

# **MULTILIMITER AM/FM**

## **OPERATING AND SERVICE MANUAL**

**PACIFIC RECORDERS AND ENGINEERING CORPORATION**  
11100 ROSELLE ST., SAN DIEGO, CALIFORNIA 92121  
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# MULTILIMITER AM/FM OPERATING AND SERVICE MANUAL

MODEL Mk-Fm

SERIAL NUMBER F-1018

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## Section I General Information

The Multilimiter has been designed to provide the broadcaster with a high-performance modulation limiter with a wide adjustment range of the compression and limiting dynamics. This adjustability permits the broadcaster to tailor the apparent dynamic range to the requirements of the station's format. The equipment design is free of secret circuits and magic boxes. Complete schematics and parts lists are included in this manual. The limiter is straightforward, easy to understand, operate and service. The modular construction enhances serviceability, and, as technology permits, newer and better function modules will be developed to keep the limiter's "sound" up to date.

The signal processing is accomplished in three separate function modules. The RMS compression module controls signal level by measuring the energy content and adjusting gain. The circuitry features low distortion and excellent output tracking. Two "feed-forward" control loops, slow and fast, adjust the module gain through a LED optical attenuator.

The fast limiting module uses a FET as the gain control device. Signal amplitude is converted to a DC control voltage for the FET, which is the variable element in the feed-back loop of an amplifier. This particular circuit eliminates the need for a FET biasing network.

The AM or FM process module provides the absolute peak control required to prevent overmodulation. The AM process module also provides an adjustable positive modulation control and an automatic circuit for turning the peak polarity of asymmetrical signals to the positive. The FM process module accommodates the two pre-emphasis characteristics in use today. The 25 micro-second compensation is provided for use with the Dolby Laboratories' FM Noise Reduction System; the 75 micro-second compensation is for standard FM broadcast.

The limiter motherboard contains the input, output, and power supply circuitry. All components are conservatively rated and designed to provide extended full-time operational life.

## Section II

### Technical Specifications

Metering	3 separate meters for: RMS compression Fast limiting Output level	Signal-To-Noise Ratio High Pass Filter	Better than 72dB for -20dB input. $\pm 0.5$ dB 50Hz to 15KHz -6dB @ 40Hz -40dB @ 25Hz
Controls	Input Level, Fast Limiting, Coarse Output Level, Fine Output Level, Output Meter Calibration, AM/Positive Threshold, FM/Pre-emphasis.	Attack Time, RMS Compressor Attack Time, Fast Limiter Release Time, RMS Section	Fast section: 100 milliseconds Slow section: 500 milliseconds 5 milliseconds. Fast: 200 milliseconds Slow: 1 second
Input Impedance	600 ohms, bridged-T input control, floating. Transformer isolated.	Asymmetrical Operation/AM	Positive voltage peaks 100-150% continuously adjustable.
Output Load Impedance	Designed to work into 600 ohm Output transformer isolated.	Pre-Emphasis Operation/FM	Flat, 25 $\mu$ s, and 75 $\mu$ s, switchable.
Input Level	-25dBm minimum for 5dB limiting.	Power Requirements	110-120 VAC 50-60Hz 10 watts.
Maximum Output Level	+24dBm.	Weight	10 pounds
Frequency Response	$\pm 0, -1.0$ dB, 50Hz-15kHz. Reference 1kHz.	Shipping Weight	14 pounds
Distortion	Less than .25% THD 50Hz to 15kHz, at +24dBm. Below threshold of limiting, or measured in test mode. Less than .5% THD 50Hz to 15KHz with 6dB RMS compression and 3dB Fast limiting at 1KHz Reference.		

## Section III Installation

### 3-1. Unpacking and Inspection

Carefully examine the unit for any sign of physical damage which could have occurred in transit. The limiter was carefully packed in a container designed to protect the unit through rough handling. However, accidents do happen.

If damage is evident, do not destroy or discard any of the packing materials or carton. Immediately notify the carrier of a possible claim for damage. Shipping damage claims must be made by the consignee.

Besides the unit itself, you should verify that the shipment included the following:

- a.) This instruction manual
- b.) A warranty card, bearing the same serial number as the unit.
- c.) If ordered; the accessory spares kit; and/or stereo-couple cable.

### 3-2. Environmental Considerations

The limiter will operate satisfactorily over a wide range of ambient temperatures. (From 0°C to 50°C (32°F to 122°F).) If installed in an equipment rack with high heat producing equipment, adequate ventilation should be provided to prolong component life.

The input transformer and other circuitry are adequately shielded from moderate electromagnetic fields; the installation should be planned to avoid mounting the unit immediately adjacent to large power transformers, etc.

To comply with existing electrical codes, the limiter is provided with a three-wire AC power cord. In some installations, this may create a ground-loop problem if a significant potential difference exists between the mounting enclosure and the AC conduit ground. If hum is experienced, check for this differential by using a 3-wire to 2-wire adapter at the power receptacle.

### 3-3. Power

The limiter is designed to be operated from 110-120VAC mains supply, 50-60Hz single phase. Verify this voltage before applying power to the unit. The AC fuse should be ¼ Amp, "Slo-Blo" type.

### 3-4. External Connections

During initial set-up the INPUT, FAST LIMITING, and OUTPUT controls should be set to minimum (counter-clockwise). Input and output signal pair wires should be connected as indicated on the rear chassis above the terminal strip, following standard practices. The limiter has a second transformer-coupled output on the rear panel labeled MONITOR. This 600 ohm output was provided for feeding either a local monitor amplifier/speaker, or a return line for transmitter line monitor on the control consoles, engineering shop, etc. If the main OUTPUT is to be connected to a high-impedance circuit, a 620 ohm resistor should be shunted across the output terminals. Termination of the MONITOR output is not required.

### 3-5. Stereo Coupling

Both the AM and FM versions of the Multilimiter are equipped with a STEREO COUPLE BNC connector on the back panel.

Traditionally, it has been assumed that the gain control systems of transmitter limiters must be coupled to prevent "center image shift". Unfortunately, if the faster control systems are coupled; fast dynamic material in one channel can cause severe amplitude modulation of low frequency material in the other. For this reason, the Multilimiter system is designed to be coupled at only the slow RMS gain control stage.

At this time, most contemporary and popular music is mastered to disc with most of the bass information in the center. The main reasons are to minimize the chance of cutter "lift" during mastering and to share the energy required to reproduce bass between the two amplifier/loudspeakers.

With a contemporary or popular format, the broadcaster may find the sound slightly louder and less "restricted" appearing when the limiters are not coupled.

Classical music is not usually recorded or mastered in this way and coupling of the Multimiters is recommended. The coupling cable should be a 1 foot BNC to BNC coaxial cable similar to Pomona Electronics No. 2249-C-12.

## Section IV Operation

### 4-1. General

The Multilimiter has been designed for very easy adjustment. Operating controls are located behind the removable security cover. Before applying power, set the controls as follows:

INPUT	Counter-Clockwise
FAST LIMITING	Counter-Clockwise
COARSE OUTPUT	Counter-Clockwise
FINE OUTPUT	Mid-Rotation
OUTPUT METER	Clockwise
OPERATE/TEST	Operate
POSITIVE THRESHOLD-AM	Counter-Clockwise
PRE-EMPHASIS-FM	25 $\mu$ or 75 $\mu$ s, Accordingly

Apply power and check zero readings on RMS and FAST meters. A "cold" reading of  $\pm 1/2$  dB is within tolerances. Refer to section VI for adjustment procedure if required.

Apply input signal and advance INPUT control clockwise until RMS meter indicates 5 to 8 dB of gain reduction.

Advance FAST LIMITING control until 3 to 5 dB of gain reduction is indicated on FAST LIMITING meter.

Advance COARSE and FINE output controls for modulation of transmitter as indicated on modulation monitor.

On AM Multilimiters, if positive assymetry is to be used, advance the positive threshold control for the desired amount of positive modulation.

Adjust the Output Meter sensitivity to a convenient indicating reference. In FM installations, where the limiter is feeding a single stereo generator, the "normal" setting will be +4, as most generators achieve 100% at a static level of +10 dBm. VU meter ballistics "ignore" about 6 dB of program material peaks. In installations where the limiter is feeding two generators through a 6 dB loss-split pad, the meter sensitivity will be set at +10.

### 4-2. Proof of Performance Test

Proof of performance tests should be performed with the OPERATE/TEST switch, in the TEST position. All audio circuitry remains in the signal line, the test switch defeats the control circuitry only. In AM units, the test switch also returns the polarity correlator to the non-inverting mode. In FM units, the test switch does not disable the pre-emphasis selector switch. To check transmitter pre-emphasis, set the limiter switch to FLAT.

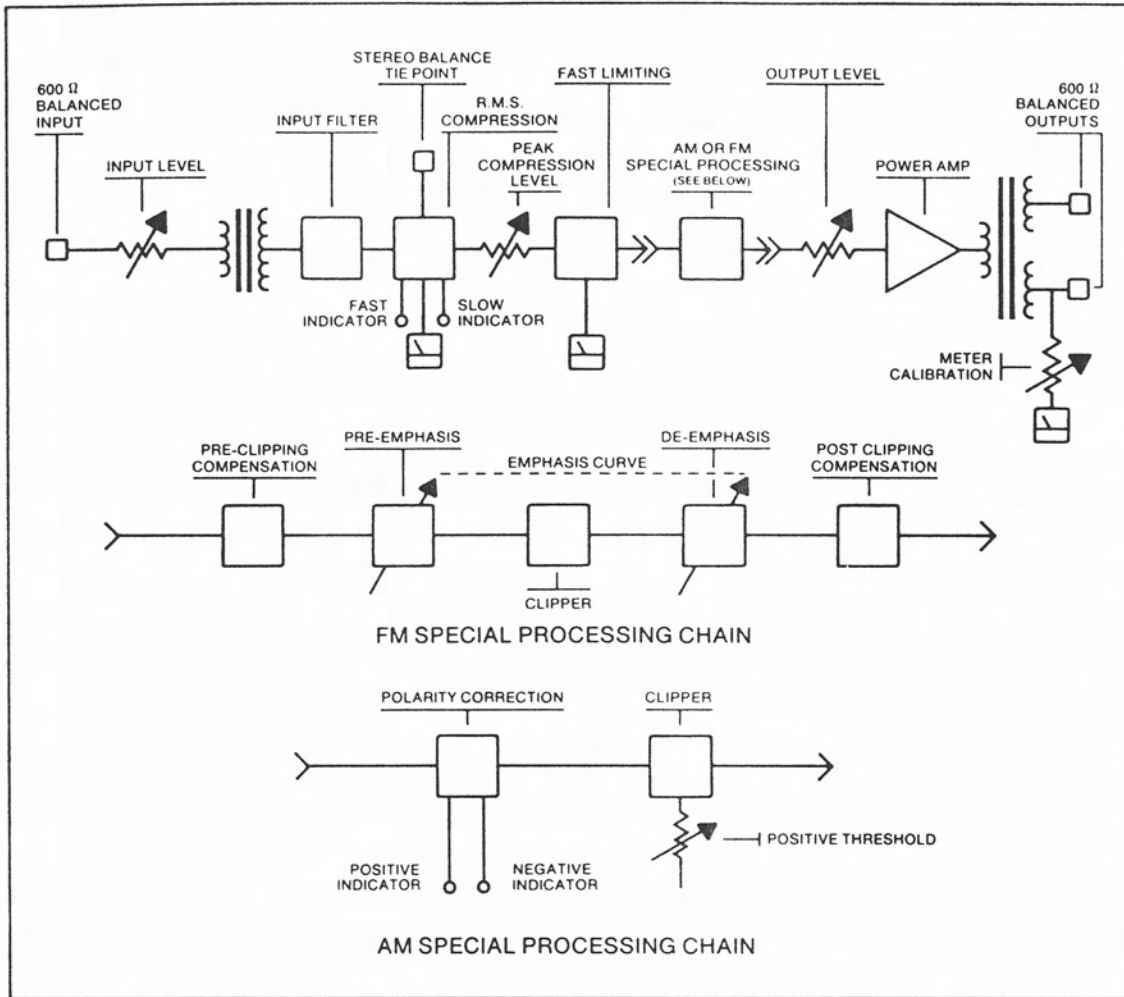
### 4-3. Automatic Polarity Correlator-(AM-Multilimiters)

The calibration of your limiter's Automatic Polarity Correlator circuit has been factory set for optimum operation on a wide range of program material. It is desirable to defeat this circuit in cases where symmetrical modulation only will be used. Please refer to Section VII, paragraph 7-1.

### 4-4. Limiter De-Emphasis-(FM-Multilimiters)

An improvement in modulation accuracy may be attained by the removal of the pre-emphasis network from the transmitter and the bypass of the de-emphasis network in the Multilimiter. Please refer to Section VII, paragraph 7-2.

## Section V Theory of Operation



### 5-1. Input Section

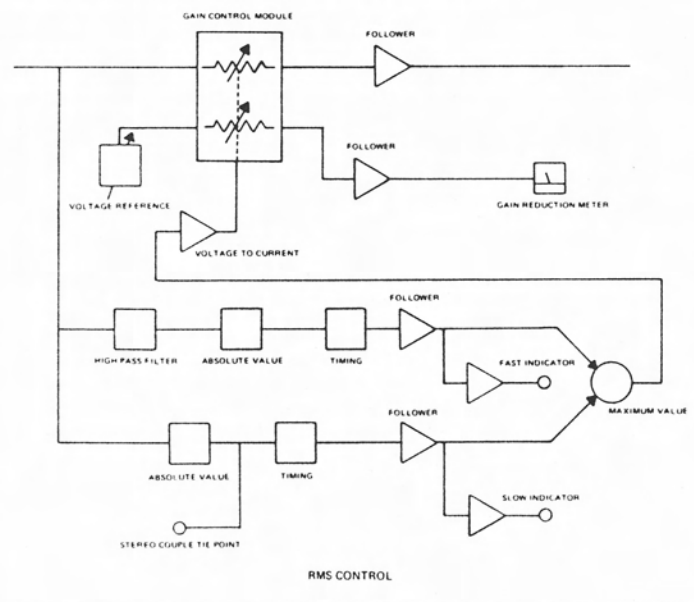
The input section is designed to be directly connected to phone lines or to other 600 ohm balanced or unbalanced inputs. The range of accommodation is -25dBm to +25dBm. The transformer (T402) and compensation network (R404, R405, C409) are chosen to give flat coupling from 40Hz to well above 20KHz with virtually no overshoot. A voltage follower (IC407) is used to match the high impedance of the transformer to subsequent stages.

The Multilimiter will accommodate a wide range of input levels and degrees of compression. To guarantee the proper operating environment for the compression stages, the input signal is high-pass filtered. The filter is of the constant-K type employing gyrators as inductors. This three-section filter, (IC404, 405, 406, 407), has a roll-off of 54db per octave with a cutoff frequency of approximately 40Hz. This filter has no appreciable attenuation above 50Hz and will change the characteristic of the broadcast material indetectably. However, the removal of the subsonic and low frequency audio components greatly benefits the subsequent audio processing.

### 5-2. R.M.S. Compressor

The R.M.S. compressor employs a feed-forward, open-loop control design. The gain control module (GCM) employed is capable of 25db of linear control with fast response characteristics. The control signal for the GCM is obtained by adding together fast responding and slow responding control voltages. The time response character

of these controls being 100 milliseconds and 500 milliseconds. The control circuit is designed such that short duration peak information contributes little to long term gain reduction and long term audio information contributes little to peak gain reduction.



The fast section consists of capacitor coupled absolute value amplifier, IC102, C102 and R109 form a single-pole high-pass filter with a 6dB point at 200Hz. The output of this amplifier is processed by time constant circuit, D103, R114, R115 and C103. This voltage is then buffered and amplified (IC101) and used for the fast response LED indicator. The slow circuit is similar except for altered response timing. The output from the fast and slow responding sections are combined by D104, D105, R119; such that the greater of the two appear at TP15. IC105 is a voltage to current amplifier providing the current drive to the Gain Control Module.

Note the current to the GCM is proportional to the audio input appearing at TP11. Since the resistance of the photo resistor in the GCM is inversely proportional to the current supplied to the LED, it can be shown that the output of the audio voltage divider consisting of  $R_A$  and  $R_Q$  has a constant average level.

Since:

$$R_Q = \frac{C1}{ILED} \quad (1)$$

and

$$ILED = C2 * V_{in} \quad (2) \quad C1; C2 \text{ determined by circuit}$$

also:

$$V_{out} = V_{in} * \frac{R_Q}{R_Q + R_A}$$

for:

$$R_A \gg R_Q$$

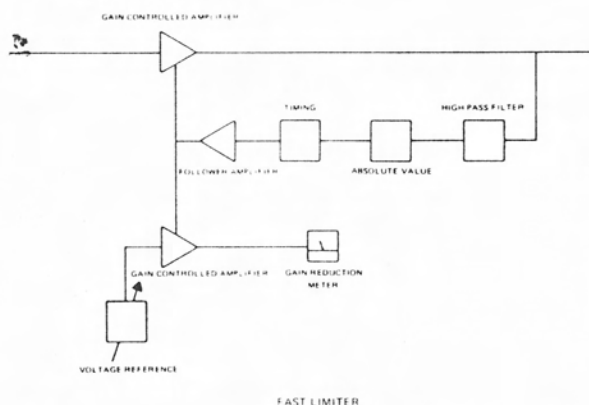
$$V_{out} \sim V_{in} * \frac{R_Q}{R_A} \quad (3)$$

Combining 1; 2; 3:

$$V_{out} = V_{in} * \frac{C1}{R_A * ILED} = V_{in} * \frac{C1 = C1}{R_A * C2 * V_{in} * C2} = \text{Constant}$$

Follower IC107A is used to convert the high impedance voltage divider point to a low impedance output to drive the fast limiter stage. IC107B is used in a metering circuit. Voltage divider R105, using R106 and DS101 as a reference voltage supply, sets the VU meter to zero with no gain reduction.  $R_M$  and  $R_A$  form an identical circuit with  $R_M$  and  $R_Q$  respectively. Since the metering circuit has a constant input, the meter reads the "gain reduction"; the amount of voltage shunted by  $R_M$ .

### 5-3. Fast Limiter

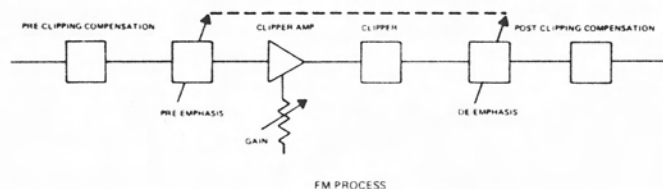


The fast limiter stage provides audio control by using the peak information of the audio signal. This circuit consists of a follower amplifier whose gain may be controlled by the resistance of a FET transistor. R203, R227, and Q203A form the feedback path for

IC203. Thus, in the zero bias condition, when Q203A exhibits minimum resistance, circuit gain is at a maximum. Bias is accomplished by a feed-back stabilized circuit consisting of absolute value amplifier IC201A, IC202B, and time constant network D201, R210, R211, C205, and servo gain amplifier IC202A.

Distortion in the FET attenuator is minimized by compensation network C204, R204 and R205. The metering circuit's control elements are the same as that for the audio with the exception of A.C. compensation. A constant input level is derived by reference circuit R219, DS201 and the voltage divider R220, R221 and R222. The meter is calibrated to read zero VU with no gain reduction. Since both amplifier's have the same control voltage the VU meter reads gain reduction. Such a circuit requires matched FET's.

### 5-4. FM Process (FM Multilimiter Only)



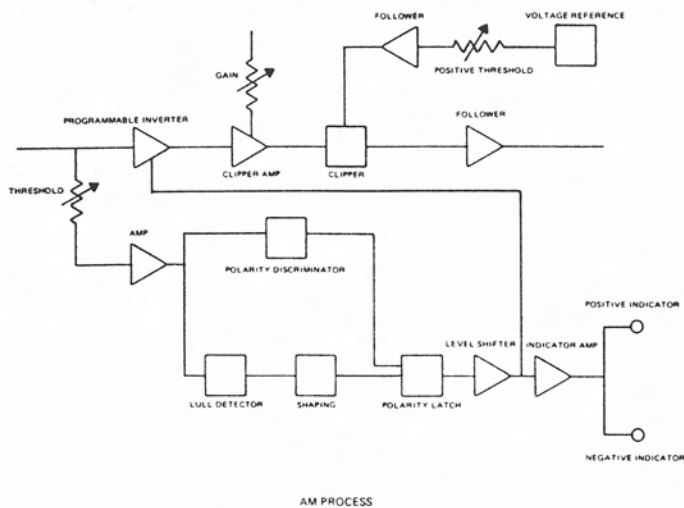
The FM process section must provide absolute over-modulation protection. This is accomplished by shelving filters and the proper pre-emphasis, de-emphasis networks, and L.E.D. clipping. Consider first, the FM process unit operating in the "flat" condition. The final limiting step is to clip the peak information at a level three times greater than the average level for a sine wave input. Such a clipping level introduces very little distortion in the output signal while still maintaining a high average program level. Since many FM stereo generators employ low pass filtering at 17KHz, it is necessary to compensate for the effect that a square wave with it's high order harmonics removed has a higher peak level than the composite signal. This is corrected for, by two complimentary shelving filters. The input filter consists of R601, R602, R603, and C601. This filter boosts the level of a 6KHz signal 2db from a 1KHz reference. The output filter consisting of R622, R624 and C621 reduces the level by 2db at 6KHz from 1KHz reference. Therefore, below the clipping level the two filters offset each other. However, when clipping occurs, harmonic information above 6KHz is reduced in level, when the resulting signal is low pass filtered, peak information is not boosted above the sine wave peak levels. Since the transmitter requires 25 or 75µs pre-emphasis protection, the FM process also simulates these networks before clipping, and de-emphasises the material after clipping. Thus, below the clipping level, the networks offset each other. The clipping amplifier's (IC602) gain may be altered by R613. C612 is used to eliminate any DC offset. The clipper consists of R617 and DS601, DS602 and follower amplifier IC601. LED's were chosen as clippers because of their low ON voltage and light tolerance.

### 5-5. AM Process (AM Multilimiter Only)

To take advantage of positive modulation greater than 100%, it is well to optimize the phase of the audio so the maximum peak information is positive going. The programmable amplifier IC306B will invert it's output if Q301 is on, and not invert if Q301 is off.

To optimize the phase, it is necessary to determine the symmetry of the signal and the optimum time to switch the polarity. The input is first amplified by IC306. This signal is high pass coupled by C315, R335 to a peak discriminator R314, D301, D302, C309 and C310. The threshold level controls the input level and along with the diode drop of D301 and D302 allow comparison of peaks above 100%

modulation. The summed and filtered output of the discriminator is fed to a schmitt trigger IC302B whose hysteresis loop is determined by R318, R319, to be 150 millivolts. This dead zone along with the filtering provided by C311, assures the polarity signal, will change only when a substantial change in symmetry is present.



Polarity switching is allowed to occur only during lulls in the program material. This assures the minimum "pop" when polarity is switched. The signal level is determined by the circuit consisting of IC302A. When a high level signal is present at R322, both C312 and C313 are charged, the differential voltage on IC302A forces a positive output voltage. If not audio is present, both C312 and C313 are discharged. R324 and R323 forms a feedback loop in a follower amplifier. With zero input, therefore, the output voltage will be zero. By adjusting R321, a level can be established where the lull detector is in the transition region on comparatively low level signals. IC301B and R326 form a signal shaping circuit converting the slow analog signal to a fast edge. This signal, along with the polarity information is sent to a "D" flip-flop IC301A, such that the data is the polarity detector and the clock is the lull detector, thus switching occurs only on signal lulls. IC303A is used to convert the logic level signals (0-15 volts) to an analog signal to drive the polarity switching FET and the indicator drive Q302. R332 limits the current to the LED's. When Q302 is off, current passes through D310 to the "INVERT" indicator. When Q302 is on, the collector of Q302 is below the voltage threshold of the "INVERT" indicator with current passing through to the "NORMAL" indicator.

The output of the programmable inverter is coupled to the amplifier IC304, whose gain may be set by R309; C307 eliminates D.C. offset. The output is then clipped by R310, D305, D306, and coupled by voltage follower IC305A to the output. R311, D309, R337, and the "Positive Threshold" control form a voltage divider and along with voltage follower, IC305B and C308 set the bias level to D306, thus controlling the positive clip level. A clipper bypass is available for test purposes.

### 5-6. Output Amplifier

The power amplifier is designed to amplify the signal with a minimum amount of phase shift and distortion. IC408 provides a high gain element coupled into voltage follower transistors Q401, Q402, by C430, C431, D407 and D409. R437, R438 bias both transistors on against D407 and D409 respectively. R435, C426, provide a feedback path to IC408. Current limiting is provided by R439, R440, D408 and D410.

Variable gain is provided by R430 and the "Fine Output" control. D.C. offset is eliminated by C423. Two transformer coupled outputs are provided. One with twice the voltage of the other is used for the VU metering. The network R445, R446 and the Output Meter control allow the meter to be set at "OVU" for output levels between +4dBm and +16dBm.

### 5-7. Power Supply

Power is switched by a D.P.D.T. switch on the rear panel and is fused at 1/4 amp. The power transformer chosen provides the current needed through the full wave bridge, FWC 100, to the filter capacitors, C403 and C405. Regulation is provided by IC401 and IC402. D405, D406, C404 and C406 protect the regulators from being back biased during the removal and insertion of modules with the power on. The lumped sum of the capacitors on each card and the output section stabilize the voltages for each circuit.

### 5-8. Switching

Test switching is accomplished by disabling all gain reduction. The R.M.S. section is disabled by opening R101, the feedback path for the current amplifier IC105A. The indicator LED's are disconnected from ground. The fast limiter is disabled by shorting the control voltage to ground. The FM process board need only lift the clipping diodes from ground. Notice that the pre-emphasis and de-emphasis networks are still in the circuit. In the AM process board, the clipper is bypassed, and the polarity latch is forced to the "positive" state.

## Section VI

### Check-out and Alignment

#### 6-1. Test Equipment

- 1.) Audio Oscillator. 30Hz to 20KHz; less than 0.1% total harmonic distortion; 10dB/step attenuator; 600 ohm output.  
Recommended Model: Hewlett Packard 204D
- 2.) Distortion Analyzer. Measure to 0.1% THD; 50Hz to 20KHz.  
Recommended Model: Hewlett Packard 331
- 3.) A. C. Voltmeter. Average responding; -60dBm to +30dBm; 30Hz to 15KHz; 100KHz low-pass filter switch.  
Recommended Model: Hewlett Packard 400F
- 4.) Oscilloscope. 500KHz bandwidth; display accuracy of 3%; .01 volt to 10 volts/div.; dual trace.  
Recommended Model: Hewlett Packard 1205A
- 5.) Function Generator. Square wave; adjustable duty cycle (for AM asymmetry).  
Recommended Model: Interstate Electronics F34

#### 6-2. Initial Tests

- 1.) Connect audio oscillator to INPUT terminals.
- 2.) Set INPUT control to maximum clockwise.
- 3.) Set oscillator output for -20dBm.
- 4.) Connect A.C. voltmeter to Test Point No. 2.
- 5.) Sweep oscillator between 50Hz and 15KHz. Voltmeter reading should be constant within 1dB.
- 6.) Set oscillator to 25Hz. Voltmeter reading should be at least 40dB below reading at 1KHz.

#### 6-3. RMS Compressor

- 1.) Remove the FAST LIMITER and PROCESS card.
- 2.) Set TEST/OPERATE switch to TEST.
- 3.) Adjust trimpot, R105, for a "0" VU.
- 4.) Set audio oscillator to 1KHz output and verify its output at -15dBm.
- 5.) Set TEST/OPERATE switch to OPERATE.
- 6.) Adjust front panel INPUT control for a gain reduction indication of 6dB on COMPRESSION VU meter.
- 7.) Switch audio oscillator to 100Hz. Fast LED should dim slightly.
- 8.) Reset oscillator to 1KHz. Do not change output level.
- 9.) Connect A.C. voltmeter to Test Point No. 12 on RMS card. Note the voltmeter reading.
- 10.) Switch TEST/OPERATE switch to TEST.
- 11.) Voltmeter reading should increase 6dB,  $\pm 2$ dB.
- 12.) Return TEST/OPERATE switch to OPERATE. Note voltmeter reading.
- 13.) Increase audio oscillator output 10dB.
- 14.) Voltmeter reading should stay constant within 3dB.

#### 6-4. Fast Limiter

- 1.) Insert FAST LIMITER card.
- 2.) Set TEST/OPERATE switch to TEST.
- 3.) Adjust trimpot, R220, for a "0" VU reading on FAST LIMITING meter.

- 4.) Return TEST/OPERATE switch to OPERATE.
- 5.) Remove RMS card.
- 6.) Set audio oscillator to 1KHz and connect signal to center terminal of FAST LIMITING control with oscillator common lead connected to control terminal with black wire attached.
- 7.) Advance FAST LIMITING control fully clockwise.
- 8.) Connect A.C. voltmeter to Test Point No. 22 on FAST card.
- 9.) Adjust oscillator for a gain reduction indication of -6dB on FAST LIMITING VU meter. Note voltmeter reading.
- 10.) Set TEST/OPERATE switch to TEST.
- 11.) Voltmeter reading should increase 6dB,  $\pm 2$ dB.
- 12.) Return TEST/OPERATE switch to OPERATE.
- 13.) Note voltmeter reading.
- 14.) Increase oscillator output 10dB. Voltmeter reading should increase 2dB,  $\pm 1$ dB.
- 15.) Disconnect oscillator from LIMITING control and reconnect to rear panel INPUT terminals.
- 16.) Re-insert RMS card. Adjust oscillator for -6dB RMS COMPRESSION.
- 17.) Adjust R133 on RMS card for 4dB of fast limiting.

#### 6-5. FM Process

- 1.) Insert FM card and remove fast limiter card.
- 2.) Set TEST/OPERATE switch in TEST.
- 3.) Connect oscillator and A.C. voltmeter to Test Point No. 63 on FM card.
- 4.) Set pre-emphasis switch on front panel to FLAT.
- 5.) Adjust audio oscillator for -20dB reading on A.C. voltmeter at 1KHz.
- 6.) Connect A.C. voltmeter to Test Point No. 62.
- 7.) Set oscillator to 10KHz and note voltmeter reading.
- 8.) Set pre-emphasis switch to 25 $\mu$ s. Voltmeter reading should increase 6dB,  $\pm 1$ dB.
- 9.) Set pre-emphasis switch to 75 $\mu$ s. Voltmeter reading should increase 14dB,  $\pm 2$ dB with respect to level noted in step 7.
- 10.) Set pre-emphasis switch to FLAT and connect voltmeter to Test Point No. 64. Note voltmeter reading.
- 11.) Set pre-emphasis switch to 25 $\mu$ s. Meter reading should be within  $\frac{1}{2}$ dB of FLAT reading.
- 12.) Set pre-emphasis switch to 75 $\mu$ s. Meter reading should be within 1dB of FLAT reading.
- 13.) Return TEST/OPERATE switch to OPERATE. Leave oscillator set to 10KHz. Install Fast Limiter. Connect oscillator to input.
- 14.) Adjust input level for 6dB of RMS COMPRESSION. Set FAST LIMITING control fully clockwise.
- 15.) Connect oscilloscope to Test Point No. 61.
- 16.) Turn trimpot R613 fully clockwise, (MAXIMUM clipping). Observe symmetry of clipped signal, within 0.2 volts.
- 17.) Adjust oscilloscope for a conveniently large scale display.

- 18.) Set audio oscillator to 1KHz.
- 19.) Adjust trimpot R613 so that sine wave peak-to-peak level is  $\frac{1}{2}$  the amplitude of the clipping level.

#### 6-6. AM Process

- 1.) Insert AM card.
- 2.) Adjust input, if necessary, for 6dB of RMS COMPRESSION and set FAST LIMITING control fully clockwise.
- 3.) Set POSITIVE THRESHOLD control fully counterclockwise.
- 4.) Remove IC302. Connect one channel of the dual-trace oscilloscope to Test Point No. 31, the other channel to Test Point No. 32.
- 5.) Connect Test Point No. 37 to +15 volt supply at positive end of C315. Then connect Test Point No. 38 to +15 volt supply. "Negative" POLARITY L.E.D. should illuminate.
- 6.) Traces on oscilloscope should be 180 degrees out of phase.
- 7.) Set TEST/OPERATE switch to TEST.
- 8.) "Positive" POLARITY L.E.D. should illuminate and oscilloscope traces should be in phase.
- 9.) Disconnect Test Points No. 37 and No. 38 from +15 volt supply. Connect oscilloscope to Test Point No. 33. Connect RMS voltmeter to Test Point No. 33. Replace IC302.
- 10.) Check input level for 6dB of RMS COMPRESSION, and FAST LIMITING control fully clockwise.
- 11.) Adjust trimpot R309 clockwise to determine the clipping level as observed on the oscilloscope. Reduce R309 so that the sine wave level is 4db below the threshold of clipping.
- 12.) Connect the A.C. voltmeter to Test Point No. 35 and connect the oscilloscope to Test Point No. 38.
- 13.) Adjust trimpot R321 for a voltmeter reading of +4dB. Reduce limiter input until voltage at Test Point No. 38 is 7 volts, (Ripple should be present on displayed signal). The level at Test Point No. 35 should be -3dB,  $\pm 2$ dB.
- 14.) Set TEST/OPERATE switch to OPERATE.
- 15.) Connect oscilloscope to Test Point No. 36, and connect the function generator to the limiter input terminals.
- 16.) Insert a 50% duty cycle square wave at 1KHz and adjust input for 6dB RMS COMPRESSION.
- 17.) Voltage at Test Point No. 36 should be 0 volts,  $\pm 0.05$  volts.
- 18.) Adjust square wave to 75% duty cycle. Voltage should be below -0.2.0 volts.
- 19.) Adjust square wave to 25% duty cycle. Voltage should be above +0.20 volts.

#### 6-7. Overall Checkout and Performance Measurements

- 1.) Set TEST/OPERATE switch to TEST. Set INPUT, FAST LIMITING, OUTPUT METER COARSE OUTPUT, and FINE OUTPUT controls fully clockwise. Set pre-emphasis switch of FM model to FLAT. Connect 1KHz oscillator to limiter input at a level of -20dBm. If oscillator is an unbalanced source, connect "C" input terminal to chassis ground terminal, also connect "C" output terminal to chassis ground terminal.
- 2.) Connect the oscilloscope, voltmeter and a 600 ohm termination to the OUTPUT terminals. Adjust COURSE OUTPUT to a level just below clipping. Verify phasing of MONITOR OUTPUT with second trace of oscilloscope.
- 3.) Measure output level; should be greater than +24dBm.

- 4.) Connect distortion analyzer to output. Distortion should be less than 0.1% THD.
- 5.) Disconnect audio oscillator from input. Noise at output, measured with 100KHz low-pass filter, should be less than -48dB.
- 6.) Reconnect 1KHz audio oscillator and verify -15dBm oscillator output level. Set TEST/OPERATE switch to OPERATE.
- 7.) Adjust INPUT for 6dB RMS COMPRESSION; Adjust fast limiter for -3db gain reduction.
- 8.) Distortion should measure less than .3%.
- 9.) Set oscillator to 100Hz and measure distortion without resetting panel controls. (FAST LIMITING meter will show less gain reduction). Distortion should be less than .5%.

## Section VII Field Modifications

### 7-1. AM, Auto-Polarity Defeat

Should it be desired to defeat the APC circuit, simply turn trimpot R321 on the AM PROCESS card fully counter-clockwise and cycle the TEST/OPERATE switch to the TEST position and back to OPERATE. The APC will now remain in the "Positive" state. To re-activate the APC, please refer to Section VI, sub-section 6-6.

### 7-2. FM, 75 $\mu$ s De-emphasis Bypass

An improvement in modulation accuracy may be attained by using the Multilimiter's 75 $\mu$ s pre-emphasis, defeating the de-emphasis and removing or by-passing the transmitter pre-emphasis. To bypass the 75 $\mu$ s de-emphasis in the Multilimiter, cut the solid wire jumper on the mother board immediately adjacent to wire eyelet No. 14. On early models cut or unsolder the yellow wire at eyelet No. 14. Be

sure to insulate the wire after disconnection. The pre-emphasis switch will still operate normally, but the 75 $\mu$ s position will not provide de-emphasis.

### 7-3. Increased Output Capability

The Multilimiter's output transformer has three identical secondaries; two are connected in series for the main OUTPUT and the third is connected to the MONITOR terminals. The output capability and level may be increased 3dB by connecting the main and MONITOR outputs in series. DO NOT CONNECT IN PARALLEL! The transformer was designed for the flexibility of driving 600 ohm loads from either set-up. The output meter is connected across the main OUTPUT; therefore, add 3dB to the meter calibration setting.

## Section IX Recommended Spares

**9-1.) The following spare parts are recommended for field support of the Multimeter:**

Operational Amplifiers:	3 each	HA-2505	Diodes:	1 each	FWC-100, bridge
	3 each	1458		2 each	TIL-209A L.E.D.
Transistors:	1 each	2N3642		2 each	TIL-211 L.E.D.
	1 each	2N4303 (AM)		2 each	IN34
	1 each	MJE-170		2 each	IN914
	1 each	MJE-180		2 each	IN4003

## Section VIII Major Parts List

### 8-1. Main Frame

Description	Reference	Part No.
Transformers	T401	*48-102
	T402	*49-102
	T403	*49-303
Integrated Circuits	IC401	LM-340T-15
	IC402	LM-320T-15
	IC404-407	1458
	IC408	HA-2505
Diodes	D401-404 (bridge)	FWC-100
	D405,406	IN4003
	D407-410	IN914
Potentiometers	INPUT	600 ohm, T-attenuator
	FAST LIMITING	10K ohm, Linear
	COARSE OUTPUT	10K ohm, Audio taper
	FINE OUTPUT	10K ohm, Linear
	POSITIVE THRESHOLD (AM)	10K ohm, Linear
	OUTPUT METER	10K ohm, Linear
	Switches	PRE-EMPHASIS (FM)
	TEST/OPERATE	3P2T Toggle
Meters	RMS COMPRESSION (early)	*47-0001
	FAST LIMITING (early)	*47-0001
	RMS COMPRESSION	*47-0003
	FAST LIMITING	*47-0003
	OUTPUT LEVEL	*47-0003

### 8-2. RMS Compressor

Description	Reference	Part No.
Integrated Circuits	IC101-105	1458
	IC106 (attenuator)	*101-002
	IC107	1458
Diodes	D101,102	IN914
	D103-105	IN34
	D106,107	IN914
	D108	IN34
	DS101 (L.E.D.)	TIL-209A
Transistors	Q101,102	2N3642
Potentiometer	R105	1K Trimpot
	R133	100K Trimpot

### 8-3. Fast Limiter

Description	Reference	Part No.
Integrated Circuits	IC101,102	1458
	IC103	HA-2505
Diodes	D201	IN34
	D202,203	IN914
	DS201 (L.E.D.)	TIL-209A
F.E.T.	Q203	*82-001
Potentiometer	R220	1K Trimpot

### 8-4. AM Process

Description	Reference	Part No.
Integrated Circuits	IC301	74C74
	IC302,303	1458
	IC304	HA-2505
	IC305,306	1458
Diodes	D301-304	IN914
	D305,306 (L.E.D.)	TIL-211
	D309 (L.E.D.)	TIL-209A
	D310	IN914
Transistors	Q301	2N4303
	Q302	2N3642
Potentiometers	R309	10K~Trimpot
	R321	100K~Trimpot

### 8-5. FM Process

Description	Reference	Part No.
Integrated Circuits	IC601-605	HA-2505
Diodes	DS601,602	TIL-211
Potentiometer	R613	10K Trimpot

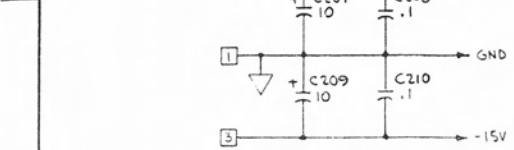
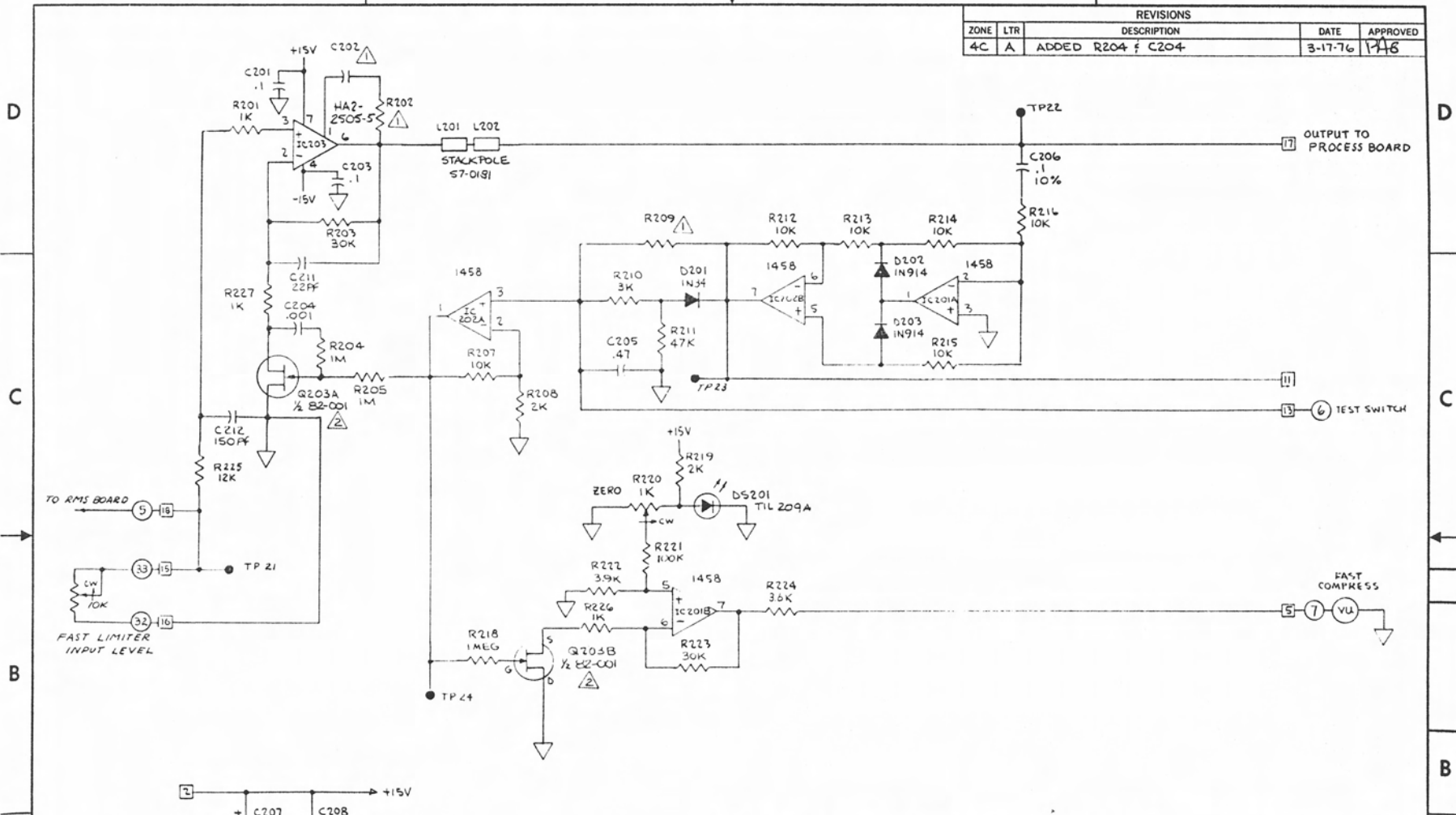
(\*House Part no.)





4 3 2 1

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
4C	A	ADDED R204 f C204	3-17-76	PA8



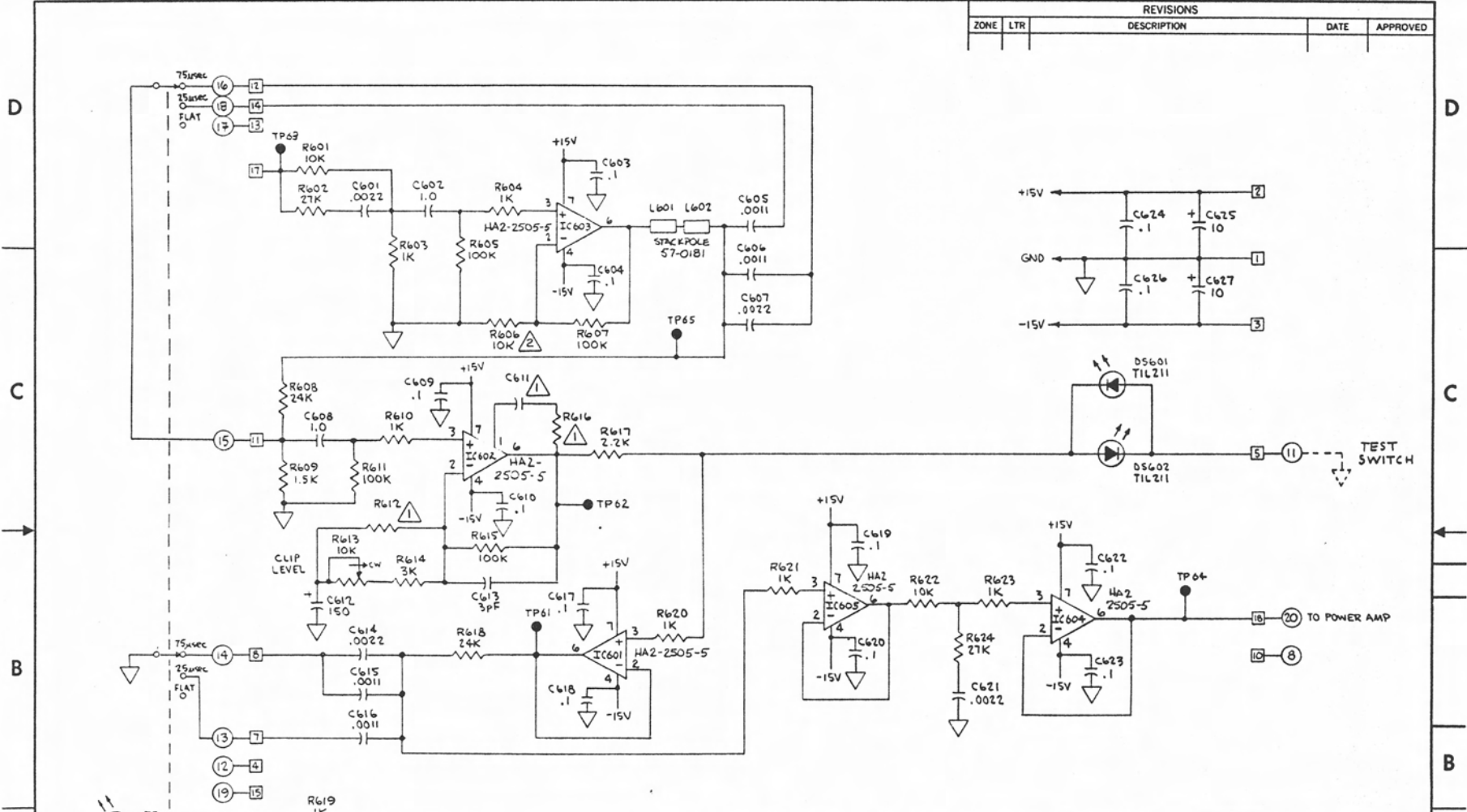
ALL RESISTORS 1/4W 5% UNLESS SPECIFIED

NOTES:   
 1. PACIFIC RECORDERS PART NBR.   
 2. COMPONENT NOT USED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
PARTS LIST			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:		CONTRACT NO.	
FRACTIONS	DECIMALS	ANGLES	
=	XX =	XXX =	
MATERIAL		APPROVALS	DATE
FINISH		DRAWN G. CARR	12-9-75
NEXT ASSY USED ON		CHECKED M. COPLEY	12-19-75
APPLICATION		SIZE C	CODE IDENT NO. K1-SD-002A
DO NOT SCALE DRAWING		SCALE NONE	DRAWING NO. K1-SD-002A
		SHEET 1 OF 1	

4 3 2 1

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



RESISTORS 1/4 W 5% UNLESS SPECIFIED

NOTES

RESISTOR SYMBOLS:  $\triangle$  NOMINAL VALUE SHOWN,  $\triangle$  NOT USED

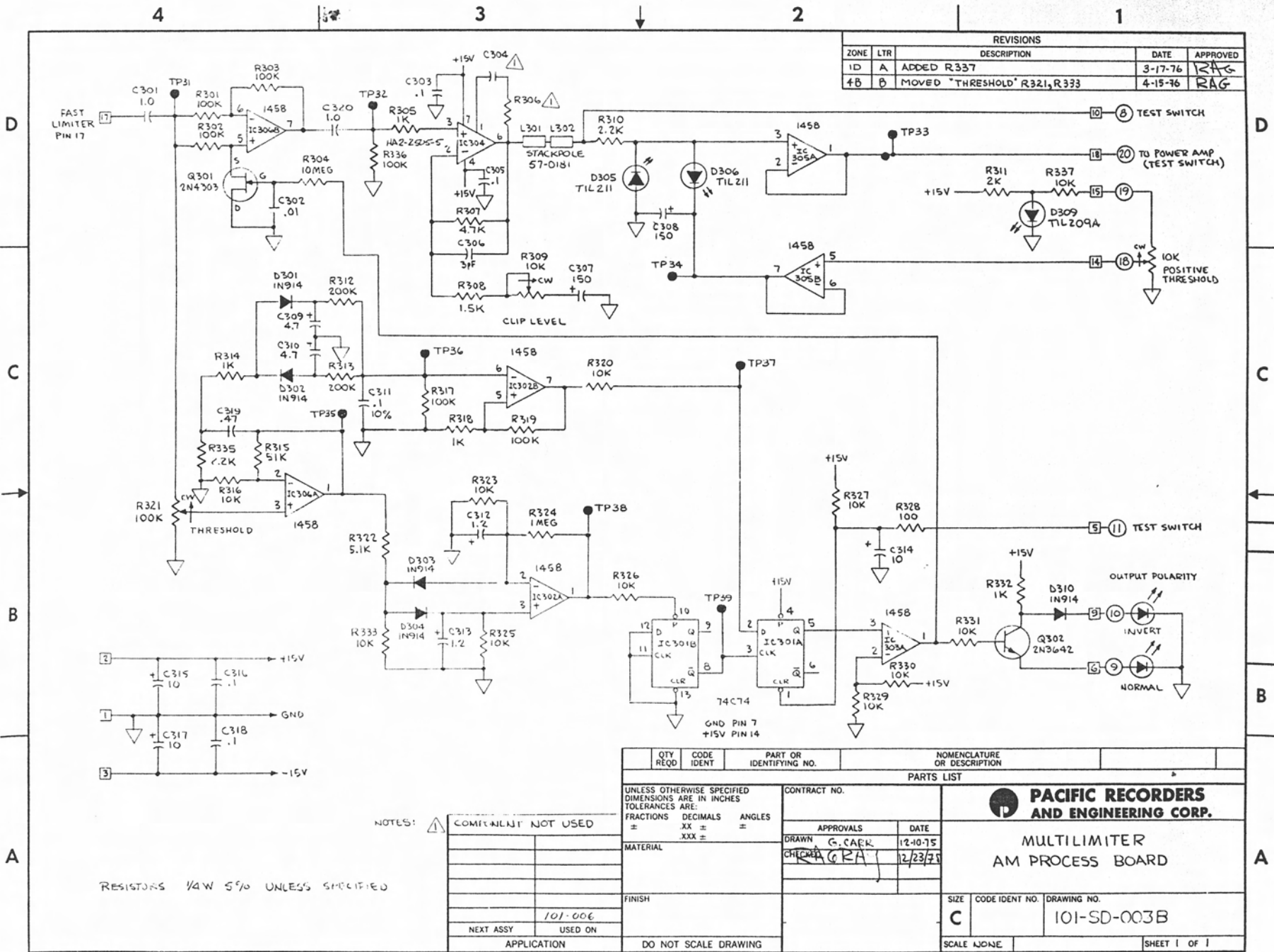
QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
PARTS LIST			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:			
FRACTIONS	DECIMALS	ANGLES	
=	.XX ±	=	
	.XXX ±		
MATERIAL		CONTRACT NO.	
FINISH		APPROVALS	
NEXT ASSY USED ON		DATE	
APPLICATION		DRAWN G. CARR 2-12-76	
DO NOT SCALE DRAWING		CHECKED R. GRAY 2-29-76	

**PACIFIC RECORDERS AND ENGINEERING CORP.**

MULTILIMITER FM PROCESS

SIZE C CODE IDENT NO. 101-SD-006 DRAWING NO.

SCALE NONE SHEET 1 OF 1

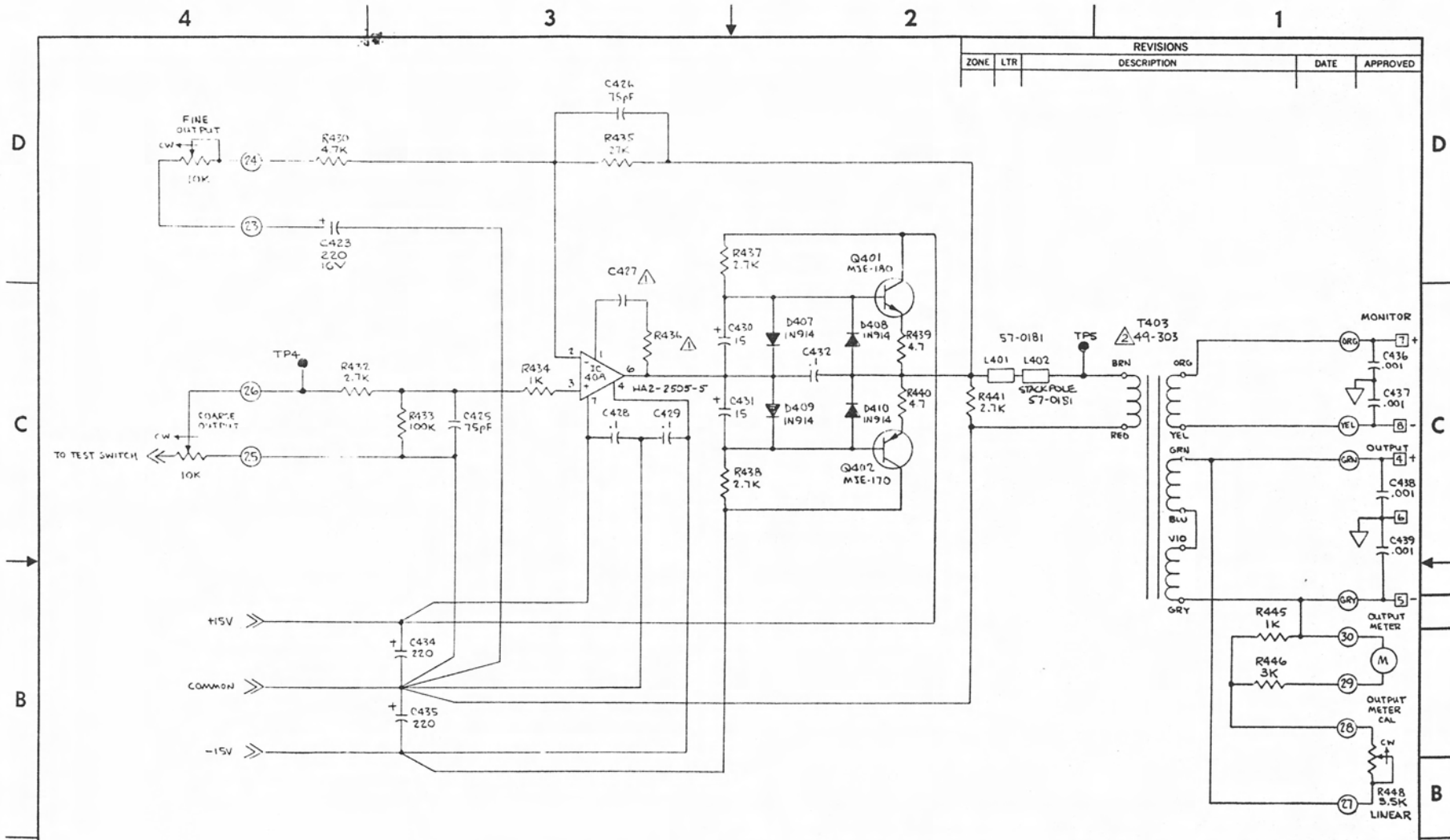


REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
1D	A	ADDED R337	3-17-76	RAG
4B	B	MOVED 'THRESHOLD' R321, R333	4-15-76	RAG

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
PARTS LIST			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:		CONTRACT NO.	
FRACTIONS	DECIMALS	ANGLES	
±	±	±	
MATERIAL		APPROVALS	
		DRAWN	DATE
		G. CAER	12-10-75
		CHECKED	12/23/75
		PACIFIC RECORDERS AND ENGINEERING CORP.	
		MULTIMETER AM PROCESS BOARD	
FINISH		SIZE	CODE IDENT NO. DRAWING NO.
		C	101-SD-003B
NEXT ASSY USED ON	101-006	SCALE NONE	SHEET 1 OF 1
APPLICATION	DO NOT SCALE DRAWING		

NOTES: 1. COMPONENT NOT USED

RESISTORS 1/4W 5% UNLESS SPECIFIED



REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

ALL RESISTORS - 1/4W 5% UNLESS SPECIFIED

NOTES:   
 1. PACIFIC RECORDERS PART NUMBER NOT USED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
PARTS LIST			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:		CONTRACT NO.	
FRACTIONS	DECIMALS	ANGLES	APPROVALS
±	±	±	DATE
±	±	±	DRAWN G. CARR 1-2-76
MATERIAL		CHECKED [Signature] 2/15/76	
FINISH		SIZE CODE IDENT NO. DRAWING NO.	
NEXT ASSY USED ON		C 101-SD-004 SH,3	
APPLICATION DO NOT SCALE DRAWING		SCALE NONE SHEET 3 OF 3	



**PACIFIC RECORDERS AND ENGINEERING CORP.**  
 MULTILIMITER  
 MOTHERBOARD POWER AMP





PACIFIC RECORDERS AND ENGINEERING CORPORATION  
11100 ROSELLE STREET, SAN DIEGO, CALIFORNIA 92121 (714) 453-3255 TELEX 695-008

August 2, 1976

Subject: Multilimiter Manual, Field Bulletin #1  
RE: RMS Compressor PC Board, Schematic #101-SD-001B  
Effective: Units Prior to Serial # 1099

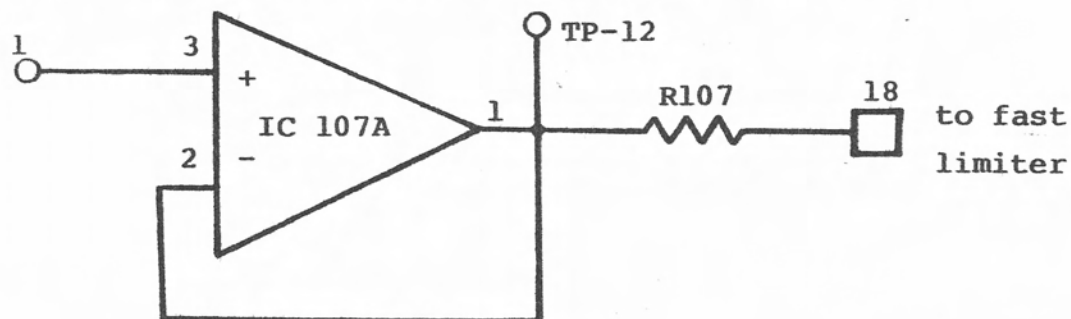
RMS circuit cards do not have the following parts:

Gain trimpot R133

R134

R135

The schematic for these cards is as follows:



The value of R107 is selected to satisfy step #17 of the fast limiter alignment instructions.



PACIFIC RECORDERS AND ENGINEERING CORPORATION  
11100 ROSELLE STREET, SAN DIEGO, CALIFORNIA 92121 (714) 453-3255 TELEX 695-008

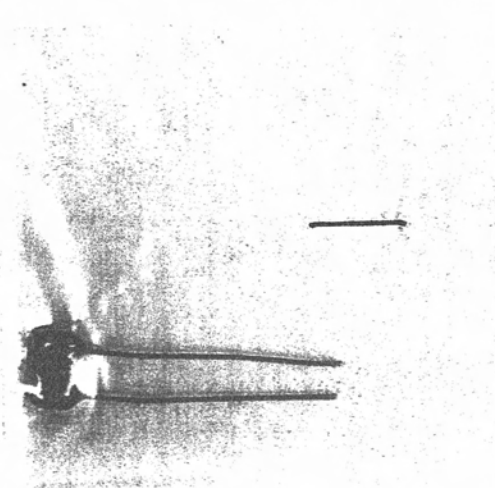
August 5, 1976

Subject: Multilimiter Manual, Field Bulletin #2  
RE: FM Process P.C. Board, Schematic #101-SD-006  
Effective: FM Units Prior to Serial #F-1091

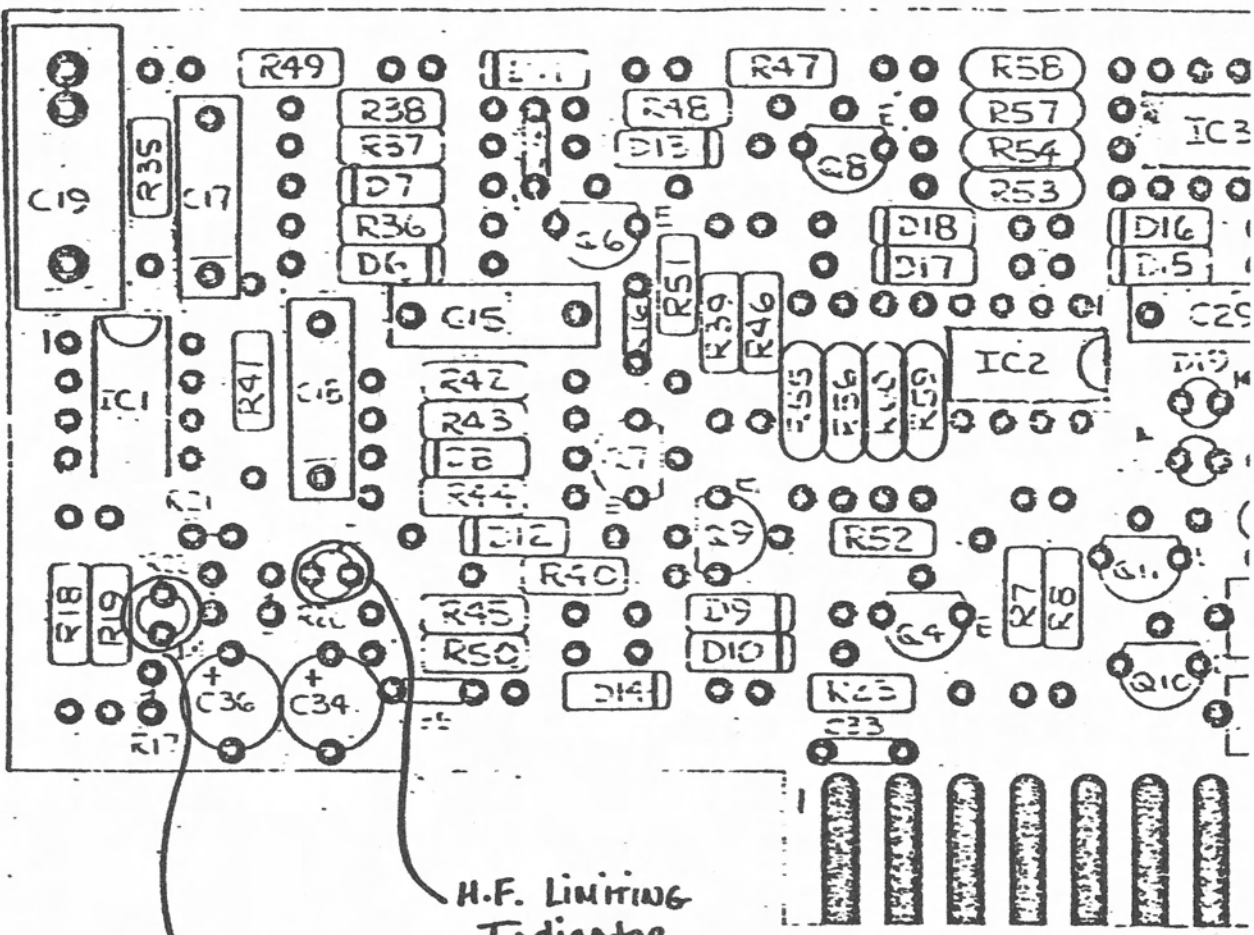
High frequency compensation capacitor C613 should be changed to 33pf, part enclosed.

This change is required when using field modification 7.2, FM, 75us de-emphasis bypass. The new value does not affect normal operation or specifications.

Please use care in removing existing part as P.C. holes are plated through.



OSCILLOSCOPE  
POINT



H.F. Limiting  
Indicator

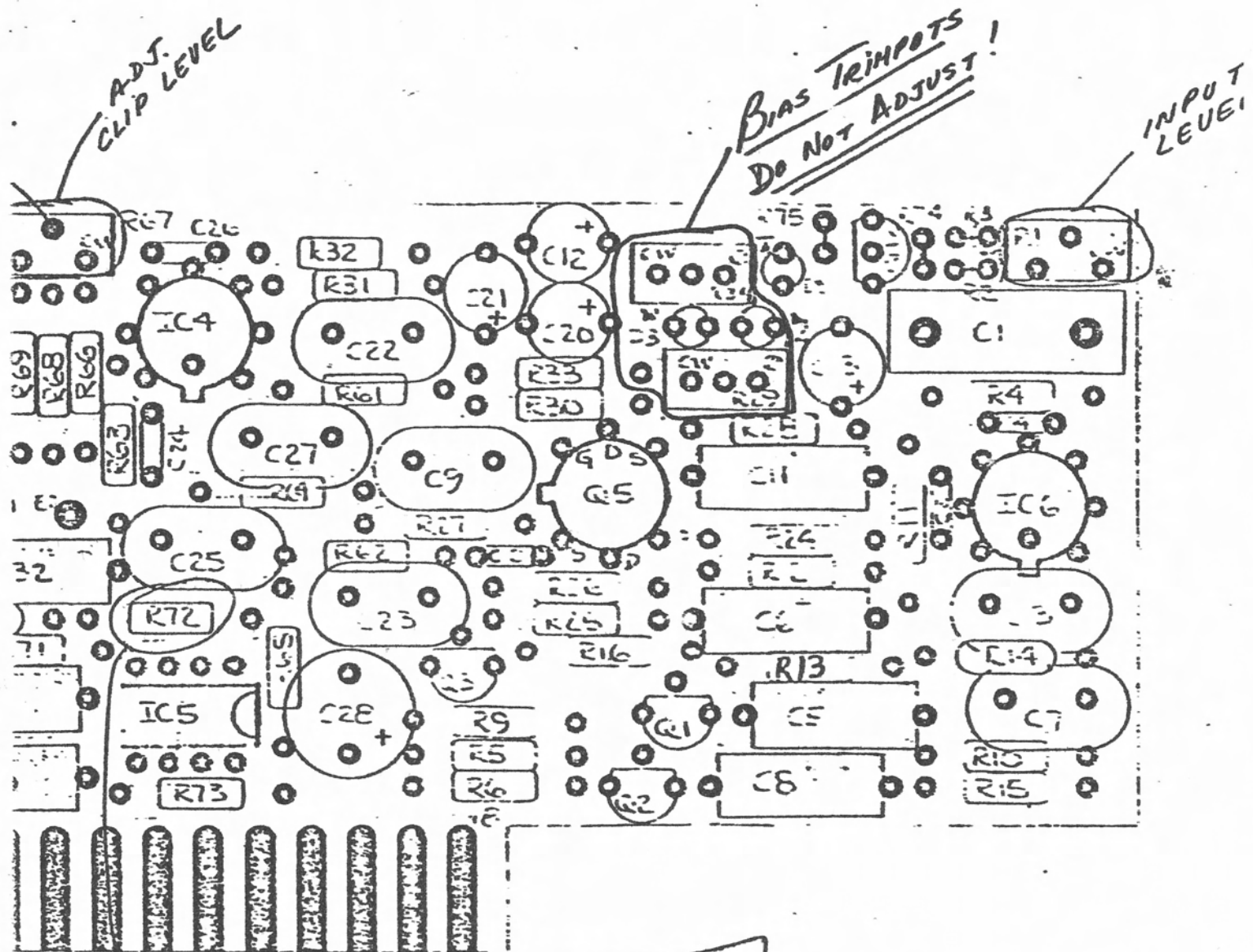
Peak Limiting  
Indicator


NEXT ASSY

USED ON

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPR



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:		
FRACTIONS	DECIMALS	ANGLES
±	.XX ±	±
	.XXX ±	
MATERIAL		
FINISH		

CONTRACT NO.	
APPROVALS	DATE
DRAWN	
CHECKED	

**PACIFIC RECORDERS AND ENGINEERING CORP**

ASSY. DIA.  
MULTILIMITER/FM PROCESS

SIZE	CODE IDENT NO.	DRAWING NO.
B		

After my Departure from the project

## ADDENDUM

### FM PROCESS MODULE #2

#### 5-4. THEORY OF OPERATION

The FM Process Module must provide absolute over-modulation protection. This is accomplished by complimentary shelving filters, pre-emphasis and de-emphasis networks and a unique dual control Limiter. The Limiter is capable of holding peak excursions without the clipper. At the user's option, the clipper may be set to provide higher apparent loudness.

Since most FM stereo generators employ low-pass filtering at 17KHz, it is necessary to compensate for the effect that when the high order harmonics of some composite waveforms are removed they have a higher peak level than the original signal. This is corrected for by two complimentary shelving filters. The pre-limiting filter boosts the level of a 6KHz signal 2dB from a 1KHz reference. The post-limiting filter reduces the level by 2dB at 6KHz from 1KHz reference. Therefore, below the limiting threshold the two filters offset each other. However, when limiting occurs, harmonic information above 6KHz is reduced in level. When the resulting signal is filtered in the stereo generator, the composite information will not be boosted above the equivalent sine wave peak level.

Since the transmitter requires 25 $\mu$ s Dolby or 75 $\mu$ s pre-emphasis protection, the FM process module also simulates these networks before limiting and de-emphasizes the material after limiting. Thus, below the limiting level, the networks offset each other.

Pre-emphasis is provided by switching C-5 or C-8 into the feedback network of IC6 using saturated transistors Q-1 or Q-2. The pre-limiting shelving filter consists of R-12, R-13, R-25 and C-6. Q-3 switches in an additional 2dB of attenuation in the 75 $\mu$ s mode to compensate for the increase in total energy at that pre-emphasis characteristic.

The high frequency Limiter consists of a voltage controlled shelf equalizer operating on the 75 $\mu$ s characteristic. FET Q5a serves as a voltage variable resistor which shunts C-11 across series limiting resistor R-24 providing high frequency attenuation. The peak limiter consists of a FET, Q5b voltage controlled attenuator operating in the shunt mode. Regulated bias voltage for Q5a + Q5b is provided by LED's D3, D4 and D5 through trimpots R-29 and R-34.

IC-4 operates at a fixed gain of 36dB which amplifies the output of the limiter stages and provides the necessary drive to peak gain reduction amplifier IC-3, Q-8 and Q-6, high frequency gain reduction amplifier IC-2, Q-9, Q-7 and clipper circuit R-68, D-19 and D-20. Trimpot R-67 sets the output and/or clip point of the module. De-emphasis is provided by R-70 and C-30, C-31 switched by transistors Q-10 and Q-11. The post-limiting shelf filter consists of R-71, C-32 and R-72 buffered by amplifier IC-5.

## 6-5. MODULE CHECKOUT AND ALIGNMENT

- 1) Insert FM card.
- 2) Set trimpots R-1 and R-67 counter-clockwise.
- 3) Turn multiturn trimpots R-29 and R-34 full counter-clockwise.
- 4) Connect distortion analyzer to limiter output terminals. Be sure to terminate output with 600 ohms.
- 5) Check to confirm that oscillator frequency is 1KHz and that RMS COMPRESSION is 6dB and FAST LIMITING is 4dB.
- 6) Set pre-emphasis switch to FLAT.
- 7) Set output controls to obtain 0dBm on distortion analyzer.
- 8) Reduce oscillator output by 10dB.
- 9) Set test switch to TEST. Trim limiter output control for 0dBm on analyzer.
- 10) Be sure the output level of the oscillator remains constant for the following steps.
- 11) Connect A.C. voltmeter to test point #4 and note reading.
- 12) Switch oscillator to 100Hz, level at output and at test point #4; should remain flat  $\pm 0.2$ dB.
- 13) Switch oscillator to 10KHz, level at output and at test point #4; should remain flat  $\pm 0.2$ dB.
- 14) Return oscillator to 1KHz and set pre-emphasis switch to 25 $\mu$ s. Level at test point #4; should not increase more than 0.3dB.
- 15) Switch oscillator to 10KHz. Level at test point #4; should increase by 6dB,  $\pm 0.5$ dB. Level at limiter output should increase by 0.4dB,  $\pm 0.2$ dB.
- 16) Switch oscillator to 1KHz.
- 17) Set pre-emphasis switch to 75 $\mu$ s. Limiter output level should decrease by 2dB,  $\pm 0.3$ dB.
- 18) Switch oscillator to 10KHz. Level at test point #4; should increase by 14dB,  $\pm 0.5$ dB over level noted in step 11. Level at limiter output; should be the same as noted in step 17  $\pm 0.3$ dB.
- 19) Return pre-emphasis switch to FLAT and switch oscillator back to 1KHz.
- 20) Rotate bias trimpot R-34 clockwise until the output level drops by 1dB. Allow for some initial drift as capacitors charge. Re-trim after one minute.
- 21) Switch oscillator to 10KHz and rotate bias trimpot R-29 clockwise until output drops by 0.2dB. This control should not drift.
- 22) Switch oscillator to 1KHz, pre-emphasis switch to 75 $\mu$ s and test switch to OPERATE.
- 23) Increase oscillator output by 10dB.
- 24) Verify that RMS COMPRESSION is 6dB and FAST LIMITING is 4dB; trim if necessary.
- 25) Set oscillator at 2.5KHz,  $\pm 100$ Hz, and advance trimpot R-1 until LED D-2 just illuminates indicating high frequency limiting threshold.
- 26) Sweep upward towards 12KHz. Peak limit indicator LED D-1 should illuminate at a point between 5KHz and 12KHz.

- 27) Connect oscilloscope channel #1, 0.5 volts/division, to center terminal of R-67. Connect horizontal input of oscilloscope to test point #3 and set sensitivity to 1 volt/division.
- 28) Switch the oscillator to 10KHz and set the oscilloscope for X-Y display.
- 29) Advance trimpot R-67 to full clockwise and note the symmetry of the clipping as far as amplitude and shape. Reduce the control just to the point that produces a straight diagonal line.
- 30) Disconnect both oscilloscope leads from the card.

## **6-7. OVERALL CHECKOUT AND PERFORMANCE MEASUREMENTS**

- 1) Set test switch to TEST.  
Set INPUT, OUTPUT METER, COARSE and FINE OUTPUT controls fully clockwise. Set FAST LIMITING control full counter-clockwise.
- 2) Set pre-emphasis switch of FM model to FLAT.
- 3) Connect audio oscillator to limiter input, set at 1KHz, -20dBm exactly. If oscillator is an unbalanced source, connect "C" INPUT terminal to chassis ground terminal.
- 4) Connect A.C. voltmeter and a 600 ohm termination to the OUTPUT terminals. Connect the "C" OUTPUT terminal to the chassis ground terminal.
- 5) Adjust FAST LIMITING control so that limiter output is  $\pm 24$ dBm.
- 6) Connect distortion analyzer to limiter OUTPUT. Distortion should be less than 0.25% THD.
- 7) Disconnect audio oscillator from INPUT. Noise at output, measured with 100KHz low-pass filter, should be less than -46dBm.
- 8) Reconnect 1KHz audio oscillator and set for -15dBm oscillator output level. Set TEST switch to OPERATE.
- 9) Adjust INPUT for 6dB RMS COMPRESSION; adjust FAST LIMITING for 3dB gain reduction. Distortion should measure less than 0.3% THD.
- 10) Set oscillator to 100Hz and measure distortion without resetting any limiter controls (FAST LIMITING meter will show less gain reduction). Distortion should be less than 0.5% THD.
- 11) Set oscillator to 10KHz. Distortion should be less than 0.5% THD.
- 12) Reset oscillator to 1KHz and set pre-emphasis switch to 75 $\mu$ s. Distortion should be less than 0.5% THD.
- 13) Set oscillator to 15KHz. Distortion should be less than 0.5% THD.

*( See back page for diagram )*

