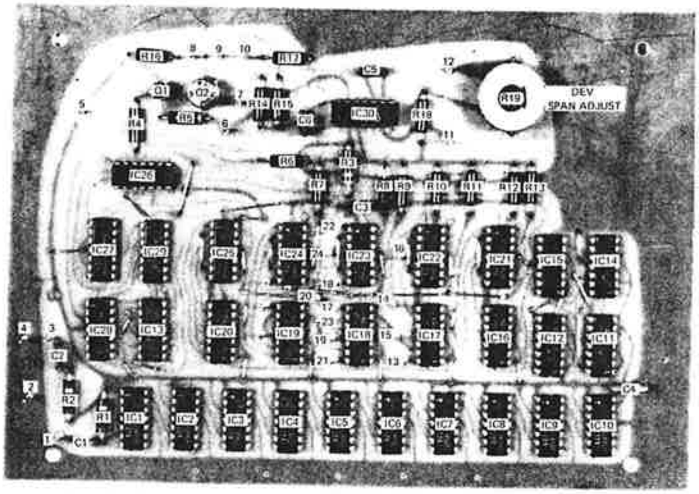


Fig 5. AMM-1 Counter and Logic Assembly Components.

In the BW-50, a 10-bit binary counter is used with a time base of 2.048 sec. The digital deviation counter has a resulting range of $\Delta f = 2^{10}/2.048 = 1024/2.048 = 500$ Hz or ± 250 Hz from any nominal frequency which is an integral multiple of 500 Hz.

Circuit functions are illustrated by Figure 8. The monitor comprises a time base generator consisting of a crystal oscillator and binary countdown chain, RF limiter and buffer amplifier, gated binary frequency counter, binary storage or holding register, digital to analog converter, and front panel display meter, together with associated control and alarm logic.

The output of a stable, crystal-controlled 2.048000 MHz Colpitts oscillator, Q1 (Fig. 9) is amplified by U1. Variable bias AGC feedback circuit CR1, 2, R9-11, enhances stability and accuracy of the oscillator. The resulting signal appearing at pins 1 and 3 is the master reference clock. For proper operation the clock is adjusted by R11 to have an amplitude of 2.4 V P-P. The master reference clock frequency is divided by a binary countdown chain consisting of 23 flip-flops U1-12A (Fig. 15) to yield a periodic time base pulse which is high for 2.048 seconds.

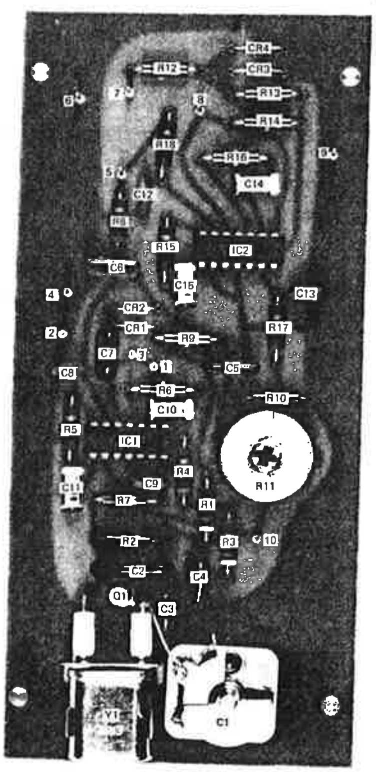
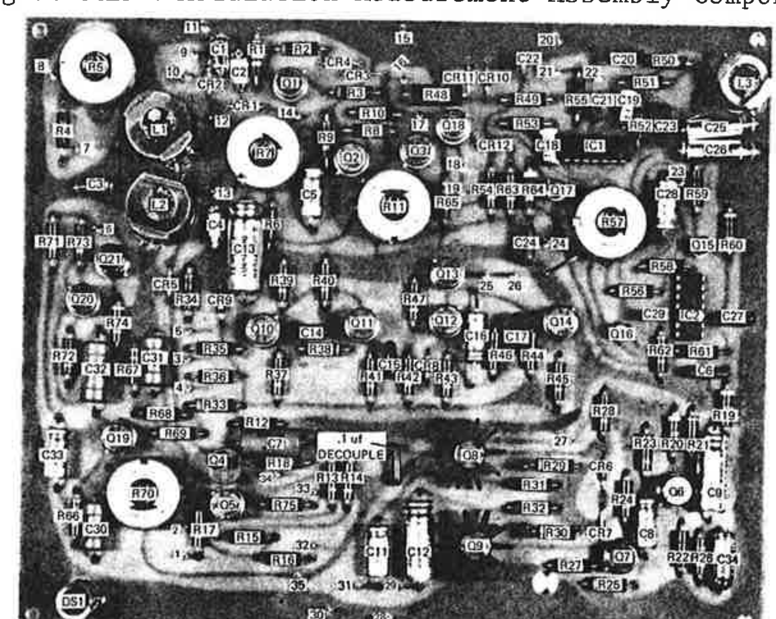


Fig 6. AMM-1 Clock Oscillator and Counter Driver Components.

Fig 7. AMM-1 Modulation Measurement Assembly Components.



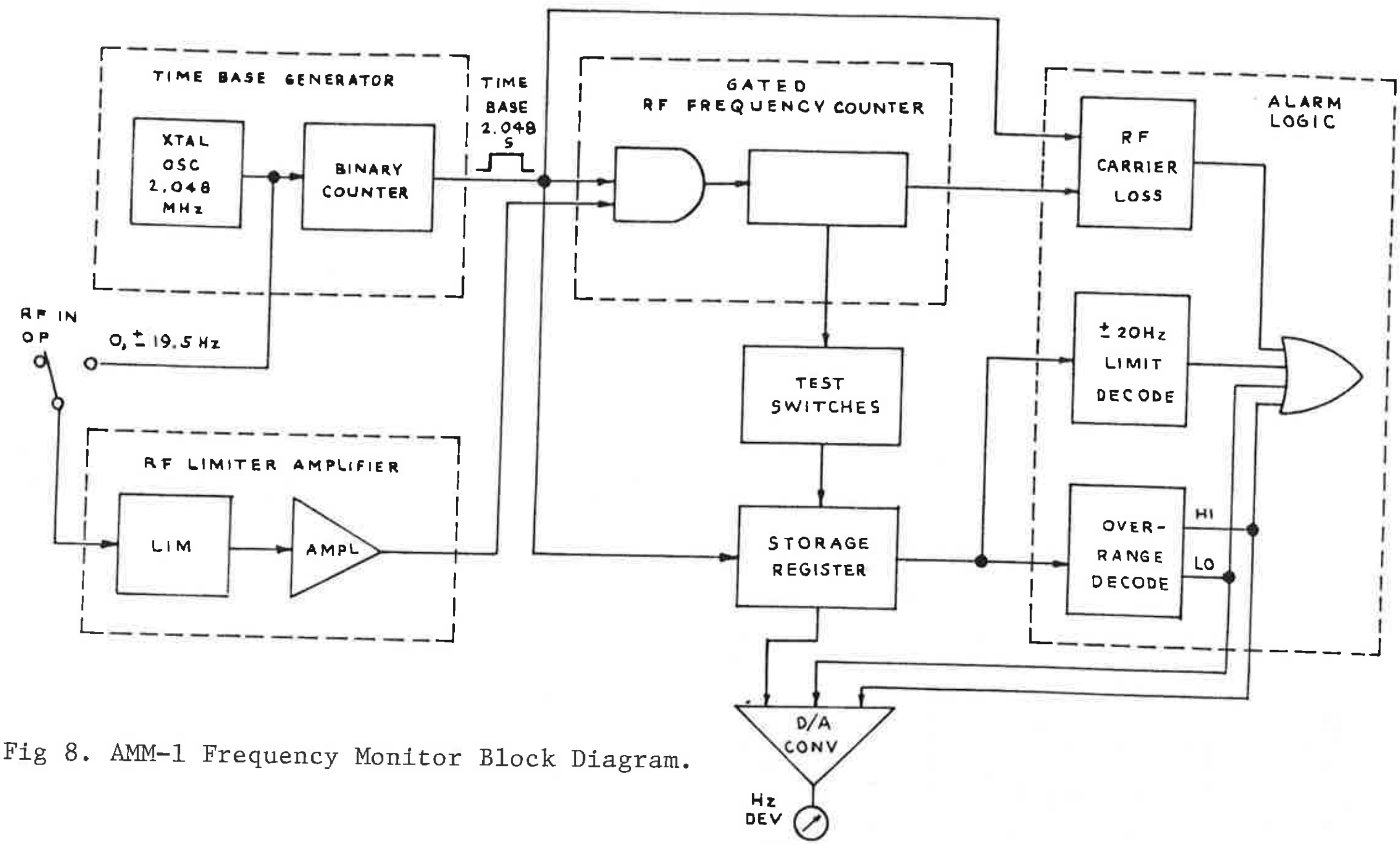


Fig 8. AMM-1 Frequency Monitor Block Diagram.

RF carrier to be measured is applied to FREQ RF IN/jack, J3, on the rear panel. The carrier is limited by CR3, 4 (Fig. 9) and amplified by U2 to produce a squarewave at the carrier frequency.

Limited RF carrier is gated in NOR gate U13A (Fig. 15) by the 2.048-second time base pulse. Gated RF drives a 10 flip-flop binary ripple counter, U16-20. This counter recycles to its initial state every 1024 pulses. For any frequency exactly divisible by 500, the number of RF carrier cycles gated into the counter will be exactly divisible by 1024, and the final state of the counter will be the same as its initial state. Since the counter is cleared to a zero initial state before each measurement cycle, a final state between 0 and 511 represents a positive deviation, while a final state between 512 and 1023 represents a negative deviation.

At the end of the 2.048-second measurement cycle, the final state of the counter is strobed (transferred) into the 10 flip-flop storage register U21 to U25 (Fig. 15). This allows the information to be displayed until updated by the next completed measurement. After the state of the counter has been strobed into the storage register, the counter is cleared in preparation for the next measurement cycle. After a 2.048-second "off" cycle, a new measurement cycle is initiated by gating on the RF carrier. The display is thus updated every 4.096 seconds. Storage register outputs are fed to the D/A converter, the overrange decoders, and the limit alarm decoders.

NOTE: The counter and holding register flip-flops are considered to be binary weighted so that U16A and U21A = 1 wt., U16B and U21B = 2 wt., . . . U20B and U25B = 512 wt. The count in the register is then equal to the sum of the weights of the flip-flops whose Q outputs are high. To allow display of the deviation on a zero center meter, the 64-weight "bit" (binary digit) is inverted during the transfer. This inversion has the effect of "biasing" the count in the holding register by 64.

The outputs of the least significant seven bits of the storage register are applied to the binary-weighted precision resistance ladder R7 to R13 (Fig. 15) which forms a part of the D/A converter. The most significant four bits of the storage register (weighted 512, 256, 128, and 64) are applied to the overrange decoders U26A, U27, U29A, U29B. Storage register counts between 128 and 575 activate the positive overrange detector, while counts between 576 and 1023 activate the negative overrange. Additional weighted resistors R6 and R14 are driven by the overrange decoders so as to display appropriate positive or negative full-scale reading when the measured deviation exceeds ±32 Hz. The summing amplifier U30 is balanced for a correct zero deviation null by means of the front panel FREQ ZERO pot R9 (Fig. 15).

The alarm limit decoder, U13B-D, U28, U29C-F, is driven by the storage register bits weighted 64, 32, 16, and 8. The output of this decoder is activated by counts representing a frequency deviation greater than ±20 Hz. A regular production

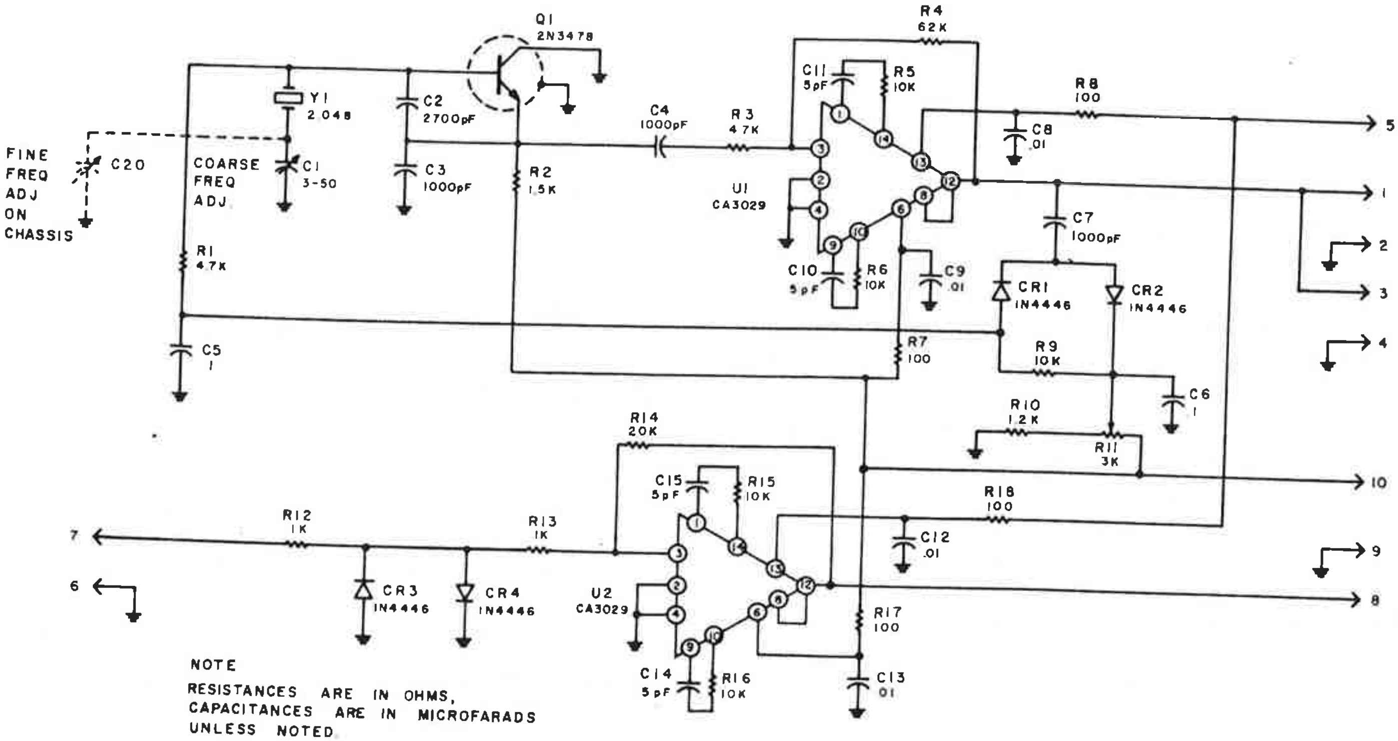


Fig 9. AMM-1 Clock Oscillator and counter Driver Schematic.

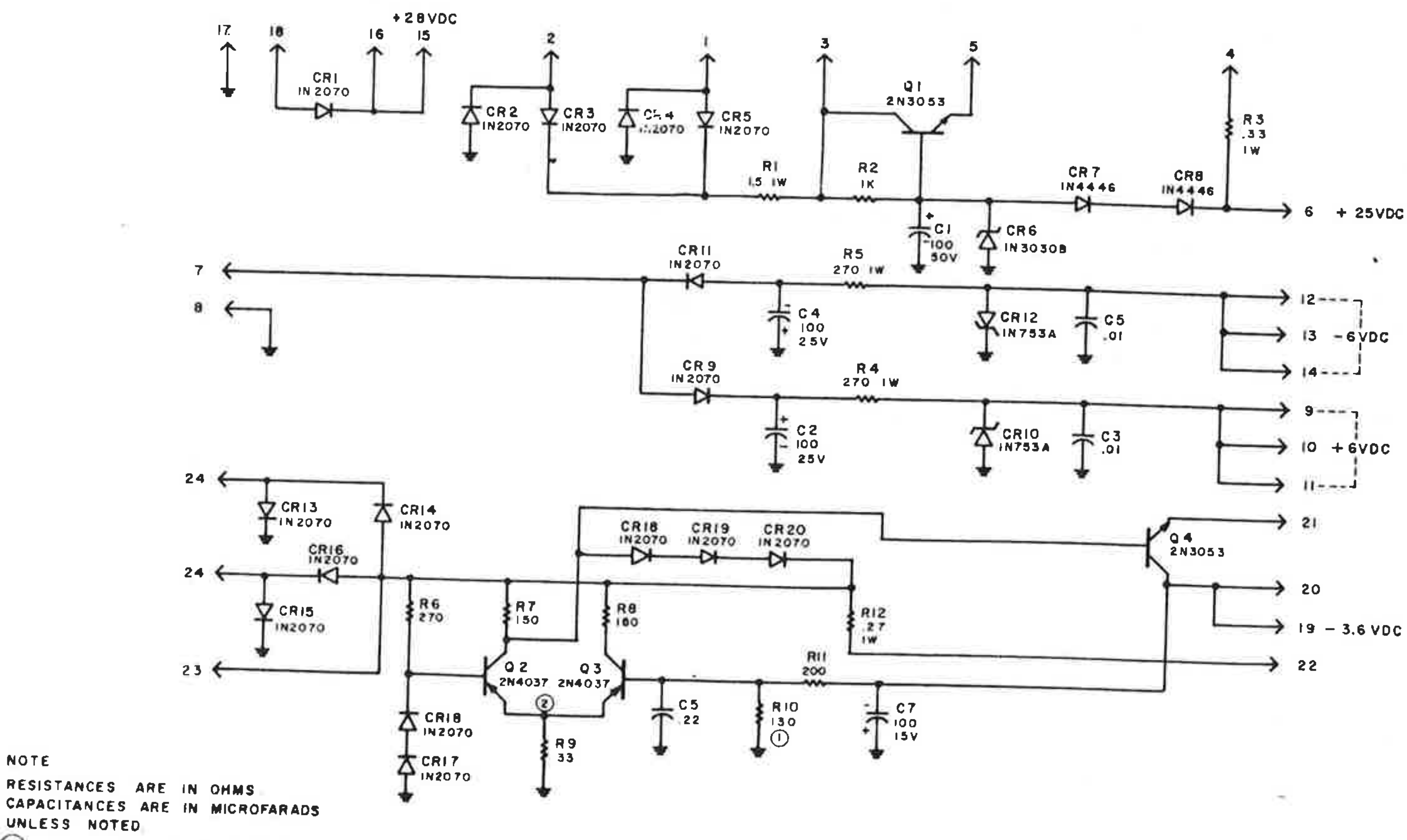


Fig 10. AMM-1 Power Supply Regulator Schematic.

option places the frequency deviation alarm limits at ±16 Hz, and may be requested at the time the monitor is ordered. Outputs of the limit decoder and overrange decoder are combined in the alarm output driver circuit, U26B, Q1 Q2.

An additional alarm condition is generated by loss of RF input to the monitor. An alarm flip-flop , U12B, is set by the leading edge of the time base gate pulse. When RF carrier is present, it will be counted by the RF frequency counter, as described. The switching of the tenth state of the counter resets the alarm flip-flop. Should carrier be lost, the RF frequency counter will not accumulate a count, and the alarm flip-flop will remain activated.

Self-test functions are provided to check the logic. Operation of any of the self-test switches (ZERO, +19.5, or -19.5) causes the RF frequency counter to count the master reference clock. Since the time base gate pulse is developed from this clock, an exact multiple of 1024 pulses will be counted, and the RF frequency counter will return to its initial zero state. If the ZERO switch is depressed, this count will be transferred to the storage register with a reversal of the 64 weight bit so as to indicate a zero on the Hz DEVIATION meter. If the −19.5 switch is depressed, the signal paths between the counter and the storage register are modified so that a 24 is transferred into the register, causing the meter to indicate −19.5 Hz. If the +19.5 switch is depressed, a 104 is transferred, resulting in a meter indication of +19.5 Hz.

NOTE: Since the count has been biased by reversal of the 64 weight bit, a 64 in the storage register represents a zero deviation. For the ±19.5 test points, $\Delta f = \Delta N/T$ or $\Delta f = (64-24)/2.048 = (104-64)/2.048 = 40/2.048 = 19.5$ Hz.

INSTALLATION

RACK MOUNTING

The BW-50 mounts in a standard 19-inch equipment rack using four No. 10 screws and washers.

> NOTE: If the BW-50 is mounted above high heat generating equipment such as tube power supplies, provision should be made for free circulation of cooling air around the unit. Do not allow ambient chassis temperature to rise above 50°C (122°F.).

CONNECTIONS

Before operating or applying signals to instrument, observe necessary precautions given here and in "Preliminary Adjustments".

AC Power

BW-50 instrument MI-560767-1 is factory wired for 117 volt, 50 to 60 Hz power; and MI-560767-2 is wired for 234 volt, 50 to 60 Hz power. Choice of either primary voltage can be made by reconnecting the transformer primary.

Attach BW-50 line cord to a three-wire, single phase grounded power receptacle.

Signal Connections

> CAUTION: Before applying any RF input, turn carrier level front panel control, R1, fully counterclockwise. Do not apply more than 10 volts RMS RF to monitor. Failure to observe this precaution may result in damage.

MODULATED CARRIER. If a modulated carrier alone is to be sampled, connect RF LIM OUT Jack (J2) to FREQ RF IN Jack (J3) with short coaxial cable supplied. Connect an RG-58U (or RG-59) coaxial cable between modulated RF sampling point of transmitter, (or modulated output of an RF amplifier) and MOD RF IN Jack (J1) of monitor. Observe above precaution regarding excessive RF levels.

MODULATED AND UNMODULATED CARRIER. If separate modulated and unmodulated carriers are to be used from transmitter or RF amplifier, connect an RG-58U coaxial cable from modulated RF sampling point to MOD RF IN Jack (J1) of monitor. Connect a second cable from unmodulated RF carrier sampling point to FREQ RF IN Jack (J3) of monitor.

EXTERNAL AURAL MONITORING AMPLIFIER. Connect amplifier to rear terminals TB1 and TB2. This is an unbalanced 600-ohm output with Terminal 1 grounded.

REMOTE METERS AND FLASHERS. This is an RCA accessory that complies with FCC regulations, and can be connected to rear terminal block of the BW-50. It includes a

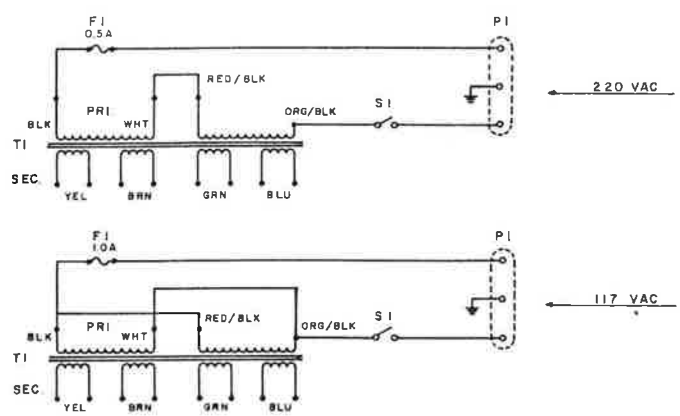


Fig. 11. BW-50 Power Connections.

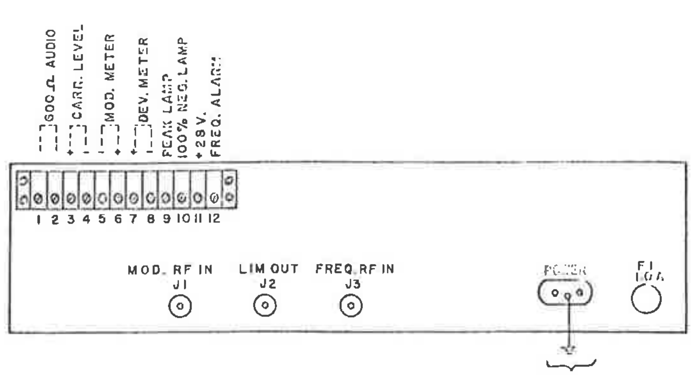
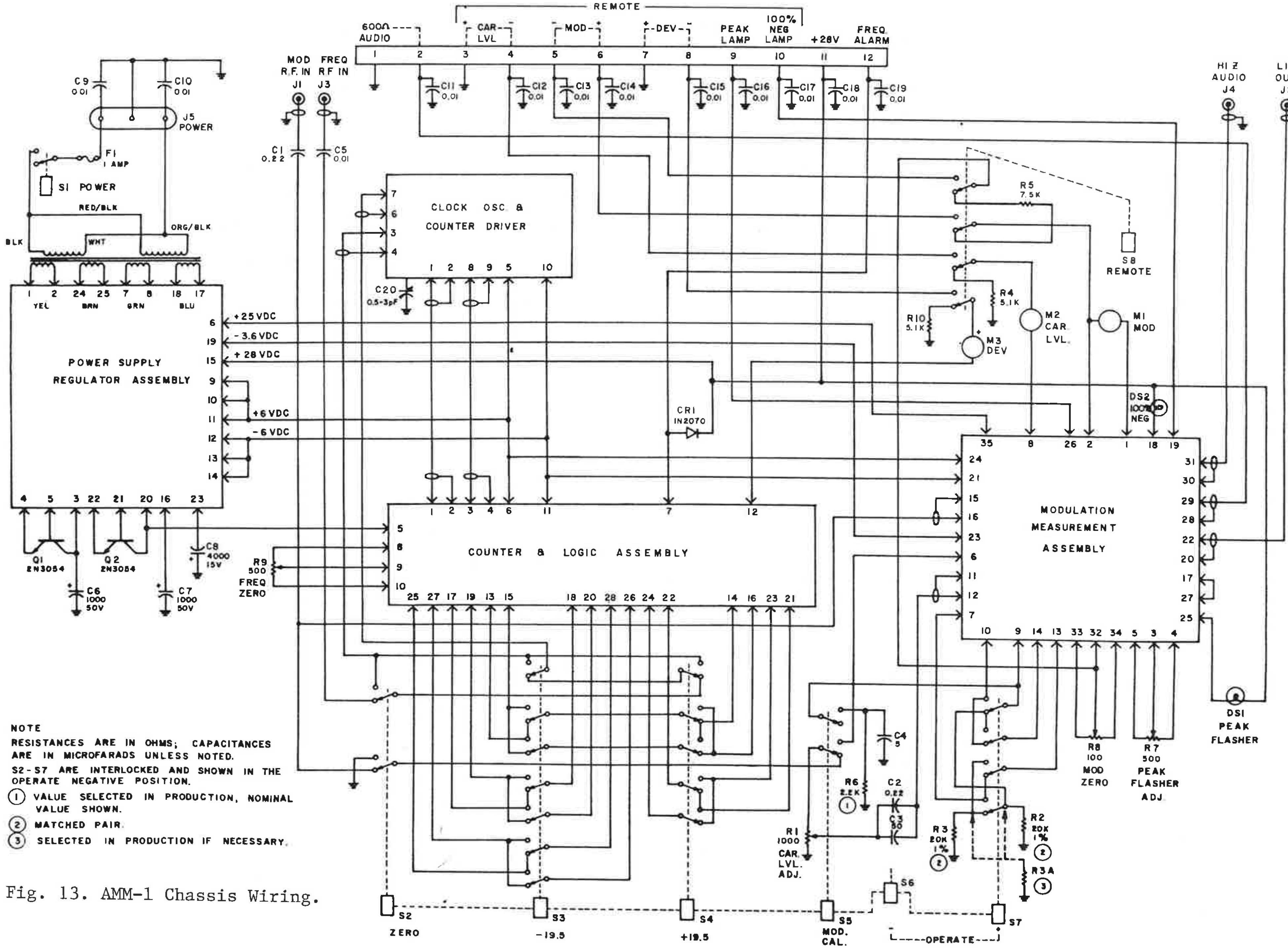


Fig. 12. Rear Chassis Connections.



NOTE
RESISTANCES ARE IN OHMS; CAPACITANCES ARE IN MICROFARADS UNLESS NOTED.
S2-S7 ARE INTERLOCKED AND SHOWN IN THE OPERATE NEGATIVE POSITION.
(1) VALUE SELECTED IN PRODUCTION, NOMINAL VALUE SHOWN.
(2) MATCHED PAIR.
(3) SELECTED IN PRODUCTION IF NECESSARY.

Fig. 13. AMM-1 Chassis Wiring.

center frequency deviation meter, carrier level meter, modulation meter, and 100% negative modulation and peak flasher lamps.

Observe correct polarities in connecting remote meters. See Fig. 12. Connect deviation meter to TB1-7 (+) and TB1-8; connect carrier level meter to TB1-3 (+) and TB1-4; and connect modulation meter to TB1-5 and TB1-6 (+). Connect one side of each remote indicator lamp or external alarm to +28 V rear panel Terminal TB1-11. Return cold side of peak modulation lamp to TB1-9; return cold side of 100% negative modulation lamp or alarm to TB1-10; and return cold side of external frequency lamp or alarm to TB1-12.

> CAUTION: Do not exceed 500 mA total current drain for all external lamps and alarms. This is the capacity of the +28 V source.

To permit red 100% negative modulation lamp, DS2, to serve as a carrier loss indicator, connect a jumper wire between TB1-10 and TB1-12. The light will then remain on whenever there is a loss of signal to the frequency monitor.

PRELIMINARY ADJUSTMENTS

The BW-50 incorporates a number of self-test functions to verify correct performance. Before placing instrument in service, check its operation by making the tests and adjustments outlined in this section. If any difficulty is had in satisfying these conditions, turn to appropriate instructions in the "Maintenance" section.

PERFORMANCE CHECKS

Release all pushbuttons to out position. Depress ZERO switch S2. Disconnect all leads to back terminals or connectors except AC line cord to J5. Make following tests.

AC Power

With AC power connected to BW-50, and POWER switch (S1) off, all meters should indicate zero. If necessary, zero each meter with its adjustment screw. Depress POWER switch to turn unit on. The reading of CARRIER LEVEL meter (M2) should decrease below its rest point.

Frequency Meter Amplifier

Depress ZERO switch S2, and adjust FREQ ZERO potentiometer R9 fully counterclockwise (CCW) to fully clockwise (CW). The pointer of FREQ DEVIATION meter M3 should move from a negative to a positive indication. Return pointer to zero for normal operation.

Frequency Meter

Zero frequency meter as in previous step. Depress -19.5 Hz switch S3. The pointer of FREQ DEVIATION meter M3 should settle within 6 seconds to a steady indication of -19.5 ±0.5 Hz. Depress +19.5 Hz switch S4. The pointer of FREQ DEVIATION meter M3 should settle within 6 seconds to a steady-state indication of +19.5 ± 0.5 Hz. Depress ZERO switch S2. The pointer of FREQ DEVIATION meter M3 should return within 6 seconds to zero.

Modulation Meter Amplifier

Depress ZERO switch S2, and adjust MOD ZERO potentiometer R8 fully CCW to fully CW. The pointer of MODULATION meter M1 should move in a negative and positive direction about zero. Return pointer to zero for normal operation.

Modulation Meter

Depress MOD CAL switch S5 and adjust CARRIER LEVEL potentiometer R1 so that pointer on CARRIER LEVEL meter M2 indicates 100%. MODULATION meter M1 should indicate 100%.

Peak Flash Potentiometer

Depress MOD CAL switch S5 and adjust CARRIER LEVEL potentiometer R1 so that pointer on CARRIER LEVEL meter M2 indicates 100%. Adjust PEAK FLASHER potentiometer R7 fully CCW. Yellow PEAK MOD FLASHER DS1 should illuminate. Light will flash at a rate of approximately 250 ms on, to 50 ms off. Adjust PEAK FLASHER potentiometer R7 CW until PEAK MOD FLASHER, DS1, flashes with an off time of approximately 1/2 second. The hairline indicator on the potentiometer knob should agree with MODULATION meter M1 within ±1%. Further CW adjustment of PEAK FLASHER potentiometer R7 should cause PEAK MOD FLASHER DS1 to turn off and remain off through full remaining CW adjustment.

Remote Meter Switch

Depress MOD CAL switch S5 and adjust CARRIER LEVEL potentiometer R1 so that CARRIER LEVEL meter M2 indicates 100%. MODULATION meter M1 should read 100% as in MOD METER adjustment. Adjust FREQ ZERO potentiometer R9 so that FREQ DEVIATION meter M3 indicates +5 Hz. Depress REMOTE METER switch S8. MODULATION meter M1 reading should decrease approximately 6% and CARRIER LEVEL meter M2 and FREQ DEVIATION meter M3 should return to zero. Release REMOTE METER switch S8 and meters should return to their previous readings. Return FREQ ZERO potentiometer R9 to normal.

Carrier Level

Refer to "Installation" section for making RF connections.

> CAUTION: Before applying RF input, turn carrier level control fully counterclockwise. Do not apply more than 10 volts RMS RF to unit or damage may result.

Apply RF input.

Depress +OPR switch S7. Adjust CARRIER LEVEL potentiometer (R1) CW until CARRIER LEVEL meter M2 reads 100%. Continue adjustment of CARRIER LEVEL potentiometer R1 and verify that sufficient range is available to permit full-scale indication on CARRIER LEVEL meter M2. If considerable excess range beyond full scale remains on CARRIER LEVEL potentiometer, reduce RF input signal level applied to MOD RF IN jack J1. Adjust CARRIER LEVEL potentiometer R1 so that CARRIER LEVEL meter M2 indicates 100%.

+ Operate

With modulated RF carrier applied as in CARRIER LEVEL check, depress +OPR switch S8. Adjust CARRIER LEVEL potentiometer R1 so that CARRIER LEVEL meter M2 indicates 100%. MODULATION meter M1 will indicate positive modulation. Set PEAK FLASHER potentiometer R7 to correspond with modulation peaks indicated on MODULATION meter. PEAK MOD FLASHER DS1 will indicate positive modulation peaks exceeding the level at which PEAK FLASHER potentiometer is set.

NOTE: MODULATION meter M1 may not always track PEAK MOD FLASHER DS1. This is because PEAK MOD FLASHER indicates instantaneous peaks, while MODULATION meter characteristic has been damped in accordance with FCC regulations.

- Operate

After performing + OPERATE check, depress -OPR switch S7.

CARRIER LEVEL meter M2 should indicate approximately 100% (within 1%) without further adjustment of CARRIER LEVEL potentiometer R1. MODULATION meter M1 will indicate negative modulation.

NOTE: Positive and negative modulation readings may not always track while monitoring program material. This is due to asymmetrical nature of certain types of program material, i.e. positive and negative peaks are not equal in amplitude.

Set PEAK FLASHER potentiometer R7 to correspond with modulation peaks indicated on meter. PEAK MOD FLASHER will indicate negative modulation peaks exceeding level at which PEAK FLASHER potentiometer is set.

NOTE: MODULATION meter M1 may not always track PEAK MOD FLASHER due to characteristics of meter circuit in accordance with FCC requirements.

Frequency Deviation Operate

With unmodulated RF applied to FREQ RF IN jack J3 in accordance with "Installation", depress either -OPR switch S6 or +OPR switch S7. FREQ DEVIATION meter M3 should indicate deviation of the station's carrier from its assigned frequency. Accuracy of this indication may be verified by means of an external frequency measurement service.

100% Negative Flasher

With modulated RF applied to MOD RF IN jack J1 in accordance with "Installation", the 100% NEGATIVE MOD FLASHER DS2 should indicate negative modulation peaks exceeding 99% regardless of position of function selection switches S2-8 or adjustment of front panel potentiometers (R1, R7-9).

OPERATION

Before operating unit, complete the procedures given under "Installation" and "Preliminary Adjustments". These steps verify correct installation and performance of instrument.

> CAUTION: Do not apply more than 10 volts RMS RF input. RF levels in excess of 10 volts may damage monitor.

Normal Operation

Depress POWER switch S1, and allow a five minute warmup.

To zero FREQUENCY DEVIATION and MODULATION meters, depress ZERO switch, and adjust FREQ ZERO and MOD ZERO potentiometers.

To monitor positive modulation, depress +OPR switch S7. Adjust CARRIER LEVEL potentiometer R1 so that CARRIER LEVEL meter M2 indicates 100%. Set PEAK FLASHER potentiometer R7 at desired positive peak modulation level.

To monitor negative modulation, depress -OPR switch S6. Adjust CARRIER LEVEL potentiometer R1 so that CARRIER LEVEL meter M2 indicates 100%. Set PEAK FLASHER potentiometer R7 at desired negative modulation peak level.

Center frequency carrier deviation will be indicated by the FREQUENCY DEVIATION meter M3. MODULATION meter M1 will indicate modulation in accordance with Part 73.500 of FCC Rules. Modulation peaks exceeding selected level will be indicated by yellow PEAK MOD flasher DS1. Modulation peaks exceeding 99% will be indicated by red 100% NEG flasher DS2, independently of any front panel adjustment.

Transmitter Measurements

Normal transmitter proof-of-performance measurements may be made with BW-50. Frequency response, distortion and noise measurements may be made through front panel AUDIO test jack J4. Five volts RMS is available, so that most distortion and noise analyzers may be used.

MAINTENANCE

Maintenance will ordinarily be confined to "Preliminary Adjustments and Performance Tests" after servicing, or whenever misadjustment is suspected or performance is erratic.

TROUBLESHOOTING, CALIBRATION

The following troubleshooting and calibration procedures are used, if necessary, to obtain correct operation as outlined in "Preliminary Adjustments and Performance Tests" section.

AC Power and Carrier Level Meter

a. If CARRIER LEVEL meter M2 reading fails to decrease below rest point, note whether any momentary deflection of either of front panel meters (M1, 3) or momentary flashing of either indicator light (DS1, 2) occurs when POWER switch S1 is operated. If not, depress MOD CAL switch S5. Turn CARRIER LEVEL potentiometer R1 CW. Pointers of both CARRIER LEVEL meter M2 and MODULATION meter M1 should move upscale toward 100%. If neither pointer moves, check fuse F1 (1.0A), and verify that line cord is firmly seated in POWER jack J5 and is connected to a live 115-VAC three-wire grounded receptacle.

b. If pointer of MODULATION meter M1 moves upscale, but pointer of CARRIER LEVEL meter M2 fails to move, verify that REMOTE METER switch S8 is released (out), and check continuity of S5 by looking for the calibrating signal at pin 12 (Fig. 14). If correct deflection of CARRIER LEVEL meter M2 is still not obtained, check CARRIER LEVEL meter circuit continuity as follows:

c. Disconnect AC line cord, remove top cover of monitor and locate pin 13 of Mod Measurement Assembly (See Fig. 14). Remove white wire from pin 13 and measure resistance between end of white wire and chassis ground. Measured resistance should be approximately 20 K ohms. Isolation of an observed discontinuity may be made with assistance of Chassis Wiring Diagram (Fig. 13) and the schematic of the Mod Measurement Assembly (Fig. 14). After repairing discontinuity, replace white wire on pin 13.

Frequency Meter Amplifier

a. If FREQUENCY DEVIATION meter indicates full-scale positive or negative, check overrange alarm by attaching a 1 K ohm resistor to rear panel TB1-1 and a milliammeter between free end of resistor and TB1-12. If a non-zero current (approximately 28 mA) is observed, check overrange logic on Counter and Logic Assembly (Fig. 15).

b. Check DC power supplies at the appropriate test points on Counter and Logic Assembly and the master clock amplitude (2.4V P-P) at pin 1. Adjust master clock amplitude, as required, by means of R11 (Fig. 9).

c. If FREQUENCY DEVIATION meter indicates on-scale, but does not track FREQ ZERO potentiometer, check potentiometer circuit for loose wiring or a discontinuity.

d. If FREQUENCY DEVIATION indicator will not settle, clean switches S2-4, and check transfer wiring and storage logic.

e. If FREQUENCY DEVIATION indicator does not move from its zero rest position, operate the -19.5 Hz and +19.5 Hz switches, allowing six seconds after each operation. If indicator still does not move, verify that REMOTE METER switch S8 is released and check continuity of meter circuit.

Frequency Meter Calibration

a. If plus and minus FREQUENCY DEVIATION meter indications are symmetrical but do not fall at $\pm$19.5 Hz when the -19.5 Hz and +19.5 Hz self-check switches are operated, adjust R19 (Fig. 15) to obtain correct (39 Hz) span.

b. If plus and minus indications are not symmetrical, adjust R19 to obtain a 39-Hz span (difference between the two indications).

c. If approximately correct readings are not obtained after steps a. and b., check transfer wiring.

Modulation Meter Amplifier Zero

a. If MODULATION meter indicator remains at zero rest, check meter circuit continuity.

b. If the MODULATION meter indicator moves off zero, but will not track MOD ZERO potentiometer, check potentiometer circuit.

c. If the MODULATION meter indicator tracks MOD ZERO potentiometer, but cannot be adjusted on both sides of zero, FET Q9 (Fig. 14) and resistor R9 must be rematched.

Modulation Meter Calibration

a. If the CARRIER LEVEL indication cannot be adjusted to 100%, check calibration oscillator waveform and amplitude at pin 6 (See Fig. 14). Adjust R70 as required. If correct adjustment is still not obtained, follow procedure in Paragraphs a. and b. of "Carrier Level" check.

NOTE: CARRIER LEVEL must read 100% for valid modulation reading.

b. If CARRIER LEVEL will indicate 100%, but MODULATION meter does not indicate 100%, make +OPR test using steady 1 kHz test tone to modulate carrier 100% (as observed on scope using expanded amplitude scale). Adjust R7 (Fig. 14) as required to obtain reading of 100%. If correct reading cannot be obtained, check S7 and CR2. Make -OPR check. If indication of approximately 100% is not obtained, replace CR1. Repeat "Modulation Meter" calibration check.

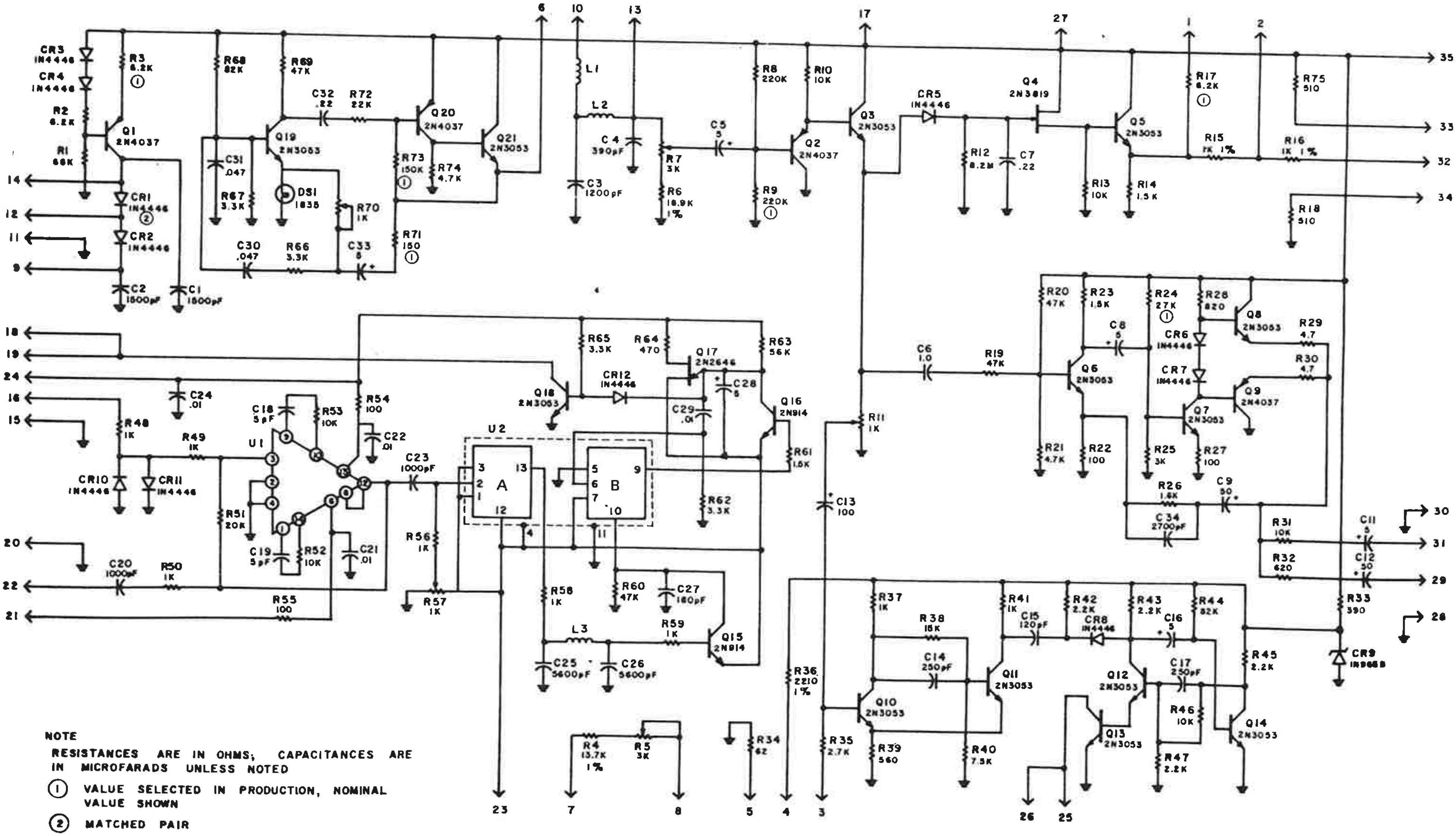
c. If calibration in steps (a) and (b) has been correctly performed, R6 may be changed to either increase or decrease the MOD CAL indication, or a trimmer resistor R6A may be added to S5 in parallel with R6 to decrease MOD CAL indication to 100%.

WARNING: Remove line cord before removing bottom cover. 120 VAC is present on pins of power switch S1.

NOTE: Readjustment of CARRIER LEVEL potentiometer to obtain 100% CARRIER LEVEL indication will be required when R6 is changed.

Peak Flasher Calibration

a. If PEAK FLASHER DS1 will not light, adjust CARRIER LEVEL potentiometer R1 fully CW so that indicated modulation is greater than 100%. Adjust PEAK FLASHER potentiometer R7 fully CCW. If PEAK FLASHER DS1 still does not light, check bulb and operation of lamp driver by attaching a 1 K resistor to TB1-11 and a milliammeter between free end of the resistor and TB1-9. A non-zero (approximately 28 mA) current indicates the lamp driver is on. Check continuity of PEAK FLASHER circuit Q13 (Fig. 14) and continuity of PEAK FLASHER potentiometer circuit.

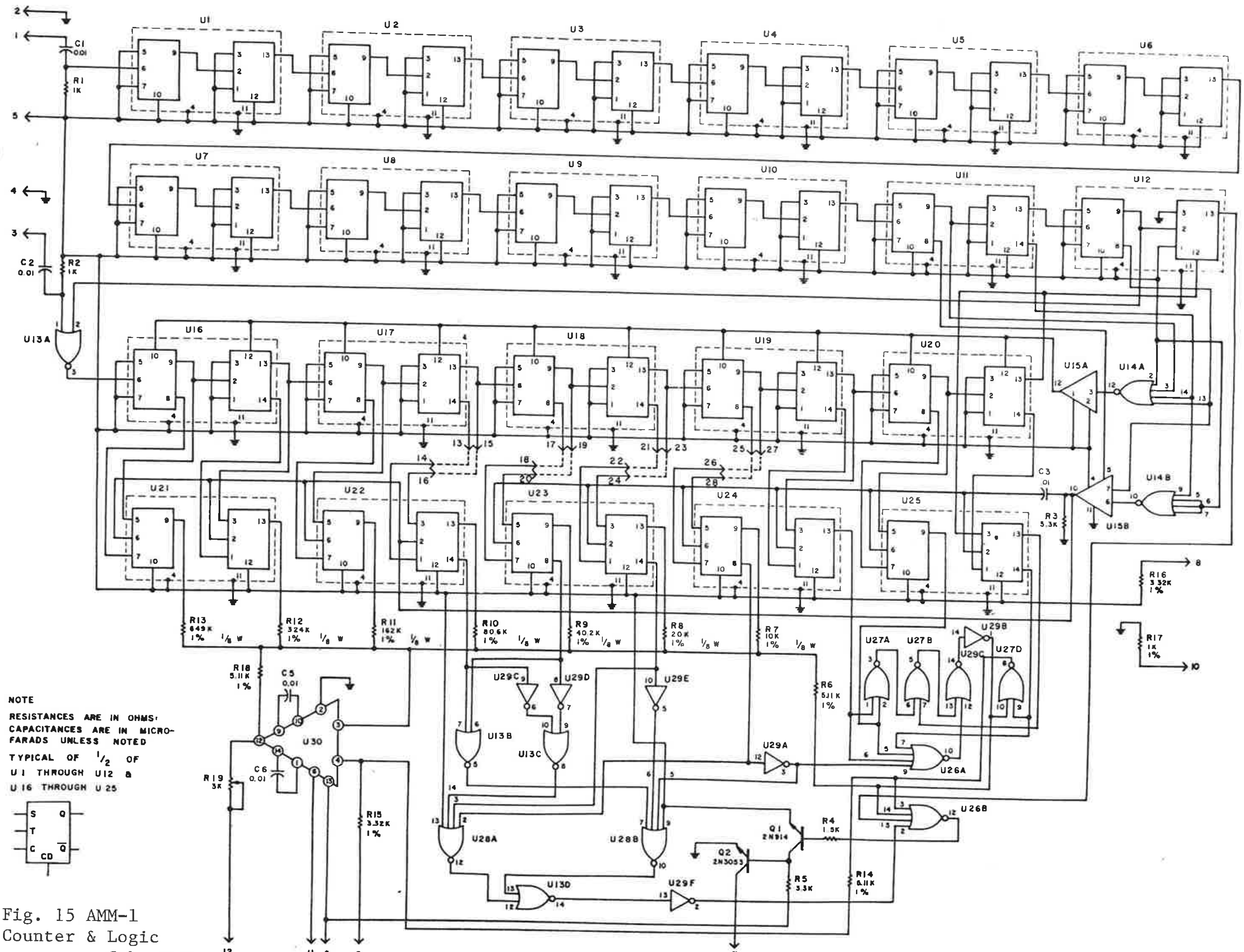


NOTE
RESISTANCES ARE IN OHMS; CAPACITANCES ARE IN MICROFARADS UNLESS NOTED
(1) VALUE SELECTED IN PRODUCTION, NOMINAL VALUE SHOWN
(2) MATCHED PAIR

Fig. 14. Modulation Measurement Schematic. (A2 Card)

CHASSIS

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
C1,C2	CAPACITOR: FXD FLM 0.22 MF 10% 80V	0120-0003
C3	CAPACITOR: FXD ELECT 50 MF 25V	0180-0005
C4	CAPACITOR: FXD ELECT 5 MF 25V	0180-0007
C5	CAPACITOR: FXD CER 0.01 MF 100V	0150-0007
C6,C7	CAPACITOR: FXD ELECT 1000 MF 50V	0180-0002
C8	CAPACITOR: FXD ELECT 4000 MF 15V	0180-0011
C9,C10	CAPACITOR: FXD CER 0.01 MF 1KV	0150-0003
C11 THRU C19	CAPACITOR: FXD CER .001 MF 1KV	0150-0004
C20	CAPACITOR: VAR CER 0.5 - 3PF	0121-0003
CR1	DIODE: SI 1N4006	1900-0016
DS1,DS2	BULB: INCANDESCENT 327	2140-0003
F1	FUSE: CARTRIDGE 3AG1A	2100-0004
J1 THRU J4	JACK: RF BNC	0360-0005
J5	JACK: POWER AC	0360-0004
M1	METER: MODULATION 0-133%	1120-0002
M2	METER: CARRIER LEVEL 80-110%	1120-0007
M3	METER: FREQ DEV ±30 HZ	1120-0006
Q1,Q2	TRANSISTOR: SI 2N3054	1850-0009
R1	RESISTOR: VAR COMP 1K 2W	2100-0014
R2,R3	RESISTOR: MF 20K 1% ¼W	0731-2002
R4,R10	RESISTOR: FXD COMP 5.1K 5% ½W	0686-5125
R5	RESISTOR: FXD COMP 7.5K 5% ½W	0686-7525
R6	RESISTOR: FXD DETERMINED BY MANUFACTURER	0686-
R7	RESISTOR: VAR WW 500 2W	2100-0001
R8	RESISTOR: VAR WW 100 2W	2100-0003
R9	RESISTOR: VAR WW 500 2W	2100-0015
S1 THRU S8	SWITCH BANK: PUSH BUTTON	



NOTE

RESISTANCES ARE IN OHMS; CAPACITANCES ARE IN MICRO-FARADS UNLESS NOTED

TYPICAL OF 1/2 OF U1 THROUGH U12 & U16 THROUGH U25

Fig. 15 AMM-1 Counter & Logic Schematic.

CHASSIS

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
T1	TRANSFORMER: POWER	9100-0002
TB1	TERMINAL BLOCK	0360-0002
XDS1,XDS2	SOCKET: LAMP	1450-0004
XF1	FUSE HOLDER	2110-0003
XQ1,XQ2	SOCKET: TRANSISTOR	1200-0002

A1 CARD-POWER SUPPLY REGULATOR

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
C1	CAPACITOR: FXD ELECT 100 MF 50V	0180-0010
C2,C4	CAPACITOR: FXD ELECT 100 MF 25V	0180-0003
C3,C6	CAPACITOR: FXD CER 0.01 MF 100V	0150-0007
C5	CAPACITOR: FXD FLM 0.22 MF 10% 80V	0120-0003
C7	CAPACITOR: FXD ELECT 100 MF 15V	0180-0006
CR1,CR2,CR3,CR4	DIODE: SI 1N4006	1900-0016
CR5,CR9,CR11	DIODE: SI 1N4006	1900-0016
CR13,CR14,CR15	DIODE: SI 1N4006	1900-0016
CR16,CR17,CR18	DIODE: SI 1N4006	1900-0016
CR19,CR20,CR21	DIODE: SI 1N4006	1900-0016
CR6	DIODE: ZENER 1N3030B	1900-0004
CR7,CR8	DIODE: SI 1N4446	1900-0002
CR10,CR12	DIODE: ZENER 1N753A	1900-0006
Q1,Q4	TRANSISTOR: SI 2N3053	1850-0008
Q2,Q3	TRANSISTOR: SI 2N4037 (MATCHED PAIR)	1850-0011
R1	RESISTOR: FXD WW 1.5 5% 3W	0811-0001
R2	RESISTOR: FXD COMP 1K 5% ½W	0868-1025
R3	RESISTOR: FXD WW 0.33 5% 1W	0811-0002
R4,R5	RESISTOR: FXD COMP 270 5% 1W	0689-2715
R6	RESISTOR: FXD COMP 270 5% ½W	0686-2715
R7,R8	RESISTOR: FXD COMP 150 5% ½W	0686-1515
R9	RESISTOR: FXD COMP 33 5% ½W	0686-3305
R10	RESISTOR: FXD DETERMINED BY MANUFACTURER	0686-
R11	RESISTOR: FXD COMP 200 5% ½W	0686-2015
R12	RESISTOR: FXD WW 0.18 5% 1W	0811-0015

A2 CARD MODULATION METERING

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
C1,C2	CAPACITOR: FXD POLY 1500 PF 2½% 160V	0170-0009
C3	CAPACITOR: FXD POLY 1200 PF 2½% 160V	0170-0008
C4	CAPACITOR: FXD POLY 390 PF 2½% 160V	0170-0004
C5,C8,C11	CAPACITOR: FXD ELECT 5 MF 25V	0180-0007
C16,C28,C33	CAPACITOR: FXD ELECT 5 MF 25V	0180-0007
C6,C24	CAPACITOR: FXD CER 1.0 MF 25V	0150-0002
C7,C32	CAPACITOR: FXD FLM 0.22 MF 10% 80V	0120-0003
C9,C12	CAPACITOR: FXD ELECT 50 MF 25V	0180-0005
C10	CAPACITOR: FXD CER 0.1 MF 50V	0150-0008
C13	CAPACITOR: FXD ELECT 100 MF 25V	0180-0006
C14,C17	CAPACITOR: FXD MICA 250 PF 5% 500V	0140-0001
C15	CAPACITOR: FXD MICA 120 PF 5% 500V	0140-0002
C18,C19	CAPACITOR: FXD CER 5 PF 2%	0150-0006
C20,C23	CAPACITOR: FXD MICA 1000 PF 5% 500V	0140-0015
C21,C22,C29	CAPACITOR: FXD CER 0.01 MF 100V	0150-0007
C25,C26	CAPACITOR: FXD POLY 5600 PF 2½% 160V	0170-0014
C27	CAPACITOR: FXD MICA 180 PF 5% 500V	0140-0010
C30,C31	CAPACITOR: FXD FLM 0.047 MF 10% 200V	0120-0004
C34	CAPACITOR: FXD POLY 2700 PF 2½% 160V	0170-0011
CR1,CR2	DIODE: SI 1N643	1900-0017
CR3 THRU CR8	DIODE: SI 1N4446	1900-0002
CR9	DIODE: ZENER 1N965B	1900-0007
CR10 THRU CR12	DIODE: SI 1N4446	1900-0002
DS1	LAMP: INCANDESCENT 55V 1835	2140-0002
L1,L2	INDUCTOR: RF FILTER	
L3	INDUCTOR: 100% NEG FILTER	

A2 CARD MODULATION METERING

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
Q1,Q2,Q9,Q20	TRANSISTOR: SI 2N4037	1850-0011
Q3	TRANSISTOR: SI 2N3053	1850-0008
Q4	TRANSISTOR: FET 2N3819	1850-0001
Q5 THRU Q8	TRANSISTOR: SI 2N3053	1850-0008
Q10 THRU Q14	TRANSISTOR: SI 2N3053	1850-0008
Q15,Q16	TRANSISTOR: SI 2N914	1850-0006
Q17	TRANSISTOR: 2N2646	1850-0012
Q18,Q19,Q21	TRANSISTOR: SI 2N3053	1850-0008
R1	RESISTOR: FXD COMP 68K 5% ½W	0686-6835
R2	RESISTOR: FXD COMP 6.2K 5% ½W	0686-6225
R3	RESISTOR: FXD DETERMINED BY MANUFACTURER	0686-
R4	RESISTOR: FXD MF 13.7K 1% ¼W	0731-1372
R5,R7	RESISTOR: VAR WW 3K 2W	2100-0005
R6	RESISTOR: FXD MF 16.9K 1% ¼W	0731-1692
R8	RESISTOR: FXD COMP 220K 5% ½W	0686-2245
R9	RESISTOR: FXD DETERMINED BY MANUFACTURER	0686-
R10,R13,R31	RESISTOR: FXD COMP 10K 5% ½W	0686-1035
R46,R52,R53	RESISTOR: FXD COMP 10K 5% ½W	0686-1035
R11,R57,R70	RESISTOR: VAR WW 2W	2100-0012
R12	RESISTOR: FXD COMP 8.2M 5% ½W	0686-8255
R14,R23,R61	RESISTOR: FXD COMP 1.5K 5% ½W	0686-1525
R15,R16	RESISTOR: FXD MF 1.0K 1% ¼W	0731-1001
R17	RESISTOR: FXD DETERMINED BY MANUFACTURER	0686-
R18,R75	RESISTOR: FXD COMP 510 5% ½W	0686-5115
R19,R20	RESISTOR: FXD COMP 47K 5% ½W	0686-4735
R21,R60,R69	RESISTOR: FXD COMP 4.7K 5% ½W	0686-4725

A2 CARD MODULATION METERING

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
R74	RESISTOR: FXD COMP 4.7K 5% ½W	0686-4725
R22,R27,R54	RESISTOR: FXD COMP 100 5% ½W	0686-1015
R55	RESISTOR: FXD COMP 100 5% ½W	0686-1015
R24	RESISTOR: FXD DETERMINED BY MANUFACTURER	0686-
R25	RESISTOR: FXD COMP 3K 5% ½W	0686-3025
R26	RESISTOR: FXD COMP 1.6K 5% ½W	0686-1625
R28	RESISTOR: FXD COMP 820 5% ½W	0686-8215
R29,R30	RESISTOR: FXD COMP 4.7 5% ½W	0686-4R75
R32	RESISTOR: FXD COMP 620 5% ½W	0686-6215
R33	RESISTOR: FXD COMP 390 5% ½W	0686-3915
R34	RESISTOR: FXD COMP 62 5% ½W	0686-6205
R35	RESISTOR: FXD COMP 2.7K 5% ½W	0686-2725
R36	RESISTOR: FXD COMP MF 2.21K 1% ¼W	0731-2211
R37,R41,R49	RESISTOR: FXD COMP 1K 5% ½W	0686-1025
R50,R56,R58	RESISTOR: FXD COMP 1K 5% ½W	0686-1025
R59	RESISTOR: FXD COMP 1K 5% ½W	0686-1025
R38	RESISTOR: FXD COMP 15K 5% ½W	0686-1535
R39	RESISTOR: FXD COMP 560 5% ½W	0686-5615
R40	RESISTOR: FXD COMP 7.5K 5% ½W	0686-7525
R42,R43,R45,R47	RESISTOR: FXD COMP 2.2K 5% ½W	0686-2225
R44,R68	RESISTOR: FXD COMP 82K 5% ½W	0686-8235
R48	RESISTOR: FXD COMP 1K 5% 1W	0689-1025
R51	RESISTOR: FXD COMP 20K 5% ½W	0686-2035
R62,R65,R66	RESISTOR: FXD COMP 3.3K 5% ½W	0686-3325
R67	RESISTOR: FXD COMP 3.3K 5% ½W	0686-3325
R63	RESISTOR: FXD COMP 56K 5% ½W	0686-5635

A2 CARD MODULATION METERING

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
R64	RESISTOR: FXD COMP 470 5% ½W	0686-4715
R71	RESISTOR: FXD DETERMINED BY MANUFACTURER	0686-
R72	RESISTOR: FXD COMP 22K 5% ½W	0686-2235
R73	RESISTOR: FXD DETERMINED BY MANUFACTURER	0686-
XQ4	SOCKET: TRANSISTOR	1200-0001

A3 CARD - COUNTER & LOGIC

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
C1,C2,C3	CAPACITOR: FXD CER 0.01 MF 100V	0150-0007
C5,C6	CAPACITOR: FXD CER 0.01 MF 100V	0150-0007
C4	CAPACITOR: FXD CER 0.1 MF 50V	0150-0008
U1 THRU U12	INTEGRATED CIRCUIT: MC890P	1820-0008
U13,U27	INTEGRATED CIRCUIT: MC824P	1820-0004
U14,U26,U28	INTEGRATED CIRCUIT: MC825P	1820-0005
U15	INTEGRATED CIRCUIT: MC888P	1820-0006
U16 THRU U25	INTEGRATED CIRCUIT: MC890P	1820-0008
U29	INTEGRATED CIRCUIT: MC889P	1820-0007
U30	INTEGRATED CIRCUIT: CA3029	1820-0003
Q1	TRANSISTOR: SI 2N914	1850-0006
Q2	TRANSISTOR: SI 2N3053	1850-0008
R1,R2	RESISTOR: FXD COMP 1K 5% ½W	0686-1025
R3,R5	RESISTOR: FXD COMP 3.3K 5% ½W	0686-3325
R4	RESISTOR: FXD COMP 1.5K 5% ½W	0686-1525
R6,R14,R18	RESISTOR: MF 5.11K 1% ¼W	0731-5111
R7	RESISTOR: MF 10K 1% ¼W	0731-1002
R8	RESISTOR: MF 20K 1% ¼W	0731-2002
R9	RESISTOR: MF 40.2K 1% ¼W	0731-4022
R10	RESISTOR: MF 80.6K 1% ¼W	0731-8062
R11	RESISTOR: MF 162K 1% ¼W	0731-1623
R12	RESISTOR: MF 324K 1% ¼W	0731-3243
R13	RESISTOR: MF 649K 1% ¼W	0731-6493
R15,R16	RESISTOR: MF 3.32K 1%¼W	0731-3321
R17	RESISTOR: MF 1K 1% ¼W	0731-1001
R19	RESISTOR: VAR WW 3K 2W	2100-0005

A4 CARD - OSC & COUNTER DRIVER

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
C1	CAPACITOR: VAR AIR 3-50 PF	0121-0001
C2	CAPACITOR: FXD MICA 2700 PF 5% 500V	0140-0027
C3,C4,C7	CAPACITOR: FXD MICA 1000 PF 5% 500V	0140-0015
C5,C6	CAPACITOR: FXD CER 0.1 MF 50V	0150-0008
C8,C9	CAPACITOR: FXD CER 0.01 MF 100V	0150-0007
C12,C13	CAPACITOR: FXD CER 0.01 MF 100V	0150-0007
C10,C11	CAPACITOR: FXD CER 5 PF 2%	0150-0006
C14,C15	CAPACITOR: FXD CER 5 PF 2%	0150-0006
CR1,CR2	DIODE: SI 1N4446	1900-0002
CR3,CR4	DIODE: SI 1N4446	1900-0002
Q1	TRANSISTOR: SI 2N3478	1850-0010
R1,R3	RESISTOR: FXD COMP 4.7K 5% ½W	0686-4725
R2	RESISTOR: FXD COMP 360 5% ½W	0686-3615
R4	RESISTOR: FXD COMP 62K 5% ½W	0686-6235
R5,R6,R9	RESISTOR: FXD COMP 10K 5% ½W	0686-1035
R15,R16	RESISTOR: FXD COMP 10K 5% ½W	0686-1035
R7,R8,R17	RESISTOR: FXD COMP 100 5% ½W	0686-1015
R18	RESISTOR: FXD COMP 100 5% ½W	0686-1015
R10	RESISTOR: FXD COMP 1.2K 5% ½W	0686-1225
R11	RESISTOR: VAR WW 3K 2W	2100-0005
R12,R13	RESISTOR: FXD COMP 1K 5% ½W	0686-1025
R14	RESISTOR: FXD COMP 20K 5% ½W	0686-2035
U1,U2	INTEGRATED CIRCUIT: CA3029	1820-0003
Y1	CRYSTAL: 2.04800 MHZ	
XY1	SOCKET: CRYSTAL	1200-0004

Belar History

Belar Electronics Laboratory, Inc. is the world's leading manufacturer of modulation monitors, which are used by radio and television stations to monitor important technical aspects of their broadcast signal. Belar also makes frequency monitors, specialized AM receiving antennas, and other related equipment for the broadcast industry.

Belar was founded in 1964 by the late Isobel ("BEL") and Arno ("AR") Meyer. Arno Meyer is still the President and owner. They started Belar in the basement of their house in Drexel Hill, PA, doing consulting and product design. The company moved to larger facilities in Upper Darby, PA in the late 60's, and then to its current location in Devon, PA in 1972.

The company was started to supply radio stations with the newly required FM stereo monitoring equipment, and later expanded to supply equipment needed by AM, shortwave, and TV broadcasters. Belar has always tried to offer products with the highest performance possible at a reasonable price. The Federal Communications Commission first used Belar monitors to verify their measurement of commercial FM broadcast stereo performance standards in the mid-1960's. Since then, Belar monitors have become industry standards, used as test instruments by many broadcast industry manufacturers (such as transmitter companies, etc.) to ensure that the products they make meet their specifications.

Belar products are also known for their durability—the vast majority are still in use today. Belar shipped its first model FMM-1 FM Monitor in 1966 to what is now WBEB 101.1, Philadelphia, where it is still in use as a back-up monitor.

In 2001, in recognition of Arno Meyer's and Belar's contribution to the industry, the National Association of Broadcasters awarded Arno Meyer with the coveted NAB Radio Engineering Achievement Award.

Belar markets its products domestically and internationally by direct sales and through distributors. Belar products are in use 24 hours a day, 7 days a week, in almost every country in the world.

BELAR

ELECTRONICS LABORATORY, INC.

119 LANCASTER AVENUE
P.O. BOX 76
DEVON, PA 19333-0076 USA
VOICE (610) 687-5550 ● FAX (610) 687-2686

http://www.belar.com
sales@belar.com
service@belar.com
parts@belar.com