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INSTRUCTION MANUAL

MODEL 1038-H12 and -H13

THIS INSTRUCTION MANUAL
TO REMAIN WITH DEMONSTRATOR

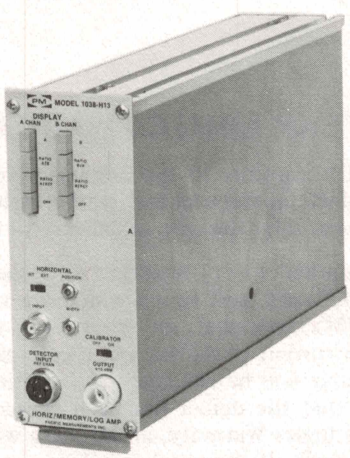
SERIAL NUMBER 589

HORIZONTAL AMPLIFIER PLUG-IN UNITS

MODEL 1038-H12
MODEL 1038-H13

PM PACIFIC MEASUREMENTS INCORPORATED

INSTRUCTION MANUAL



HORIZONTAL AMPLIFIER PLUG-IN UNITS

MODEL 1038-H12
MODEL 1038-H13

SERIAL NUMBER __________

PACIFIC MEASUREMENTS INCORPORATED

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a. Notify PM immediately, giving model number, serial or part number, code number, and a detailed description of the nature and/or conditions of failure. On receipt of this information, service, operating, or shipping instructions will be supplied to you.

b. On receipt of shipping instructions, ship the instrument transportation prepaid to PM. The instrument should be shipped in the original shipping carton or, if damaged or not available, in a suitable rigid container with the instrument wrapped in paper or plastic and surrounded with at least four inches or cushioning material on all sides. If under Warranty, the instrument will be repaired and returned transportation prepaid.

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The instrument must be thoroughly inspected immediately upon receipt. All material in the shipping container should be checked against the enclosed packing list. PM will not be responsible for shortages against the packing list unless notified immediately. Upon receipt of shipment, if there is any visible evidence of damages, make a notation on the way bill of such damage and immediately contact the nearest office of the carrier in your city. If there is evidence of damage after the goods are unpacked, contact the nearest office of the carrier, request an inspection, and save all packing and materials therein until the inspection has been completed. A full report of the damage should be obtained by the carrier's claim agent, and a copy of this report forwarded to PM. Upon receipt of this report, you will be advised of the disposition of the equipment for repair or replacement. PM shall have no responsibility for damaged instruments if the above inspection requirements are not complied with. Time is of the essence regarding the above instructions.

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SECTION 1

GENERAL INFORMATION

1.1 PACIFIC MEASUREMENTS MODEL 1038-H12 AND -H13 HORIZONTAL PLUG-IN UNITS

The Models 1038-H12 and -H13 provide access to the horizontal deflection circuits of the Model 1038 Mainframe, supply an accurate calibration source for power detectors and allow an RF power detector to be connected to the system to supply a signal for ratio comparisons to be made in the Vertical Plug-In Units. The horizontal input is able to display the sweep signal available from most sweep RF signal sources as a full-screen sweep. It will accept either positive or negative-going sweep voltages. The calibrator supplies an accurate 10 mV of RF power at 30 MHz for calibrating RF detectors to an absolute standard. The output impedance is a precise 50 ohms and the signal is low in harmonics.

The characteristics of the reference channel are similar to those of the Vertical Plug-In Units, so that the only variations displayed will be those due to differences between the signals applied to the reference channel and the measurement channel. Front panel switches allow for the selection of the channel (s) to be displayed and whether or not ratioing is to be used.

The Model 1038-H13 has the additional capability of generating memory address information corresponding to the horizontal deflection for use by Vertical Plug-In Units.

1.2 PERFORMANCE SPECIFICATIONS

A complete listing of performance specifications is given in Table 1-1.

TABLE 1-1

PERFORMANCE SPECIFICATIONS

HORIZONTAL INPUT	
Connector	BNC Jack
Impedance	>50 KΩ
Voltage	A signal having a peak to peak amplitude of between 10 and 20 V is required to give full-screen deflection. Its starting voltage must not exceed one-half its amplitude.
Polarity	Positive or negative going signals can be selected to give a left to right display by an internal switch.
Frequency Response	A 10 ms ramp will be displayed without visible delay.
Maximum Input	50 V either polarity or ac
RETRACE BLANKING	
Minimum retrace time	The CRT beam will be turned off when retracing at a rate exceeding 1 s for full-screen.
Switch	Retrace beam blanking can be selected on or off by an internal switch.
CALIBRATOR	
Connector	Type N Jack Option 02, APC-7 Option 03, SMA Jack
Level	10 mW ±1.5 % (+10 dBm)
Impedance	50 ohms

(Continued)

TABLE 1 (Continued)

SWR	1.06 (30 dB return loss)
Harmonic Output	-50 dB or less with respect to the signal.
MEMORY DRIVE (Model 1038-H13 Only)	
Coverage	Memory addresses are generated when the trace is moving left to right in the graticule area.
Compatability	The unit will supply correct data to both 256 point and 1024 point vertical units.
REFERENCE CHANNEL	
Measurement Range	<-30 dBm to >+10 dBm for a detector with between 0.5 and 1.0 mV dc output for -30 dBm input. Its output resistance must be less than 20K ohms at -30 dBm.
Drift, using Pacific Measurements compensated detectors	
At 0 dBm	0.1 dB/°C (+15 to +45°C)
At -30 dBm	<0.5 dB/24 Hrs. at constant temperature.
Linearity, using Pacific Measurements detectors	0.1 dB/10 dB
TEMPERATURE	
Operating	0 to 50°C
Non-Operating	-50 to +65°C
DIMENSIONS	
(H x W x D)	16.8 cm x 6.6 cm x 29.9 cm (6.6" x 2.6" x 11.7")
WEIGHT	2.0 kg. (4.4 pounds)

1.3 INPUT/OUTPUT CONNECTOR

The following signals appear on the Input/Output connector of the Mainframe when the Model 1038-H12 or -H13 are installed. Refer to the Mainframe manual for additional pin assignments and information.

I/O CONNECTOR PIN NO.	SIGNAL
18	Horizontal Input
17	Clock Logic (Model 1038-H13 only)
35	Overspill Logic (Model 1038-H13 only)
36	Increment Logic (Model 1038-H13 only)

SECTION 2

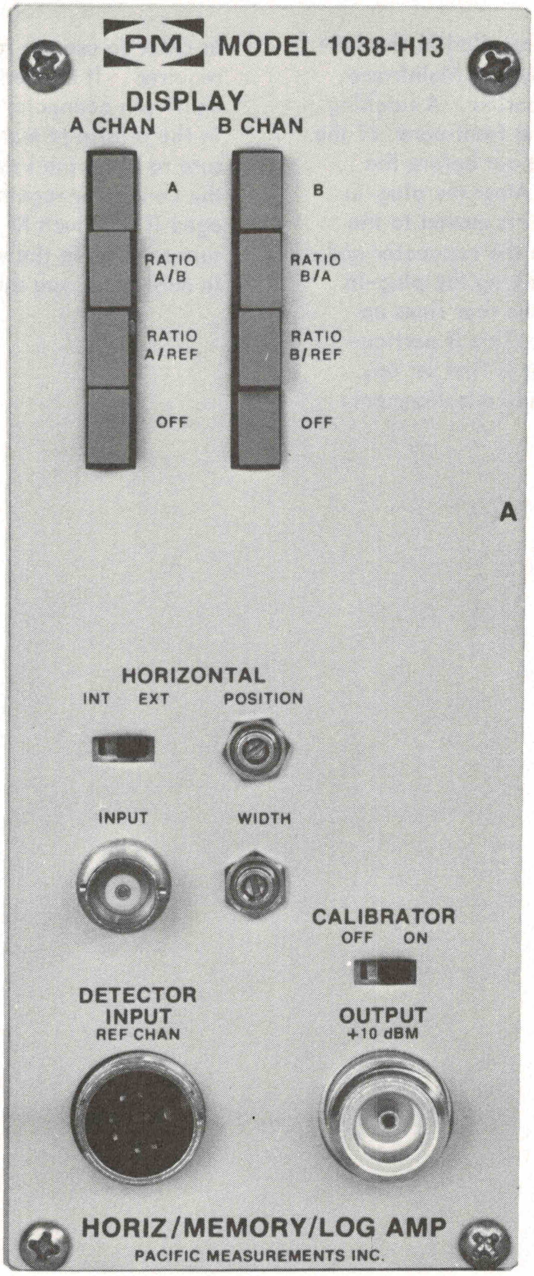
INITIAL INSTRUCTIONS

2.1 INSTALLATION

A Horizontal Plug-In unit can be installed in the left-hand location of the Model 1038 System Mainframe. It will not fit in the right-hand location. A latching lever is located at the bottom of the front panel of the plug-in. It must be pulled straight out before the plug-in is pushed all the way in. After the plug-in can be pushed no further, the lever is moved to the right. This forces the plug-in into the connector and locks it in place. Use care in inserting the plug-in and be sure that the connector at the rear lines up with the end of the plug-in board. This is particularly important when the instrument is first set up, because shipping damage might cause misalignment.

2.2 DETECTOR CONNECTION

In order to use the reference channel, a detector is required. It connects to the front panel female multi-pin connector. The connector has a keyway in the plastic to mate with the key in the plug. Be sure to align the key with the keyway before pushing the connector together. All detectors will be damaged if too much RF power is applied to them, so be sure to observe the warning affixed to the detector. In most cases you should not exceed 50 mW (+17 dBm).



FRONT PANEL

FIGURE 2-1

SECTION 3

OPERATION

3.1 GENERAL

The Model 1038 Horizontal Plug-Ins provide access to the horizontal deflection circuits of the Mainframe. For units with memory, the Model 1038-H13 provides address information to the memory in the Vertical Plug-Ins. A complete system for the generation of a display consists of the Mainframe and Display Unit, one or two Vertical Plug-In Units and a Horizontal Unit. This section will describe the controls and operation of the Horizontal Unit only; further information will be found in the manuals for the Vertical Plug-Ins, the Display Unit and Mainframe.

3.2 FRONT PANEL CONTROLS

The following controls are located on the front panel of the instrument. See Figure 2-1

a. DISPLAY SELECTOR PUSH BUTTONS. There are two groups of three buttons arranged in two vertical columns. The left hand set controls the display from the left hand (or A Channel) plug-in and the right hand group controls the right hand (or B Channel) plug-in. The top button calls for the display of the corresponding plug-in. The second button calls for the display of the ratio of the quantity displayed by the controlled plug-in divided by the opposite plug-in. The third button calls for the display of the ratio of the quantity displayed by the controlled plug-in divided by the signal from the reference channel. The fourth button turns the plug-in off allowing the opposite unit to be displayed alone. If both OFF buttons are pressed, the left-hand channel will be displayed.

b. HORIZONTAL INT/EXT SWITCH. This switch selects an internally generated signal providing a full-screen horizontal trace in the INT position, or it allows a signal supplied to the HORIZONTAL INPUT jack to provide horizontal deflection in the EXT position. The function of the internal sweep is to allow signals from CW sources to be displayed across the screen rather than to appear as a dot.

c. HORIZONTAL POSITION SCREWDRIVER CONTROL. This control permits the horizontal trace to be centered on the screen.

d. HORIZONTAL WIDTH SCREWDRIVER CONTROL. This control permits the horizontal trace to be adjusted to cover the screen.

e. CALIBRATOR ON/OFF SWITCH. This switch permits the calibrator to be turned off when not in use to avoid RF interference from its output.

3.3 FRONT PANEL CONNECTORS

The following connectors are located on the front panel. See Figure 2-1

a. HORIZONTAL INPUT BNC JACK. This connector accepts signals to move the CRT spot in the horizontal direction. The input can be either positive- or negative-going, depending upon the setting of the internal polarity switch. Signal amplitude must be between 10 and 20 V peak to peak for full-screen deflection. Input impedance is greater than 50 K ohms. It is connected in parallel with the AUXILIARY 1 BNC jack located on the rear panel of the Model 1038 Mainframe.

b. CALIBRATOR OUTPUT TYPE N JACK. This connector supplies an accurate 10 mW signal at 30 MHz when the calibrator is turned on. Its output impedance is 50 ohms. It is used to set the calibration of Vertical Plug-Ins for accurate absolute power measurements.

c. FRONT PANEL DETECTOR CONNECTOR

This multi-pin connector is keyed to prevent misalignment. Be sure that the key on the plug mates with the keyway on the panel connector before inserting. Various types of Pacific Measurements power detectors can be used and an adapter cable is available for use with detectors of other manufacture.

3.4 REAR PANEL CONNECTORS

a. AUXILIARY INPUT/OUTPUT CONNECTOR. When connected in a Mainframe, the Horizontal Input connector is in parallel with the AUXILIARY INPUT/OUTPUT 1 BNC jack on the rear of the Mainframe.

b. INPUT/OUTPUT CONNECTOR
See paragraph 1.3 for Input/Output connector pin assignments.

c. HORIZONTAL OUTPUT BNC CONNECTOR. When inserted in a Mainframe, the signal supplied by the Horizontal Plug-In to the Mainframe to deflect the CRT beam appears at the HORIZONTAL OUTPUT BNC connector located at the rear of the Mainframe. Its voltage is 0 when the beam is in the center and changes 100 mV for each division that the beam moves.

3.5 INTERNAL CONTROLS

Access to the internal switches may be had by removing the right hand cover from the instrument.

a. POLARITY SWITCH. This switch determines the polarity of the input amplifier. When set to +, a positive-going signal will move the beam to the right. When set to -, a negative-going signal moves the beam to the right. This switch is located at the upper rear of the instrument.

b. BLANKING SWITCH. This switch determines if the beam is to blanked during retrace. When set to ON, the beam will be turned off during the retrace interval.

3.6 OPERATING PROCEDURE

a. Place the unit in the left hand plug-in location of the Mainframe. Be sure that the rear connector is seated properly and the front panel lock fully engages.

b. If INT sweep is to be used, set the front panel switch accordingly. If EXT sweep is used, connect the sweep signal from the signal source to the HORIZONTAL INPUT connector, either at the front panel or at the rear of the Mainframe. Be sure that the sweep signal has a peak to peak amplitude of between 10 and 20 V. Its starting voltage must not be greater than one half its amplitude. For example, if the amplitude is 15 V peak to peak, the starting voltage can be anywhere in the range of -7.5 V to +7.5 V.

c. Adjust the POSITION and WIDTH controls so that the sweep just covers the 10 divisions of the CRT graticule. Slow the sweep down, if possible, to determine that the forward trace (left to right) is slower than the retrace. If not refer to 3.5a. The spot should move slowly from left to right, then disappear and then reappear quickly on the left when the forward sweep is slower than the retrace.

d. Select the display desired using the DISPLAY pushbuttons.

e. If it is desired to use the calibrator, turn it on and connect the detector to be calibrated to it. After use it is best to turn it off, as its signal is large and may leak and produce unwanted RF interference.

3.7 DETECTORS

RF Detectors supplied for use with the plug-ins are equipped with RF connectors for connection to sources of RF power. Depending upon the connector type and the characteristics of the detector, the maximum frequency for the detector will be different, so be sure to check the specifications for the detector before using it at the highest RF frequencies. Each detector has slightly different detection characteristics from another. If a detector and an instrument are ordered together, the instrument will be calibrated with the detector it is shipped with and a label will be affixed to the instrument to identify the detector. If the instrument is used with other detectors you should expect slight tracking errors as RF power is varied over the range. These errors will be slight, in most cases limited to less than one half dB over the entire dynamic range. If you want to calibrate an instrument to a different detector, refer to the detector calibration procedure of Section 6.

An adapter cable is available for connecting detectors or devices with built-in detectors having BNC output connectors to the DETECTOR INPUT of the plug-in. The use of the special cable is recommended because it has a low-pass filter to isolate the cable from the RF signal and a temperature compensation sensor. While the temperature sensor is close to the BNC connector in the brass block to which the connector is mounted, you should nonetheless be careful to avoid subjecting it to sources of heat not affecting the detector to which it is connected. For example, sunlight coming in a window where the detector is in a shadow and the adapter is directly illuminated.

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SECTION 4

PERFORMANCE CHECKS

4.1 GENERAL

The purpose of this section is to provide a series of tests that will insure that the instrument is operating properly. It is useful for incoming inspection and for periodic performance evaluation. All checks are performed in a Model 1038 Mainframe.

4.2 EQUIPMENT REQUIRED

The following equipment is required to check the performance of the Model 1038-H12 and -H13.

a. A frequency counter capable of measuring 30 MHz with an input of 1.4 Vrms from a 50 ohm source.

b. A precision dc source capable of supplying 1.414 V into 100 ohms within 0.1%. For example, Fluke Model 382A Voltage/Current Calibrator.

c. An ac to dc Thermal Voltage Converter. See description under 6.3.1j.

d. A differential or digital voltmeter capable of resolving 4 μV for use in measuring the output of the Thermal Converter. For example, Data Precision Model 2540 A1 or Fluke Model 881A.

e. A 50 ohm adapter as described in 6.3.1k.

f. A Function Generator capable of supplying a 50 ms ramp voltage going from 0 to 20 V into 50 K ohms.

g. A properly calibrated Model 1038 Mainframe and Display Unit.

h. A properly calibrated Vertical Plug-In Unit.

i. A step attenuator or separate individual attenuators. Steps of 10 dB from 0 through 40 dB are required. Attenuators should be within 0.4 dB of their nominal value, when measured at 30 MHz. The Attenuator return loss must be >30 dB.

j. A Type N Tee connector, so that two detectors can be connected simultaneously to the attenuator.

k. The detectors with which the Plug-In Units were calibrated.

4.3 CALIBRATOR FREQUENCY CHECK

Connect the frequency counter to the CALIBRATOR OUTPUT. The frequency should measure 30 MHz within 300 kHz.

4.4 CALIBRATOR AMPLITUDE CHECK

This measurement must be performed with a high degree of accuracy. Accordingly, the procedure must be performed with great care. If you do not have the equipment required you cannot be assured of sufficient accuracy to check the specification. Even with the required equipment, it is necessary to allow for possible errors and the figures given below include this.

a. Set the precision power supply to 1.414 V. Connect the adapter of Section 4.2e to the output of the supply and connect the Thermal Converter to the output of the adapter. Read the dc output of the Thermal Converter to a precision of 0.1%. Reverse the polarity of the supply and repeat the reading. Record the average of the two readings. Turn the calibrator on, screw the Thermal Converter to the CALIBRATOR OUTPUT and read the dc voltage from the Converter.

   If this reading differs from that obtained from the precision power supply, reconnect the Thermal Converter to the power supply and set the supply so that the voltage from the converter is the same as it was when connected to the calibrator. Note the reading, reverse the polarity and again set the supply so that the thermal converter's output matches what it was when on the calibrator. Average the two readings. The average reading should be between 1.380 and 1.450 V. You should repeat the procedure until you get consistent results.

4.5 POWER LEVEL TRACKING CHECK

a. Adjust the HIGH LEVEL and NOISE LEVEL controls of the Vertical Plug-In in accordance with the procedure described in its instruction manual.

b. Connect both the Vertical and Horizontal detectors to the Type N Tee and connect the Tee to the CALIBRATOR OUTPUT (or set the attenuator to 0 dB and insert it between the calibrator and the Tee). Connect the detector output cables to their corresponding plug-ins.

Press the INPUT dB button on the Vertical Plug-In, set the REF LINE switch to center, the OFFSET to 00.0, turn the CALIBRATOR ON and bring the trace to the center of the screen using the REFERENCE control. It will be easier to see the trace if the INT horizontal setting is used. Start at 10 dB/DIV and increase the sensitivity from there so that the final adjustment is made at 0.1 dB/DIV.

c. Add 10 dB of attenuation; the trace should move less than 0.2 dB (two divisions). For each additional 10 dB step the trace should move less than two more divisions. Note that if the impedance match of the attenuator is not as specified additional errors are to be expected.

This completes the performance checks which relate to calibration adjustments. If the instrument failed any of these checks, it may be adjusted in accordance with Section 6.3.

4.6 HORIZONTAL AMPLIFIER CHECK

Adjust any vertical plug-in so that a trace will appear in the approximate center of the screen. Connect the function generator to the HORIZONTAL INPUT and adjust it to give a 10 V ramp going from 0 to 10 V in 50 ms. It should be possible to adjust the front panel HORIZONTAL POSITION and WIDTH controls so that the trace extends from the left graticule edge to the right edge. Readjust the generator to give a signal going from 0 to 20 V and repeat the check.

4.7 MEMORY DRIVE CHECK (-H13 ONLY)

This is merely a qualitative check to ascertain that the memory drive circuits are functional. Use a vertical plug-in with a memory compatible with the Model 1038-H13. Check the operation of the memory in accordance with the instruction manual for that unit.

SECTION 5

CIRCUIT DESCRIPTION

5.1 INTRODUCTION

This section contains a description of the circuits of the Model 1038-H12 and -H13 Plug-In Units. The horizontal deflection and memory drive circuits are independent of the reference channel circuits; accordingly they are described separately. In each case there is a description of the block diagram followed by a detailed discussion of the individual circuit blocks. The detailed descriptions refer to the circuit diagrams which are to be found in Section 7. The description of the horizontal deflection and memory circuits starts immediately below with Section 5.2; that for the reference channel starts with Section 5.4.

5.2 HORIZONTAL DEFLECTION AND MEMORY DRIVE BLOCK DIAGRAM DESCRIPTION

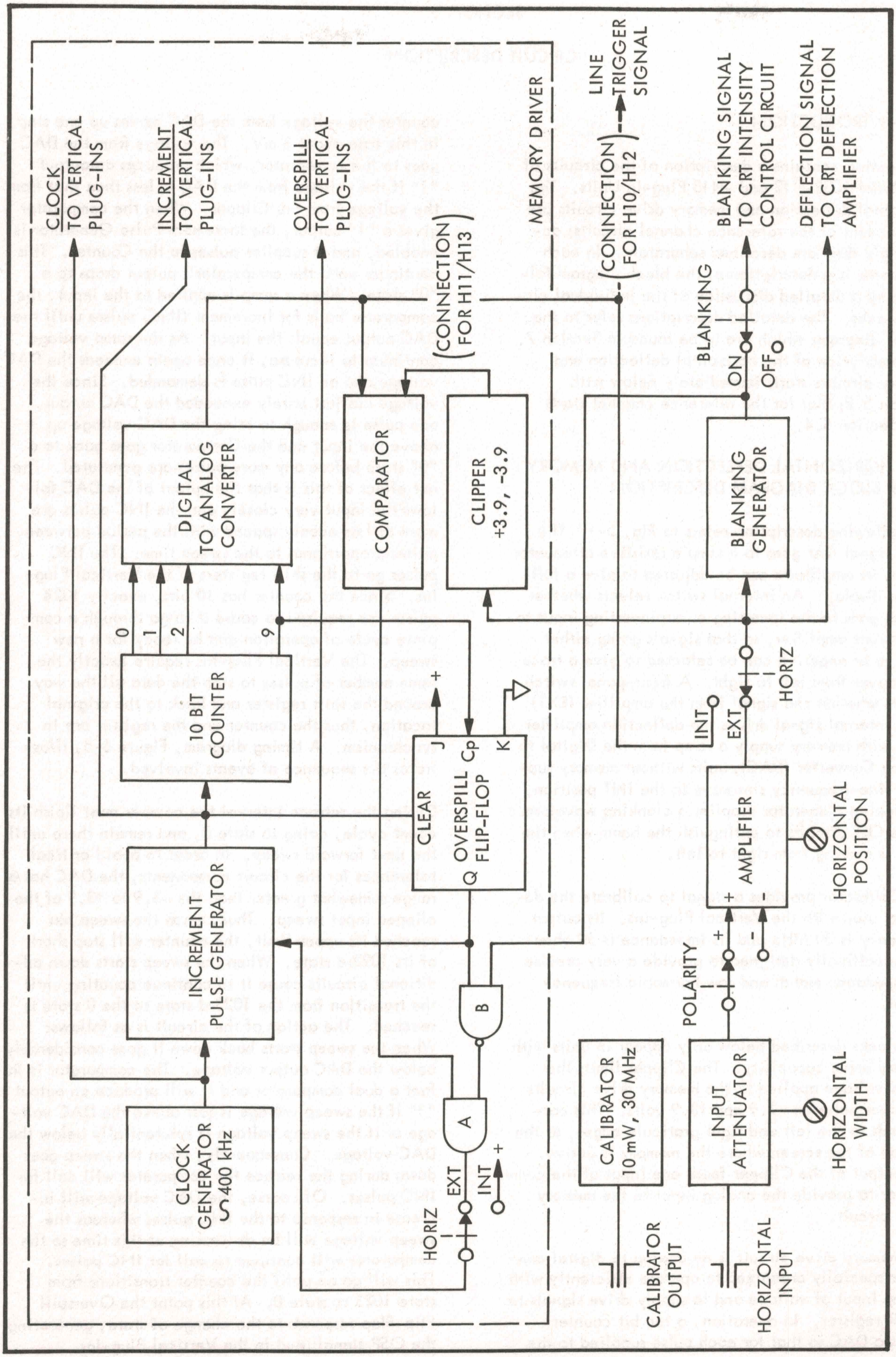
The following description refers to Fig. 5-1. The input signal first goes to a simple resistive attenuator so that its amplitude can be adjusted to give a full-screen display. An internal switch selects whether it then goes to the inverting or noninverting input to a different amplifier, so that signals going either positive or negative can be selected to give a trace that moves from left to right. A front-panel switch selects whether the signal from the amplifier (EXT) or an internal signal drives the deflection amplifier. Units with memory supply a ramp from the Digital to Analog Converter (DAC); units without memory supply a line-frequency sinewave in the INT position. A Blanking Generator supplies a blanking waveform to the CRT circuits to extinguish the beam when the trace is moving from right to left.

The Calibrator provides a signal to calibrate the detectors used with the Vertical Plug-Ins. Its output frequency is 30 MHz and its impedance is 50 ohms. It is specifically designed to provide a very precise RF impedance match and low harmonic frequency output.

The blocks described below only appear in units with memory drive capability. The Clipper limits the sweep voltage applied to the memory drive circuits to values between -3.9 and +3.9 volts. This corresponds to the left and right graticule edges, or the portion of the screen where the memory is active. The output of the Clipper feeds one input of the comparator to provide the analog input to the memory drive circuit.

The memory drive circuit is an analog to digital converter specially organized to operate efficiently with a ramp input of voltage and to supply drive signals to a shift register. In operation, a ten bit counter drives a DAC so that for each pulse supplied to the counter the voltage from the DAC moves up one step, in this case about 8 mV. The voltage from the DAC goes to the comparator, which produces an output "1" if the voltage from the DAC is less than that from the voltage from the Clipper. When the comparator gives a "1" output, the Increment Pulse Generator is enabled, and it supplies pulses to the Counter. This continues until the comparator's output drops to a "0" state. When a ramp is applied to the input, the comparator calls for Increment (INC) pulses until the DAC output equals the input. As the ramp voltage continues to increase, it once again exceeds the DAC voltage and an INC pulse is demanded. Since the voltage has just barely exceeded the DAC output, one pulse is enough to bring the DAC voltage up above the input and the Comparator goes back to a "0" state before any more pulses are generated. The net effect of this is that the output of the DAC follows the input very closely and the INC pulses are more or less evenly spaced with the period between pulses proportional to the sweep time. The INC pulses go to the shift registers of the Vertical Plug-Ins. Since the counter has 10 bits, exactly 1024 pulses are required to cause it to go through a complete cycle of operation and be ready for a new sweep. The Vertical Plug-Ins require exactly the same number of pulses to step the data all the way around the shift register and back to the original location, thus the counter and the register are in synchronism. A timing diagram, Figure 6-5, illustrates the sequence of events involved.

During the retrace interval the counter must finish its count cycle, going to state 0, and remain there until the next forward sweep. In order to avoid critical tolerances for the circuit components, the DAC has a range somewhat greater than the -3.9 to +3.9 of the clipped input sweep. Thus, when the sweep has reached its upper limit, the counter will stop short of its 1023rd state. When the sweep starts down additional circuits cause it to continue counting until the transition from the 1023rd state to the 0 state is reached. The action of the circuit is as follows: When the sweep starts back down it goes considerably below the DAC output voltage. The comparator is in fact a dual comparator and it will produce an output "1" if the sweep voltage is just above the DAC voltage or if the sweep voltage is substantially below the DAC voltage. Consequently, when the sweep goes down during the retrace the comparator will call for INC pulses. Of course, the DAC voltage will increase in response to the INC pulses whereas the sweep voltage will be decreasing at this time so the comparator will continue to call for INC pulses. This will go on until the counter transitions from state 1023 to state 0. At this point the Overspill Flip-Flop responds to the change of state, generating the OSP signal used in the Vertical Plug-Ins.



SIMPLIFIED BLOCK DIAGRAM- HORIZONTAL DEFLECTION AND MEMORY DRIVE CIRCUITS

FIGURE 5-1

As was described above, during the retrace interval a blanking signal is generated. The blanking signal together with the output of the Overspill Flip-Flop goes to NAND gate B to produce a logic "0", disabling gate A and effectively prohibiting the comparator from calling for more INC pulses. When the sweep has reached the end of its retrace period the blanking signal goes to a "0", gate B's output returns to a "1" and gate A is enabled so that the comparator can have control of the Increment Generator. Since the sweep is clipped at the -3.9 V level and the DAC 0 state voltage is slightly below this, the comparator immediately calls for enough INC pulses to bring the DAC voltage to this level. When the sweep moves up away from the clipping level, the DAC once again follows it and the process repeats.

A clock generator provides timing signals to the Increment Pulse Generator and to parts of the Vertical Plug-Ins. It operates at about 400 kHz and generates logic level voltages. Its output signal is a pulse occuring at 2.5 µs intervals and about 0.5 µs wide.

5.3 HORIZONTAL DEFLECTION AND MEMORY DRIVE INDIVIDUAL CIRCUIT BLOCK DESCRIPTIONS

The following detailed descriptions refer to the circuit schematic diagram number 12455 in Section 7.

5.3.1 INPUT AMPLIFIER AND ATTENUATOR

Input Amplifier U2 is a differential-input amplifier. Both the inverting and noninverting inputs present identical impedances to the input attenuator. The input attenuator is a simple adjustable resistor (R2) in series with the amplifier input. The Polarity Switch (S1) selects whether the input signal goes to the inverting or noninverting input. The HORIZONTAL POSITION potentiometer supplies an offsetting current to the inverting input of U2 to shift the dc level of its output. The signal from U2 is 8 volts peak to peak for full screen deflection. Voltage divider R23 and R24 reduces this signal to 0.5 V to drive the deflection amplifier of the Mainframe.

5.3.2 CLIPPER

Resistor R25 provides a high impedance connection to the clipping amplifiers U3 and U4. The action of these amplifiers is to provide a large amount of negative feedback when the voltage from U2 exceeds -3.9 V or +3.9 V respectively.

Consider first the action of U3. Pin 3 is held at -3.9 V by the voltage divider R33 and R34. When the inverting input (pin 2) is driven slightly negative with respect to pin 3, the output (pin 6) moves abruptly positive until CR5 conducts thereby completing the feedback path from output to input. Any further increase in voltage applied to R25 only cause the current in CR5 to increase and the voltage at pin 2 will remain at -3.9 V. The action of U4 is similar but for positive voltages. The result is that the voltage at the output end of R25 follows the voltage at the output of U2 until the magnitude of the voltage exceeds 3.9 V, at which point the voltage remains constant until the magnitude drops below 3.9 V and the voltage again is allowed to follow the input. Amplifier U1 is a unity-gain voltage follower providing a low input impedance to drive the comparator U7. Waveforms illustrating the action of the circuit are found in Figure 6-3.

5.3.3 BLANKING GENERATOR

The output of the Blanking Generator amplifier IC (U5) will be positive or negative depending upon the direction of the current through C15. When the sweep voltage is going positive, the current through C15 will flow away from the inverting input of U5 and, due to the feedback action of U5, through CR6 to pin 6 of U5. Since pin 2 will be held at approximately 0 V by the feedback action with CR6 conducting, the output voltage is one diode drop less, or -0.6 V. During the retrace period the action is similar. The current flows through C15 away from pin 2 but instead of the diode CR6 carrying the current, it flows through Q4. The output of U5 drives the base of Q4 through the voltage divider R37 and R38 so that it must go to approximately +4 V in order to make Q4 conduct. Thus, a logic "0" is generated during the forward trace and a logic "1" during the retrace interval. Transistor Q5 inverts this logic signal to generate the "A Gate" signal required by the display unit. Transistor Q6 supplies a low impedance logic signal identical to the output of U5 for use in the Mainframe and display unit. The output of U5 also goes to the gate U6A together with the Overspill signal to control the comparator.

5.3.4 LOGIC CIRCUITS

The clipped input signal goes into the Comparator (U7) on pins 4 and 7; the DAC output goes in on 3 and 6. Resistive divider R5, R6, R7, and R8 supplies a small voltage separation between the DAC voltages supplies pin 3 and 6. This allows the comparator to have a small "dead zone" so that it will not be sensitive to insignificant perturbations of the input voltage. U7 requires supply voltages of +12 and -6; Q2 and Q3 provide these at a satisfactorily low impedance level. Pins 2 and 8 must be at a logic "1" to allow the output of U7 (pin 9) to go to a "1"; "OVERSPILL" and "BLANKING" together cause the output of U6A (which connects to U7-2 and U7-8) to go to "0" so that U7's output cannot be a "1" when both are present.

When EXT input is selected, Q7 and U6B transmit logic signals from the comparator to the "J" input of U8. If INT sweep is selected, U6B supplies a continuous "1". U8A serves as the Increment Pulse Generator. It receives clock pulses at a constant 400 kHz rate from the clock generator. Whenever its "J" input is at a "1" its output will first switch to a "1" at the trailing edge of the next clock pulse then back to a "0" at the same point on the following clock pulse then again to a "1", etc. When a "0" is supplied to "J", if the output is a "1" it will return to a "0" state at the next clock and remain there. Thus, if the comparator (EXT operation) is at a "1" state, one or more 2.5 μs pulses will be supplied at the output of U8A, until the comparator goes to a "0" state. If set for INT operation, U8 supplies a squarewave with 2.5 μs pulses occurring at a 200 kHz rate. These INC pulses go to the counter and to the Vertical Plug-In units.

U9, U10 and U11 comprise a 10 bit counter. The output of the counter feeds the DAC. When the counter goes from state 1023 to state 0 and 2^9 line goes from a "1" to a "0"; U8B responds to this negative transition and its output "Q" goes to a "1". If this occurs during a retrace interval, the counter will stop due to the action of U6A, because "OVERSPILL" and "BLANKING" will both be present. Once the retrace is completed, "BLANKING" will go away and counting can begin again. The first INC pulse that follows will clear U8B, since its Direct Clear input connects to the "$\overline{Q}$" output of U8A. Thus, the presence of a "1" on the "OVERSPILL" (OSP) line implies that the counter is at its 0 state.

5.3.5 CLOCK GENERATOR

The Clock Generator consists of U6C, U6D and Q1. U6C, U6D, R3, R4 and C2 act as a one-shot circuit sensitive to negative triggers at pin 10 of U6C. Immediately following the arrival of a negative pulse, U6C-8 develops a positive 0.5 μs pulse and U6D-11 supplies a negative pulse. Triggers are generated by Q1, with their timing dependent upon R1 and C1. During the period when U6C-8 has a positive pulse voltage, C1 charges through the base of Q1. This takes less than 0.5 μs so Q1 turns off in less than the period of the pulse as soon as C1 finishes charging. During this period R1 is essentially grounded through U6D-8. When the 0.5 μs pulse terminates, C1 is driven negative and the top end of R1 is driven almost to the supply voltage. C1 now charges through R1 toward +5 V, in time reaching the turn-on point for Q1, causing the collector to drive U6C-10 negative and initiating a new cycle. Waveforms for this circuit are found in Figure 6-5.

5.3.6 DIGITAL-TO-ANALOG CONVERTER

Digital signals coming from the multiplexer drive the D to A converter (DAC). Resistors with binary-weighted values supply currents to tiode pairs in the DAC. One of the diodes is an ordinary computer diode connecting to the output of the multiplexer. If the output of a bit of the multiplexer is low, the current will flow through this diode and none will flow through the other diode. The other diode is part of an integrated circuit for the most significant bits (where things are most critical). When a bit is high, current flows through this diode to the input of an operational amplifier, U14. One of the diodes in the integrated circuit U12 provides temperature compensation. It connects to pin 3 or U14 causing this point to move (and pin 2 also by the action of U14) with temperature.

Pin 2 moves just enough to allow for changes in the diodes connecting the resistors to the summing point, so that the voltage across the resistors remains constant. The result of this arrangement will be that there are common-mode voltage changes affecting pin 6 and pin 3 of U14 equally. Differential amplifier U15 discriminates against these and supplies a dc offsetting signal so that the output of U14 goes from -3.98 V to +3.98 V depending upon the digital word at the input of the DAC.

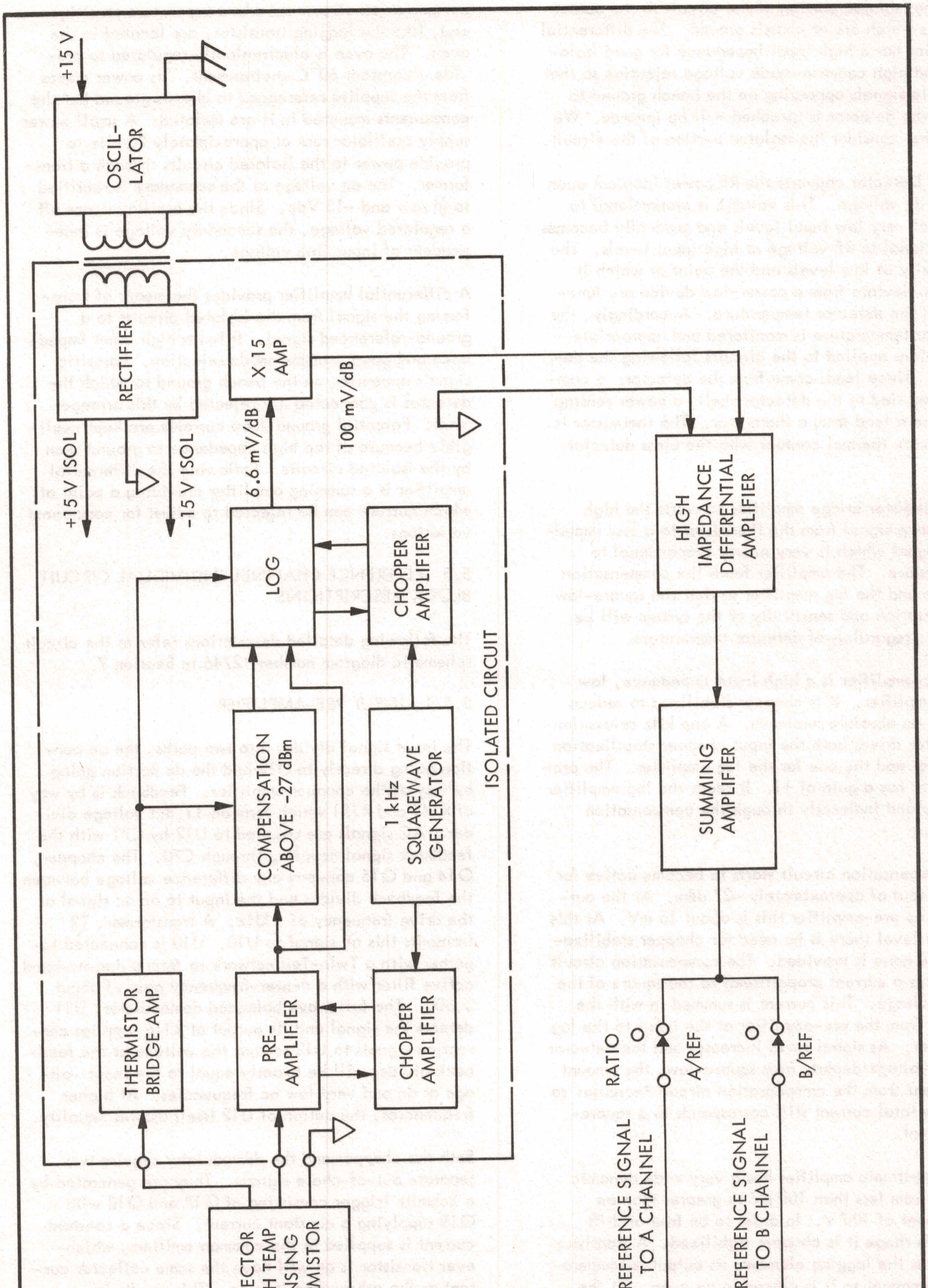
5.3.7 CALIBRATOR

Transistor Q8 is connected as a grounded-base oscillator. C34 and L1 have the primary effect on the frequency with the trimmer capacitor C29 having a small range sufficient to adjust the frequency to exactly 30 MHz. Capacitive divider C35 and C38 transmits the signal to the amplifier transistor Q10. C42, C43 and L2 set the center frequency of the amplifier with trimmer C45 giving enough range for adjustment. Transistor Q9 supplies a current to U16 if the current through Q10 exceeds a safe value, as might happen if the RF drive voltage disappeared for some reason. Coupling capacitor C46 transmits the output from the amplifier Q10 to the output attenuator and filter. Diode CR19 rectifies the RF voltage at the input of the filter so that the dc voltage at C44 is almost equal to the peak RF voltage. Current from C44 flows through R88 to the input of U16. Another current comes through R84 and R78. U16 controls the amplitude of the signal from Q10 by varying its base current through R80 and R81. Due to feedback action, the amplitude will be maintained at a level such that the current from the rectifier CR19 just equals the other current at the input to U16.

A low-pass filter consisting of L3, L4, and C48, C49, C50, C51, C52, and C53 removes harmonics of the 30 MHz frequency. A 10 dB attenuator, R93, R92 and R94 reduces the signal level to 10 mW and guarantees that the output impedance will be precisely 50 ohms. The diodes CR20 and CR21 provide temperature compensation so that the output amplitude will be independent of temperature.

5.4 REFERENCE CHANNEL BLOCK DIAGRAM DESCRIPTION

The following description refers to Figure 5-2. Because of the extremely small signals measured by the detector and the resulting sensitivity of the circuits amplifying them, it is necessary that no extraneous currents flow in the signal ground leads. For this reason the input amplifier circuits are isolated from the chassis ground. An oscillator-type power supply provides an isolated source of dc to power these circuits. A differential amplifier transmits the signal



SIMPLIFIED BLOCK DIAGRAM- REFERENCE CHANNEL
FIGURE 5-2

from the isolated portion of the circuit to the output circuits which are at chassis ground. The differential amplifier has a high input impedance for good isolation and high common-mode voltage rejection so that parasitic signals appearing on the bench ground to which the detector is attached will be ignored. We shall first consider the isolated portion of the circuit.

The RF Detector converts the RF power incident upon it to a dc voltage. This voltage is proportional to power at very low input levels and gradually becomes proportional to RF voltage at high input levels. The sensitivity at low levels and the point at which it starts to deviate from a power-law device are functions of the detector temperature. Accordingly, the detector temperature is monitored and appropriate corrections applied to the circuits following the detector. Three leads come from the detector: a common lead tied to the detector shell, a power sensing lead and a lead from a thermistor. The thermistor is in intimate thermal contact with the brass detector shell.

The thermistor bridge amplifier converts the high impedance signal from the thermistor to a low impedance signal which is very nearly proportional to temperature. The amplifier feeds the compensation circuits and the log amplifier so that the square-law compensation and sensitivity of the system will be correct, regardless of detector temperature.

The pre-amplifier is a high input impedance, low noise amplifier. It is chopper stabilized to reduce drift to an absolute minimum. A one kHz relaxation oscillator drives both the input chopper stabilization amplifier and the one for the log amplifier. The pre-amplifier has a gain of 11. It feeds the log amplifier directly and indirectly through the compensation circuit.

The compensation circuit starts to become active for an RF input of approximately -27 dBm. At the output of the pre-amplifier this is about 15 mV. At this voltage level there is no need for chopper stabilization and none is provided. The compensation circuit generates a current proportional to the square of the input voltage. This current is summed in with the current from the pre-amplifier at the input to the log amplifier. As signal level increases and the detector output voltage departs from square-law, the amount of current from the compensation circuit increases so that the total current still corresponds to a square-law signal.

The logarithmic amplifier has a very wide dynamic range, from less than 100 μV to greater than an equivalent of 100 V. In order to be free of drift over this range it is chopper stabilized. A transistor is used as the logging element; its output is temperature dependent so it is placed in an oven. At the operating temperature, its output is 6.6 mV/dB. An amplifier follows the logging circuit. Its gain of 15 raises the level to 100 mV/dB. Critical parts of the compensation circuit are also temperature sensitive and, like the logging transistor, are located in the oven. The oven is electronically regulated to provide a constant 60°C environment. Its power comes from the supplies referenced to chassis ground but the components mounted in it are isolated. A small power supply oscillator runs at approximately 20 kHz to provide power to the isolated circuits through a transformer. The ac voltage at the secondary is rectified to give + and -15 Vdc. Since the oscillator runs off a regulated voltage, the secondary voltage is independent of input line voltage.

A differential amplifier provides the means of transferring the signal from the isolated circuits to a ground-referenced signal. It has a high input impedance and good common-mode rejection. Parasitic signals appearing on the bench ground to which the detector is connected are rejected by this arrangement. Potential ground-loop currents are kept negligible because of the high impedance to ground seen by the isolated circuits. Following the differential amplifier is a summing amplifier providing a point at which current can be injected to adjust for component variations.

5.5 REFERENCE CHANNEL INDIVIDUAL CIRCUIT BLOCK DESCRIPTIONS

The following detailed descriptions refer to the circuit schematic diagram number 12746 in Section 7.

5.5.1 INPUT PRE-AMPLIFIER

The input signal divides into two paths, the ac portion going directly to U12 and the dc portion going by way of the chopper amplifier. Feedback is by way of R149 and R151 which form an 11.3:1 voltage divider. AC signals are coupled to U12 by C71 with the feedback signal coupling through C70. The chopper, Q14 and Q15 converts any difference voltage between the feedback divider and the input to an ac signal at the drive frequency of 1 kHz. A transformer, T2 transmits this ac signal to U10. U10 is connected together with a Twin-Tee network to form a narrow-band active filter with a center-frequency gain of about 3,500. The full-wave balanced demodulator, U11 detects the signal and its output at R116 supplies correction signals to U12 so that the voltage at the feedback divider will be exactly equal to the input voltage at dc and very low ac frequencies. At higher frequencies, the action of U12 itself assures equality.

Both the chopper and the demodulator require two separate out-of-phase signals. They are generated by a Schmitt Trigger consisting of Q17 and Q18 with Q19 supplying a constant current. Since a constant current is supplied to the common emitters, whichever transistor is on will have the same collector current as the other when it is on. This results in identical, but out-of-phase, square waves appearing across the equal collector load resistors. Q20 supplies a constant current required by the demodulator

IC. To make the circuit oscillate, Q16 supplies current to the capacitor C69 when Q17 is on. When the voltage on the capacitor exceeds the common-emitter potential by a few hundred millivolts Q18 turns on and positive feedback to the base of Q17 turns it off. This also turns Q16 off and the voltage on the capacitor decays until it is a few hundred millivolts above the new (and lower) potential of the common emitters. At this point Q17 begins to conduct and positive feedback turns it all the way on so that Q18 is off. This once again turns Q16 on and the process repeats. The output voltages also drive the choppers and demodulator for the log amplifier.

5.5.2 LOG CONVERSION CIRCUIT

The log conversion circuit is a high gain operational amplifier with feedback from the collector of a transistor. The emitter-base voltage is proportional to the log of the collector current over many decades of current values. The logging transistor is located in an oven operating at 60°C; at this temperature the emitter-base voltage changes by 66.5 mV for each factor of ten that the collector current changes. Since a factor of 10 represents 10 dB, this is 6.65 mV per dB. An amplifier follows the log transistor with a gain of 15, raising the level to 100 mV/dB.

The operational amplifier part of the log conversion circuit is chopper stabilized in much the same way as the pre-amplifier. Since the sensitivity is not so great the circuit is simpler. The integrated amplifier, U7 receives ac input directly through C34, dc signals are routed through the chopper amplifier and go to pin 3 of U7. The current summing junction is common to the chopper input and C34 with a voltage monitoring test point, J7 connected through an isolating resistor R59. If at any time the summing junction is not at zero dc potential, the chopper switching transistors, Q5 and Q6, will convert this potential to an ac signal. The ac amplifier, U6, amplifies the signal and supplies it to the synchronous demodulator, Q11 where it is converted to dc. A low pass filter, R67 and C33, removes the act component and the dc correction signal goes to pin 3 of U7, causing its output to change the current through the logging transistor bringing the summing junction back to zero. The 1 kHz drive for the chopper comes from the circuit driving the input chopper.

Integrated amplifier U8 provides the gain of 15 required to raise the signal level to 100 mV/dB. It also offsets the signal so that zero volts output represents approximately -20 dBm.

5.5.3 SQUARE-LAW COMPENSATION CIRCUIT

Above -27 dBm the square-law compensation circuit generates a current proportional to the square of the input signal to compensate for the detector's becoming linear rather than square-law at high input power. Q7 and U4 form a high input impedance operational amplifier. Feedback through Q8 results in the emitter-base potential of Q8 being proportional to the log of the input signal in the same way as for the log conversion circuit. Operational amplifier U5 has a gain of very nearly 2 and its output drives the emitter of another transistor, Q10, to generate an exponential current. The mathematical effect of the arrangement is to take the log, multiply by 2 then take the anti-log--simply resulting in squaring the input signal. Since the characteristics of the transistors are temperature dependent, they are located in the oven.

The output current from Q10 is summed at the input to the log conversion circuit along with the direct signal from the pre-amplifier. The direct signal is dominant at low levels with the compensation signal becoming most important at high levels.

To provide temperature compensation for the detector U9 acts as a bridge amplifier for the thermistor located in the detector mount. R87 is a resistor whose value was selected to linearize the thermistor output over the range 0 to 50° . The output at pin 6 changes approximately 2.5 mV/°C. Correction signals from U9 go to U5 to compensate the shape of the square-law compensation and to U8 to correct the absolute calibration.

5.5.4 DIFFERENTIAL AMPLIFIER

The offset circuit is referenced to chassis ground. Differential amplifier U1 has its inputs connected to the output of the log conversion circuit and the isolated signal common. Since it has good common mode rejection, only the signal between the log conversion circuit's output and isolated common will be amplified. The differential amplifier has a gain of unity. Its output feeds the summing junction through R5 and R6. R5 is adjusted so that a 10 dB input signal change causes a 1V change at TP201.

5.5.5 ISOLATED POWER SUPPLY

Power to run the isolated circuits comes from an oscillator-type power supply. Q3 and Q4 obtain positive feedback base drive from T1. The action of T1 is to supply base current to whichever transistor is turned on until the transformer saturates. At the saturation point the base-drive winding is effectively uncoupled from the primary. Without base drive, the previously conducting transistor stops conducting so the primary current drops, allowing the magnetic field to start to collapse. The collapsing magnetic field induces a voltage of the opposite polarity in the base-drive winding causing the previously nonconducting transistor to switch on. This new state continues until the transformer is saturated in the new direction, then the process repeats. The frequency of operation is about 20 kHz.

A bridge rectifier supplies dc from the secondary to the isolated circuits. Voltage breakdown diodes CR16 and CR17 provide precisely regulated sources of + and

-6.2 V to critical points. RC filter networks remove ac ripple and spikes on the secondary side and an LC filter keeps ac currents from disturbing the +15 V primary supply.

5.5.6 OVEN CONTROLLER

The oven controller maintains the temperature of the oven at 60°C. At that temperature the thermistor in the oven resistance has changed from its 25°C value of 100 kΩ to a value equal to R17, or 23.7 kΩ. At this value the two inputs to the amplifier, U3, are equal. If the oven cools slightly, the value of the thermistor increases causing the output of the amplifier to move positive increasing the current through Q1 and Q2. This causes Q2 to generate more heat, returning the oven to the proper temperature so that the thermistor circuit is once more in balance. At equilibrium, the circuit is just slightly off balance and the transistor supplies just enough heat to account for the heat loss to the surroundings.

SECTION 6

MAINTENANCE

6.1 PERIODIC MAINTENANCE

The following maintenance should be performed once a year unless the instrument is operated in an extremely dirty or chemically contaminated environment or is subjected to severe abuse. In such cases more frequent maintenance is indicated.

a. Blow out all accumulated dust with forced air under moderate pressure.

b. Inspect the instrument for loose wires and damaged components. Check to see that all wire lead connectors are properly seated on their PC board pins.

c. Make a performance check in accordance with the procedure of Section 4. If the performance is within specifications no further service is indicated.

6.2 INTERNAL ADJUSTMENTS AND TEST POINTS

The following is a list of adjustments and test points supplied for ready reference. Do not attempt to make any adjustments until you have carefully read the material in Section 6.3.

6.2.1 DESCRIPTION OF ADJUSTMENTS

The function of each adjustment is described below.

a. A1C29, CALIBRATOR FREQUENCY ADJUSTMENT. Used to adjust the frequency of the calibrator oscillator to 30 MHz ± 100 kHz.

b. A1C45, CALIBRATOR AMPLIFIER TUNING ADJUSTMENT. Used to adjust the calibrator output amplifier to obtain minimum collector current.

c. A1R77, CALIBRATOR OUTPUT ADJUSTMENT. Used to set the calibrator output amplitude to 10 mW within 1.5%.

d. A2C55, CHOPPER COMPENSATION. Used to balance the capacity of the two FETs used in the pre-amplifier chopper. Adjust for correct phase at TP210.

e. A2R5, 100 mV/dB CAL. Used to adjust the signal from the log amplifier so that it produces 1V at TP201 for each 10 dB change in input.

f. A2R8 0 dBm CAL. Used to set the absolute calibration of the instrument.

g. A2R38, SECOND STAGE INPUT NULL. Used to set the voltage measured at TP207 to 0 V within 10 μV.

h. A2R44, -27 dBm CALIBRATION ADJUSTMENT. Used to adjust the compensation amplifier so that it just becomes active at -27 dBm RF input.

i. A2R48, MEDIUM LEVEL CALIBRATION ADJUSTMENT. Used to adjust the compensation circuit for correct amplitude tracking at RF input levels near 0 dBm.

j. A2R54, MAXIMUM LEVEL CALIBRATION ADJUSTMENT. Used to adjust the compensa-circuit for correct amplitude tracking at RF input levels near +10 dBm.

k. A2R130, PRE-AMPLIFIER ZERO. Used to adjust the pre-amplifier for zero output voltage with no RF power applied to the detector.

l. A2R138, FREQUENCY RESPONSE. Used to set the pre-amplifier for minimum settling time when the input RF signal is changed abruptly from +10 dBm to -50 dBm.

m. A2R150, PRE-AMPLIFIER CHOPPER BALANCE. Used to adjust the pre-amplifier for minimum chopper frequency noise signal.

6.2.2 DESCRIPTION OF TEST POINTS

The function of each test point is described below.

a. TP11 (A1J1) +5 V POWER SUPPLY. Only found on Model 1038-H13. Provides a connection for a logic probe together with TP13.

b. TP12 (A1J2) OVERSPILL LOGIC SIGNAL. Only found on Model 1038-H13. Useful for triggering an oscilloscope when investigating the operation of the logic circuits.

c. TP13 (A1J3) COMMON.

d. TP14 (A1J4) HORIZONTAL DIGITAL TO ANALOG CONVERTER OUTPUT. Only found on Model 1038-H13. Useful for monitoring the operation of the memory drive circuits.

e. TP15 (A1J5) CALIBRATOR CONTROL AMPLIFIER OUTPUT. Useful for monitoring the operation of the amplitude-regulation feedback loop for the calibrator.

f. TP16 (A1J6) +15 V SUPPLY AT THE CALIBRATOR AMPLIFIER. Useful, in conjunction with TP17, for measuring the current through the calibrator output amplifier. Adjust A1C45 for minimum voltage across these points.

g. TP17 (A1J7) CALIBRATOR AMPLIFIER CURRENT MEASUREMENT POINT. See 6.2.2f above.

h. TP201 (A2J1), OFFSET AMPLIFIER OUTPUT. Used to monitor the operation of the circuits ahead of the offset amplifier. Voltage coefficient should be 100 mV/dB within about one percent.

i. TP202 (A2J2), OVEN CURRENT MONITOR POINT. The oven current can be measured here by subtracting the test point voltage from 15 V and dividing by 11 ohms.

j. TP203 (A2J3), GROUND. Used as a reference point for measurements on the grounded portions of the circuit.

NOTE: THE FOLLOWING TEST POINTS ARE MEASURED WITH RESPECT TO THE FLOATING COMMON, TP208.

k. TP204 (A2J4), +15 Vdc ISOLATED SUPPLY. Nominal 15 V supply, actual voltage will be between 14.4 to 14.8 Vdc.

l. TP205 (A2J5), -15 Vdc ISOLATED SUPPLY. Nominal -15 V supply, actual voltage will be between -14.4 and -14.8 Vdc.

m. TP206 (A2J6), COMPENSATION AMPLIFIER FIRST STAGE OUTPUT. Used to monitor the operation of the compensation amplifier, particularly when adjusting A2R85. Adjust so that the polarity of the voltage measured changes as the RF input signal goes through -27 dBm.

n. TP207 (A2J7), SECOND STAGE SUMMING JUNCTION. Measure with a sensitive voltmeter. Set A2R79 so that the voltage is within 10 µV of zero.

o. TP208 (A2J8), INPUT CIRCUIT FLOATING COMMON.

p. TP209 (A2J9), CHOPPER FREQUENCY. Use a frequency counter with a high input impedance. The frequency should be 1 kHz within 30 Hz.

q. TP210 (A2J10), CHOPPER DEMODULATOR INPUT. Used to monitor the action of the pre-amplifier chopper circuit when setting A2C55. Monitor with an oscilloscope and set for minimum signal and spikes lying at the zero-crossing points on the sinewave.

r. TP211 (A2J11), PRE-AMPLIFIER OUTPUT. Measure with a sensitive voltmeter. With no RF signal applied to the detector adjust A2R181 for 0 Vdc within 10 µV. The NOISE LEVEL control should be centered when this is done.

6.3 CALIBRATION

6.3.1 EQUIPMENT REQUIRED FOR CALIBRATION

The following equipment is required to calibrate the Model 1038-H12 and -H13.

a. Pacific Measurements Model 1038 Mainframe and Display. The display section can be of any type supplied with the Mainframe. It is important that the Unit be correctly calibrated, as its calibration affects that of the plug-in to be tested.

b. Pacific Measurements Power Detector Cable, Part No. 12868.

c. Pacific Measurements Model 1038, Vertical Plug-In. It is important that the Plug-In be properly calibrated before using it as part of the calibration set-up for the Horizontal Plug-In.

d. An oscilloscope with 5 mV/Division sensitivity and at least 100 kHz bandwidth.

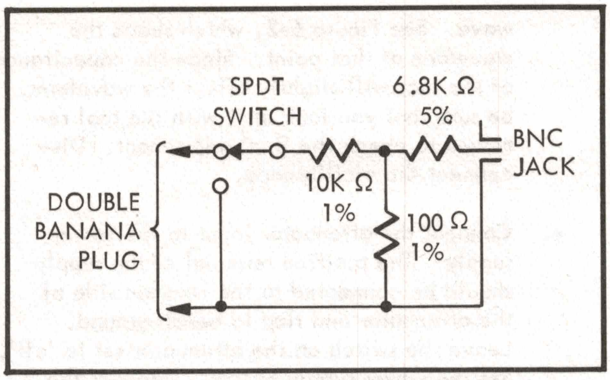
e. A Digital Voltmeter with 5-1/2 digit resolution and 1 µV per digit resolution. For example, Data Precision Model 2450A1.

f. A Precision Power Supply with 10 µV resolution in the range from 1 mV to 2V. For example, John Fluke Model 382A Voltage/Current Calibrator.

g. An attenuator made up of resistors as shown in Figure 6-1. The circuit can be conveniently constructed in a small phenolic box such as Pomona Electronics Model 2098. The box is equipped with banana plugs and jacks; since the output will connect to a BNC plug, a Double Banana to BNC adapter will be needed.

h. A frequency counter capable of measuring 30 MHz with an input of 1.4 Vrms from a 50 ohm source.

i. A dc voltmeter or multimeter capable of measuring 0.5 V with respect to a 15 V level. Almost any VOM is satisfactory.



ATTENUATOR USED FOR CALIBRATION

FIGURE 6-1

j. An ac to dc thermal voltage converter. Recommended is the Fluke Model A55. This unit has approximately 200 ohms input resistance; in use it is required to measure its input resistance and connect enough resistance across its input to make it 50 ohms within 1%. In addition, an adapter is required to connect it to the output of the calibrator on the Horizontal Plug-In Unit (either Type N, APC-7 or SMA depending upon the type ordered on the plug-in).

k. An adapter box with double banana plugs on one side and a Type N female connector on the other. Connecting the center pin of the Type N to the High Side of the double banana should be a 50 ohm 0.1% resistor. The Low Side of the banana should tie to the Type N shell.

The following items will be needed if the calibration is to be checked with an RF detector. This calibration will normally be performed if the specific RF detector with which it will normally be used is available.

l. The RF detector with which the instrument will be used. Normally this will be the Pacific Measurements detector supplied with the instrument.

m. A precision attenuator calibrated at 30 MHz. If a step attenuator is used it should have steps of 10 dB from 0 to 60 dB. Individual attenuators can be used with some sacrifice in convenience. The actual attenuation should be known to better than 0.02 dB at 30 MHz.

6.3.2 CALIBRATION PROCEDURE

The Model 1038 Horizontal Plug-In Units employ solid-state components exclusively. These are extremely reliable and generate little heat. Consequently, there is little drift due to component aging and adjustments to the instrument are rarely required. We therefore strongly recommend that if measurements indicate that an adjustment is set within the stated range, that you do not attempt to put it "right on". It is often the case that variations in the equipment used to test the instrument account for small differences in measured values. Other adjustments dependent upon a given adjustment will be affected if it is reset. In short, be absolutely sure that an adjustment is really required before making it.

If a component is replaced, depending upon where in the circuit it is located, only certain of the calibration steps need be performed. In general, only those steps shown in the section pertaining to the specific circuit repaired need be carried out.

It will be most convenient to gain access to the adjustments by placing the plug-in on an extender cable. Such a cable can be ordered from Pacific Measurements, Part No. 12715, Extender Cable Kit.

The steps listed below must be carried out in the order listed. It will be helpful for you to read the entire procedure once through before starting. Allow at least one-half hour warm-up before starting.

6.3.2.1 CALIBRATOR FREQUENCY AND AMPLIFIER TUNING

a. Connect the Frequency Counter to the CALIBRATOR OUTPUT. Adjust A1C29 to obtain 30 MHz within 100 kHz. Be sure that the frequency is correct with the tuning tool removed.

b. Connect the VOM between TP16 and TP17 and select a range that gives a good upscale reading. Adjust A1C45 until the minimum reading is obtained. Recheck step a and repeat if necessary. Disconnect the meter and counter.

6.3.2.2 CALIBRATOR AMPLITUDE ADJUSTMENT

The purpose of this adjustment is to set the output of the calibrator to 10 mW within 1.5%. This is a very high degree of accuracy for a power measurement at 30 MHz. Accordingly, the procedure must be performed with great care. If you do not have the equipment required, do not attempt to make the adjustment.

a. Set the precision power supply to 1.414 V. Connect the adapter of Section 6.3.1k to the output of the supply and connect the Thermal Converter to the output of the adapter. Read the dc output of the Thermal Converter to a precision of 0.1%. Reverse the polarity of the supply and repeat the reading. Record the average of the two voltages. Turn the calibrator on, screw the Thermal Converter to the CALIBRATOR OUTPUT and adjust A1R77 so that the Converter has the same output voltage as it did when it was connected to the supply. Reconnect the Converter to the supply through the 50 ohm adapter and check to see that you still get the same output as before. If there is a significant difference in the reading before and after the calibrator measurement, repeat the procedure. This last step is important, as the converter does drift with temperature.

6.3.2.3 REFERENCE CHANNEL

a. Check the + and -15 V isolated supplies. Measure between TP204 and TP208 then between TP205 and TP208. The magnitude of the voltage should be between 14.4 and 14.8 V. If the voltage does not fall between these limits, trouble is indicated.

b. Check the operation of the oven regulator. Measure between TP202 and TP203. The voltage should be approximately -13.7 V immediately after turn-on, dropping to about -14.7 V after 1 to 5 minutes (depending upon the ambient temperature and how long the oven has been turned off). Operation markedly different from the above is an indication of trouble with the oven circuit.

c. Using the electronic counter, measure the frequency at TP209 with the common lead of the counter connected to TP208. The frequency should be 1 kHz within 30 Hz. If not, A2R122 can be changed to correct it.

d. Connect the Power Detector Cable to the DETECTOR INPUT and connect the BNC end of the cable to the attenuator described in Section 6.3.1g. Turn the switch on the attenuator to the 'off' position. Set the attenuator and detector cable assembly on an insulated surface not connected to ground. Connect the input of the oscilloscope to TP210 and the ground lead of the oscilloscope to TP208. Be sure that the oscilloscope and the Model 1038 both have their chassis grounded through the 3 prong power cords. Connect a trigger input lead from the external trigger connection of the oscilloscope to TP209, set the sweep to 0.5 ms/DIV and adjust the trigger level control on the scope to obtain a stable display. Set the input sensitivity to 5 or 10 mV/DIV as desired.

Adjust A2C55 (use an insulated tool) to obtain the minimum signal viewed by the scope. When the correct adjustment is obtained the sharp spikes on the waveform should be centered on the zero-crossing points of the sine-wave. See Figure 6-2, which shows the waveform at that point. Since the capacitance of the tool will slightly affect the waveform, be sure that you look at it with the tool removed to check the final adjustment. Disconnect the oscilloscope.

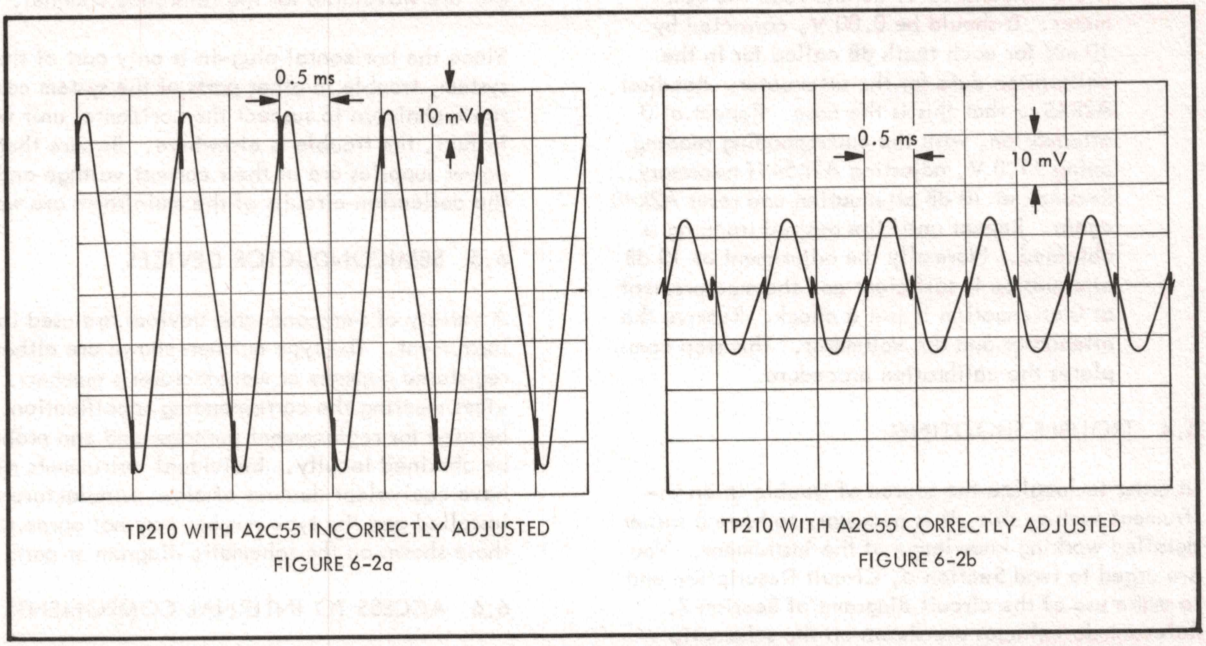
e. Connect the attenuator input to the power supply. The positive terminal of the supply should be connected to the common side of the attenuator and tied to bench ground. Leave the switch on the attenuator set to 'off'. Set the power supply to 0 V. Connect the voltmeter input to TP211 and the low side of the voltmeter to TP208. The voltmeter should be floating free of ground. Adjust A2R130 to obtain 0 V within 10 µV.

f. Move the voltmeter input to TP206 and reduce the sensitivity to 1 V full scale. Set the power supply to 0.140 V and turn the switch on the attenuator to 'on'. Adjust A2R44 so that the polarity of the measured voltage is just positive. Reduce the voltage to 0.110 V and the polarity should go negative; if not, readjust the potentiometer. Remove the voltmeter and return the attenuator switch to 'off'. Remove the attenuator from the supply and set it on an insulated place.

g. Connect the input of the digital voltmeter to TP207 and the low side of the voltmeter to TP208. Adjust A2R38 to obtain zero volts within 10 µV. Remove the voltmeter connections.

h. Connect the negative side of the power supply to TP207 and the positive side (which should be also connected to bench ground) to TP208. Set the supply to 0.01 V. Connect the DVM input to TP201 and the low side to TP203. Record the voltage, then set the supply to 0.1 V; the voltage should now be exactly 1 V different from the recorded value. If not, adjust A2R5 until the voltage changes exactly 1 V as the supply voltage is changed from 0.01 V to 0.1 V. Apply 1.0 V and check to see that the voltage changes an additional volt. A2R5 can be slightly reset if necessary to equalize the error between the 0.01 V to 0.1 V step and the 0.1 V to 1.0 V step. Disconnect the supply.

i. Reconnect the attenuator and the detector cable to the power supply (common positive tied to the bench ground). The output of the attenuator must supply a negative voltage to the detector cable center pin. Turn the attenuator switch 'on' and set the supply to 0.070 V. Record the reading of the voltmeter. Remove the attenuator and connect the detector cable directly to the supply, observing the same



TP210 WITH A2C55 INCORRECTLY ADJUSTED
FIGURE 6-2a

TP210 WITH A2C55 CORRECTLY ADJUSTED
FIGURE 6-2b

WAVEFORMS AT TP210

FIGURE 6-2

polarity so that the negative terminal of the supply is connected to the center pin of the cable input. Set the supply to 0.229 V. Adjust A2R48 so that the voltmeter reads exactly 3.0 V change from the previously recorded value.

Increase the supply voltage to 0.848 V and note the reading; it should represent a change of 4.0 V from the recorded value. If not, adjust A2R54 to a point where the error is made five times as large but in the opposite direction from that noted when the supply voltage was first increased to 0.848 V. For example, if the original voltage recorded had been -2.995 and the voltage at 0.848 V input was seen to be +1.017, A2R54 should be reset so the voltage measured would be +0.957 V.

2.995 + 1.017 = 4.012
(4.012 - 4.000)5 = .060
1.017 - .060 = .957

Now return to 0.229 V and reset A2R48 to once again obtain the 3.0 V change called for above. Repeat this procedure until the voltages are correct for both 0.229 V and 0.848 V into the detector cable.

j. With the supply set to 0.229 V, adjust A2R8 so that the voltmeter reads 0.000 V within 10 mV. Disconnect the voltmeter.

k. Set the supply to 0.070 V and insert the attenuator between the supply and the detector cable. Connect the oscilloscope to TP201 and its ground to TP203. Use ac coupling and 5 mV/DIV. Adjust A2R150 to obtain the minimum 1 kHz signal.

l. Set the power supply to 22.9 V and set the oscilloscope to 1 V/DIV. Use dc coupling. Turn the attenuator switch off and observe the action. The trace should move rapidly for the first 5 V then settle more slowly. Adjust A2R138 so that when the switch is turned off you see the best response speed without overshoot in the response. Remove the oscilloscope and disconnect the power supply.

If you have the detector with which the plug-in will be used you can improve the tracking with that detector. The following procedure will adjust the instrument for optimum tracking with a specific detector.

m. Connect the detector to the DETECTOR INPUT. Screw the detector to the precision attenuator of Section 6.3.1m. Connect the input of the attenuator to the CALIBRATOR OUTPUT of the Horizontal Plug-In. Set the attenuator for 40 dB, and turn the CALIBRATOR ON.

Connect the DVM to TP201 and TP203. Adjust A2R8 so that the DVM reads -3.00 V, ± 10 mV for each tenth of a dB error specified in the calibration data for the attenuator. Set the attenuator to 10 dB and read the voltmeter. It should be 0.00 V, corrected by 10 mV for each tenth dB called for in the calibration data for the attenuator. Readjust A2R48 so that this is the case. Repeat at 0 attenuation, with the corresponding reading being +1.0 V, adjusting A2R54 if necessary. Recheck at 10 dB attenuation and reset A2R48 again. Repeat until the desired tracking is obtained. Normally the adjustment at 10 dB attenuation is sufficient and the measurement at 0 attenuation is just a check. Remove the attenuator and the voltmeter. This step completes the calibration procedure.

6.4 TROUBLE SHOOTING

In order to localize the source of trouble in an instrument such as this, it is necessary to have a rather detailed working knowledge of the instrument. You are urged to read Section 5, Circuit Description and to make use of the circuit diagrams of Section 7. Relevant dc voltages are shown on the schematic diagrams and are typical of values to be found during normal operation. The data were taken with a digital voltmeter with 10 M ohm input impedance. The detector was connected to the calibrator of a horizontal plug-in and the calibrator turned on.

In general, dc voltages will not be shown at points where they will vary substantially depending upon the mode of operation. In many cases, such points will have a waveform shown. Figures 6-3, and 6-4 show various waveforms. Figure 6-5 is a timing diagram for the memory drive section. Figures 6-6 and 6-7 are waveforms for the reference channel.

Since the horizontal plug-in is only part of the total system, trouble in other parts of the system can lead the technician to suspect the horizontal unit when, in fact, the trouble is elsewhere. Be sure that the power supplies are at their correct voltage and that the deflection circuits of the mainframe are working.

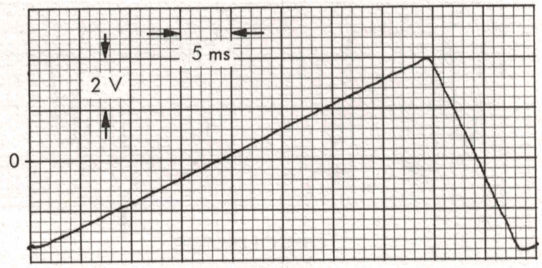
6.5 SEMICONDUCTOR DEVICES

A variety of semiconductor devices are used in this instrument. The type numbers shown are either EIA registered numbers or manufacturer's numbers. Devices meeting the corresponding specifications can be used for replacement purposes and can probably be obtained locally. Individual instruments may have equivalent devices of other manufacturers installed and the type number may not agree with those shown on the schematic diagram or parts list.

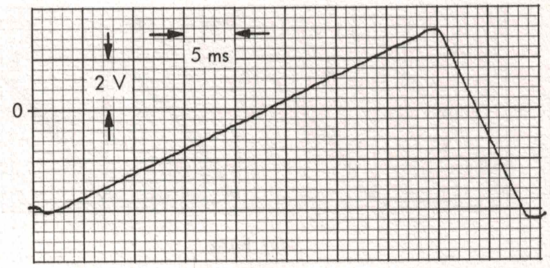
6.6 ACCESS TO INTERNAL COMPONENTS

Access to the internal components is obtained by removing the side covers. The covers are retained in slots and held in place by two screws at the rear of the unit.

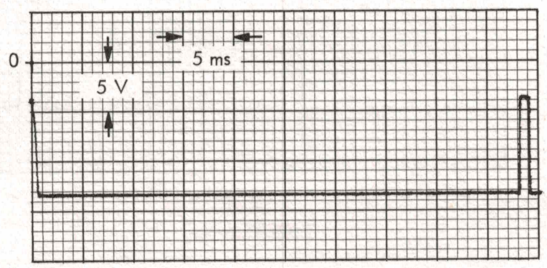
Access to the back side of the PC boards is obtained by removing the screws that secure the reference channel board and swinging the board out on its flat flexible cable. Remove the shield between the boards if access to the rear of the horizontal deflection and memory drive board is required.



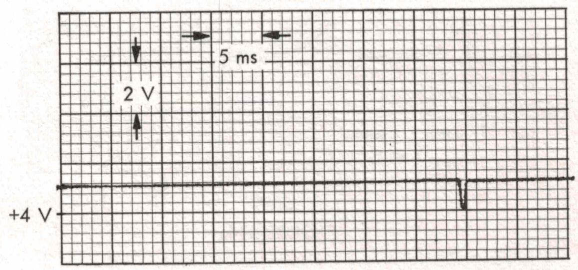
U2-6
FIGURE 6-3a



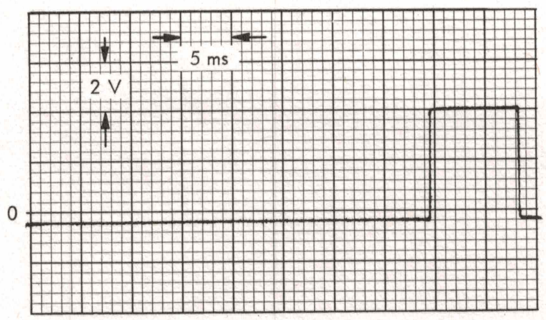
U1-6
FIGURE 6-3b



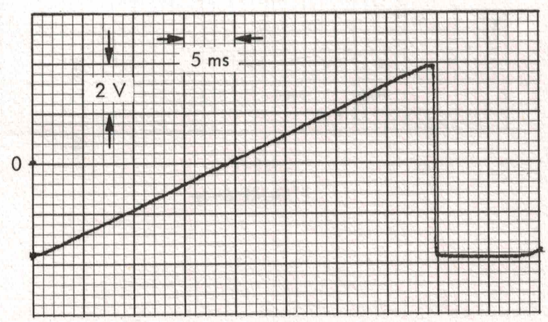
U3-6
FIGURE 6-3c



U4-6
FIGURE 6-3d



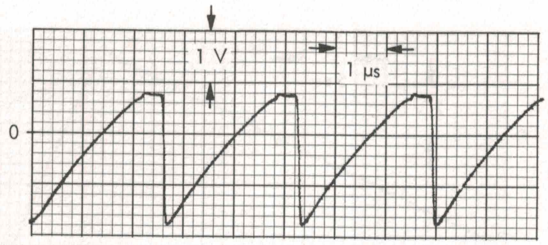
U5-6
FIGURE 6-3e



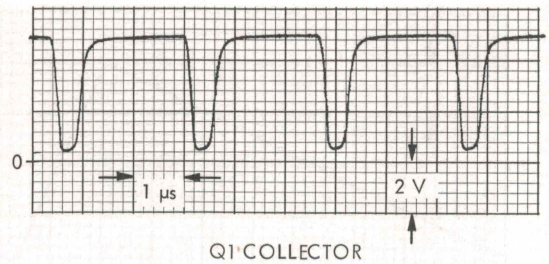
TP 14
FIGURE 6-3f

NOTE: The waveforms are for a 40 ms sweep voltage connected to the HORIZONTAL INPUT. The amplitude was sufficient to drive the trace approximately one minor division beyond the graticule at each end of the sweep. The oscilloscope was triggered externally from TP12, the negative going edge of "OVERSPILL".

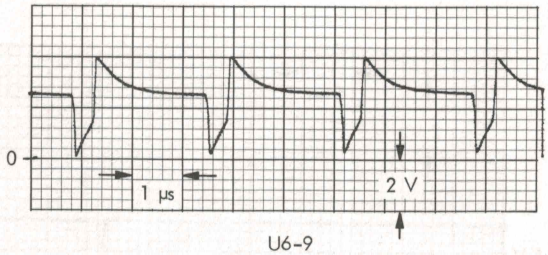
HORIZONTAL DEFLECTION AND MEMORY DRIVE CIRCUIT WAVEFORMS
FIGURE 6-3



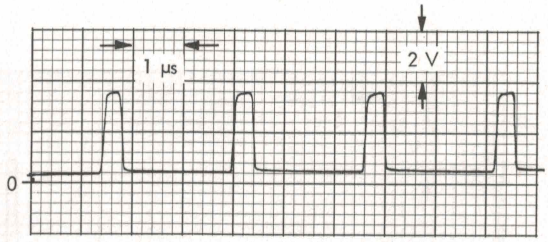
Q1 BASE
FIGURE 6-4a



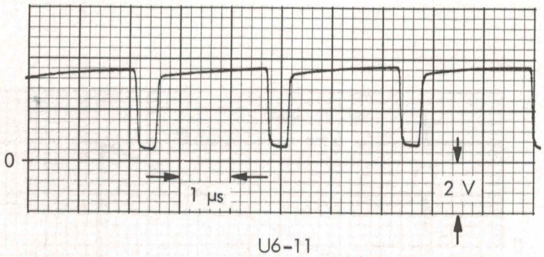
Q1 COLLECTOR
FIGURE 6-4b



U6-9
FIGURE 6-4c



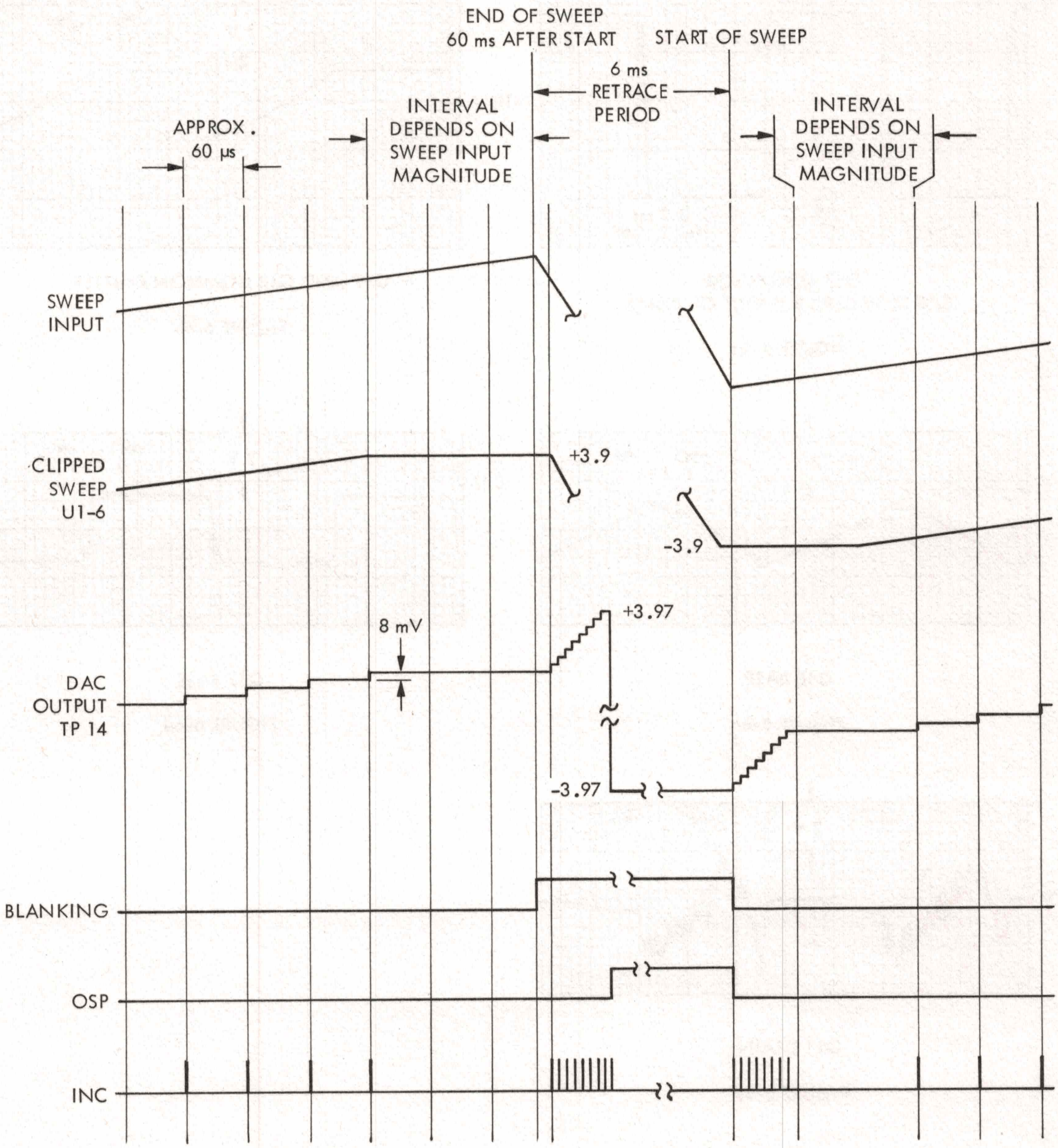
U6-8
FIGURE 6-4d



U6-11
FIGURE 6-4e

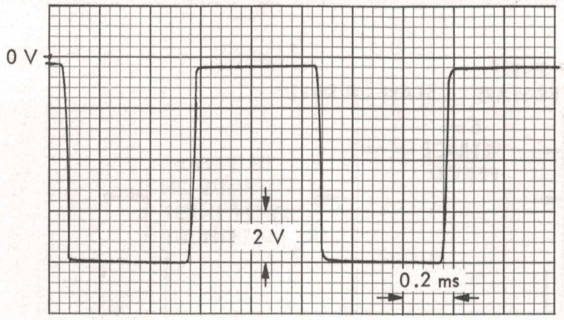
NOTE: The timing waveforms of the clock generator are independent of the HORIZONTAL INPUT. The oscilloscope was triggered internally from the signal displayed and corresponding parts of each waveform do not occur at the same horizontal scale division in each curve.

OSCILLATOR CIRCUIT WAVEFORMS
FIGURE 6-4



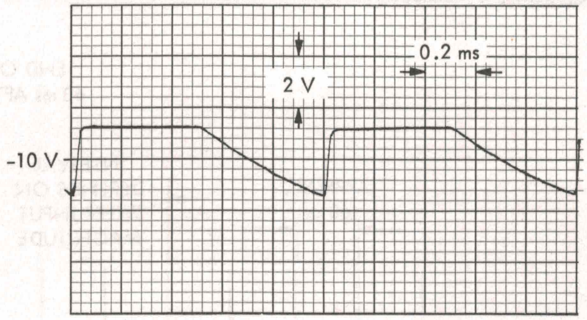
NOTE: The timing sequence shown is for a sweep input voltage large enough to drive the beam slightly beyond the graticule edges. Sweep time is 60 ms with a retrace time of 6 ms.

MEMORY DRIVE CIRCUIT TIMING DIAGRAM
FIGURE 6-5



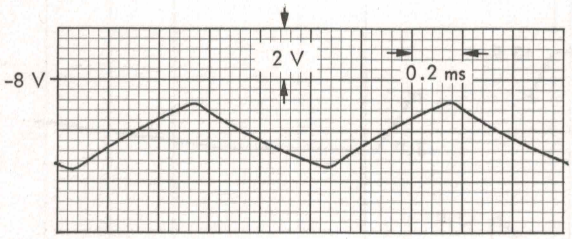
Q17 COLLECTOR
Q18 IS SIMILAR BUT OUT OF PHASE

FIGURE 6-6a



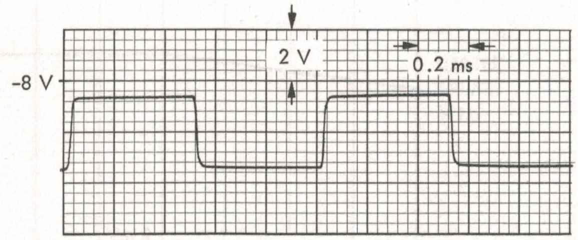
Q17 AND Q18 COMMON EMITTER

FIGURE 6-6b



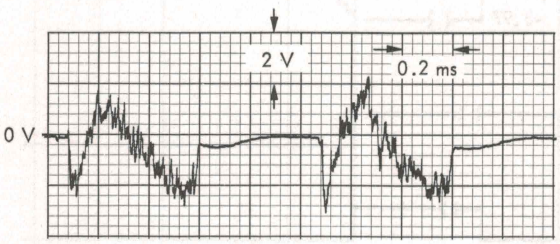
Q18 BASE

FIGURE 6-6c



Q17 BASE

FIGURE 6-6d



Q11 DRAIN

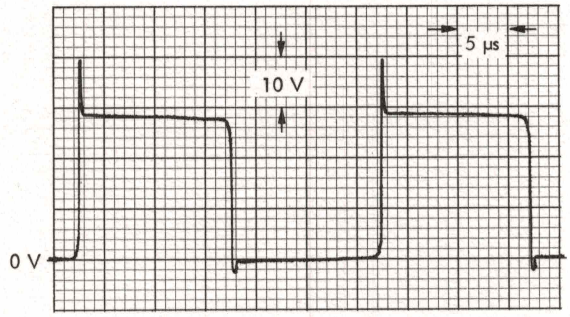
FIGURE 6-6e

NOTE: A HIGH IMPEDANCE SCOPE PROBE WAS USED. FOR THE WAVEFORMS AT U11, SEE FIGURE 6-2, THE TRIGGER SOURCE WAS TP209.

WAVEFORMS OF THE CHOPPING CIRCUIT

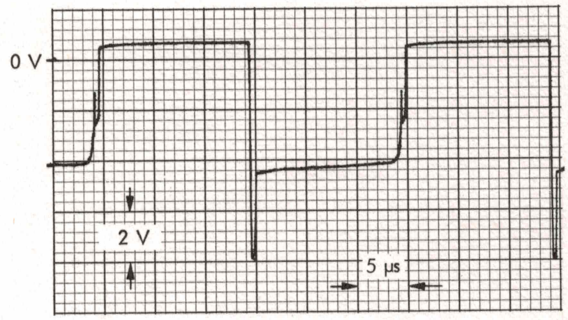
FIGURE 6-6

Ⓐ



Q3 OR Q4 COLLECTOR

FIGURE 6-7a



Q3 OR Q4 BASE

FIGURE 6-7b

NOTE: INTERNAL TRIGGERING WAS USED.

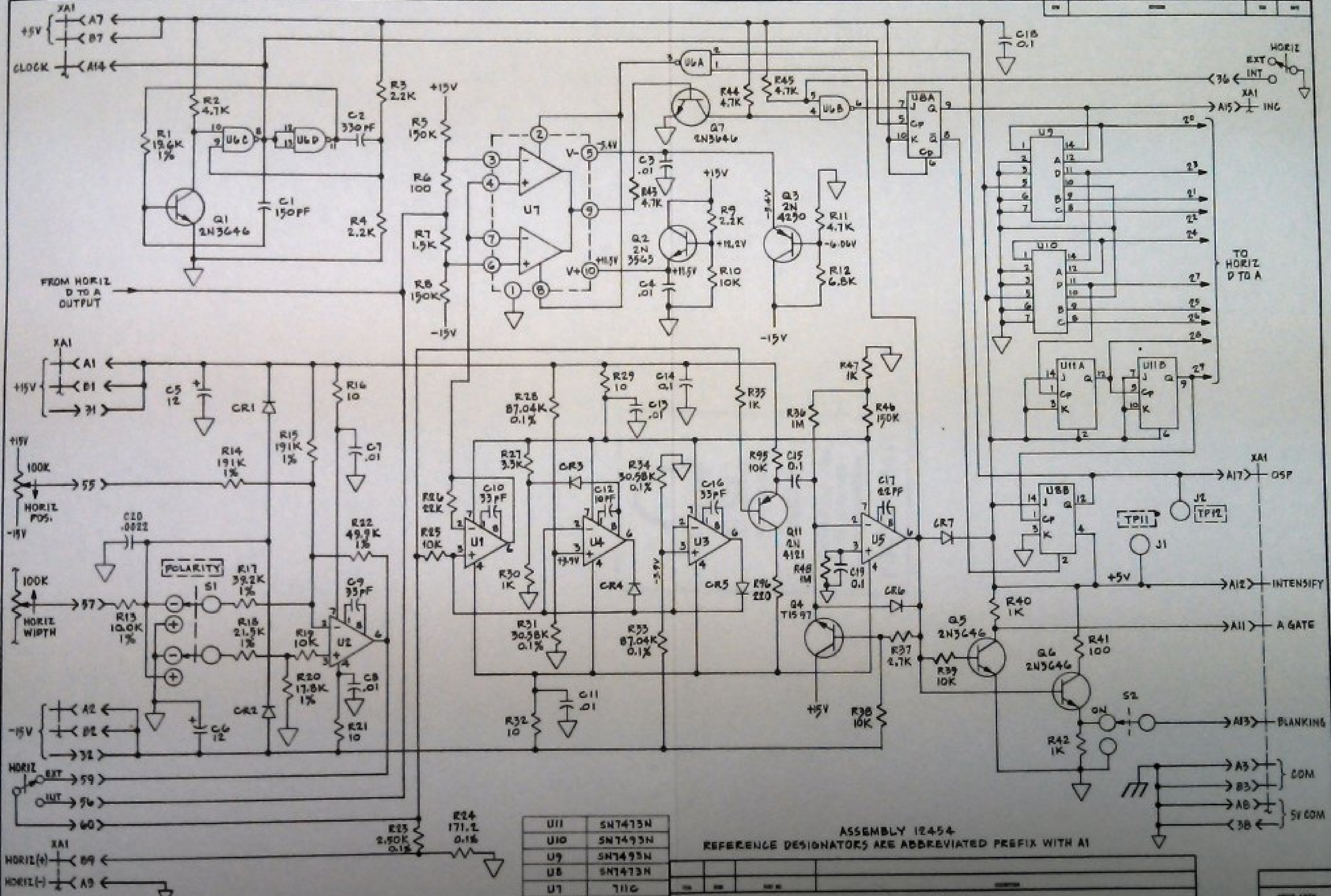
WAVEFORMS OF THE ISOLATED POWER SUPPLY
FIGURE 6-7

SECTION 7

SCHEMATIC DIAGRAMS

Schematic diagrams in this section are filed in the order of their drawing numbers

Used With Model No.	Reference Designator	Title	Drawing Number
1038-H12	--	HORIZONTAL/REFERENCE MODEL 1038-H12	12879
1038-H12	A1	HORIZONTAL AMPLIFIER	12860
1038-H13	--	HORIZONTAL/MEMORY/REFERENCE MODEL 1038-H13	12753
1038-H13	A1	HORIZONTAL AMPLIFIER (2 Sheets)	12455
1038-H13	A2	REFERENCE CHANNEL (3 Sheets)	12746



U11	SN7473N
U10	SN7493N
U9	SN7493N
U8	SN7473N
U7	711C
U6	SN7400N
U5	LM301A
U4	LM301A
U3	LM301A
U2	LM301A
U1	LM301A
REF DESIG	TYPE

ASSEMBLY 12454
REFERENCE DESIGNATORS ARE ABBREVIATED PREFIX WITH A1

NOTES:
1. UNLESS SPECIFIED OTHERWISE, RESISTOR VALUES ARE IN OHMS AND ARE ±5%, 1/4 WATT. CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL DIODES ARE IN4148.

LIST OF MATERIAL

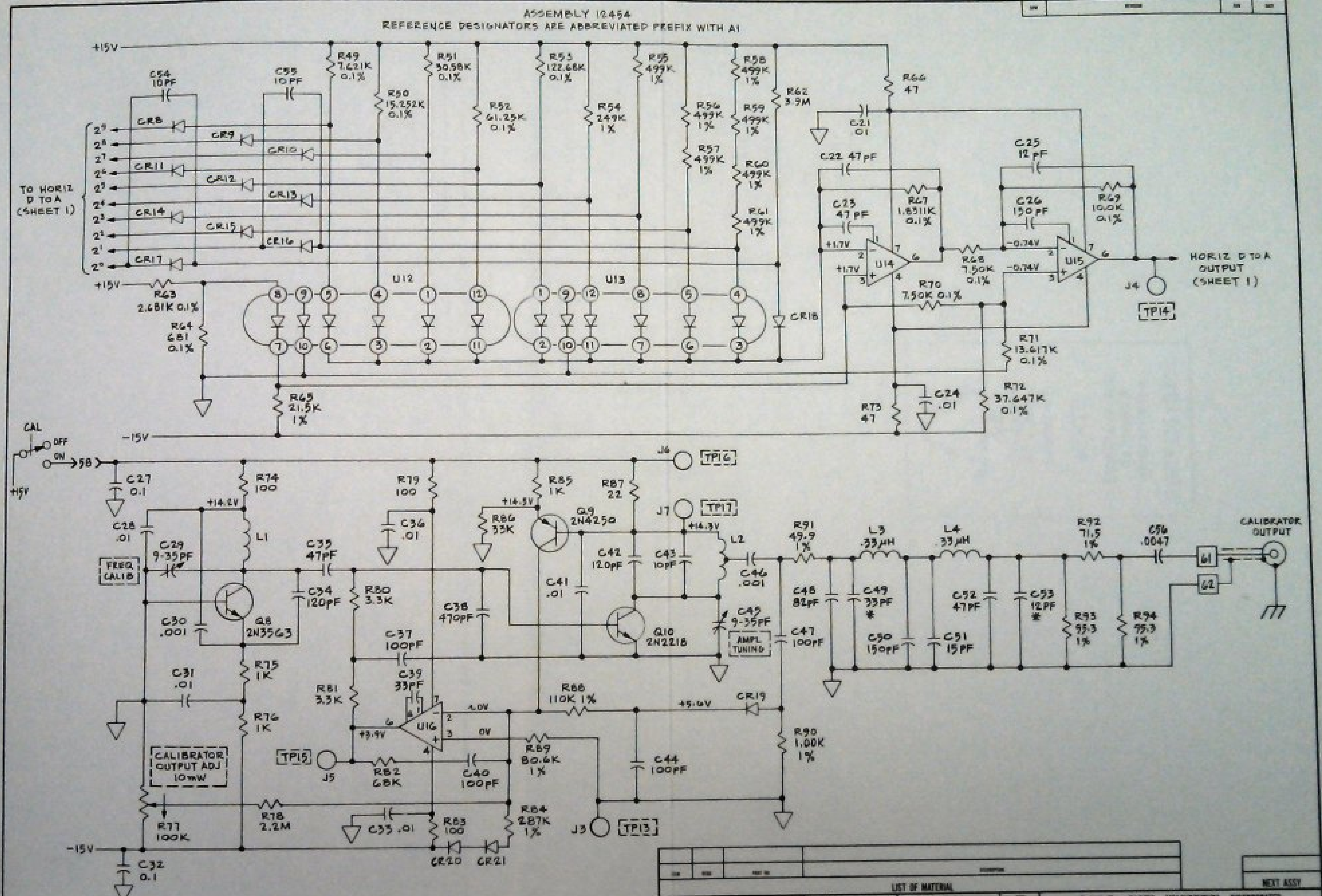
NEXT ASSY

YO 8-8-73
RHB

PACIFIC MEASUREMENTS INCORPORATED

HORIZONTAL AMPLIFIER

12455 E



NOTES:
1. UNLESS SPECIFIED OTHERWISE, RESISTOR VALUES ARE IN OHMS AND ARE ±5% ¼ WATT. CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL DIODES ARE 1N414B.
3. * DENOTES FACTORY SELECTED.

REF DESIG	TYPE
U14, U15 U16	LM301A
U12, U13	CA3039

LIST OF MATERIAL

NEXT ASSY

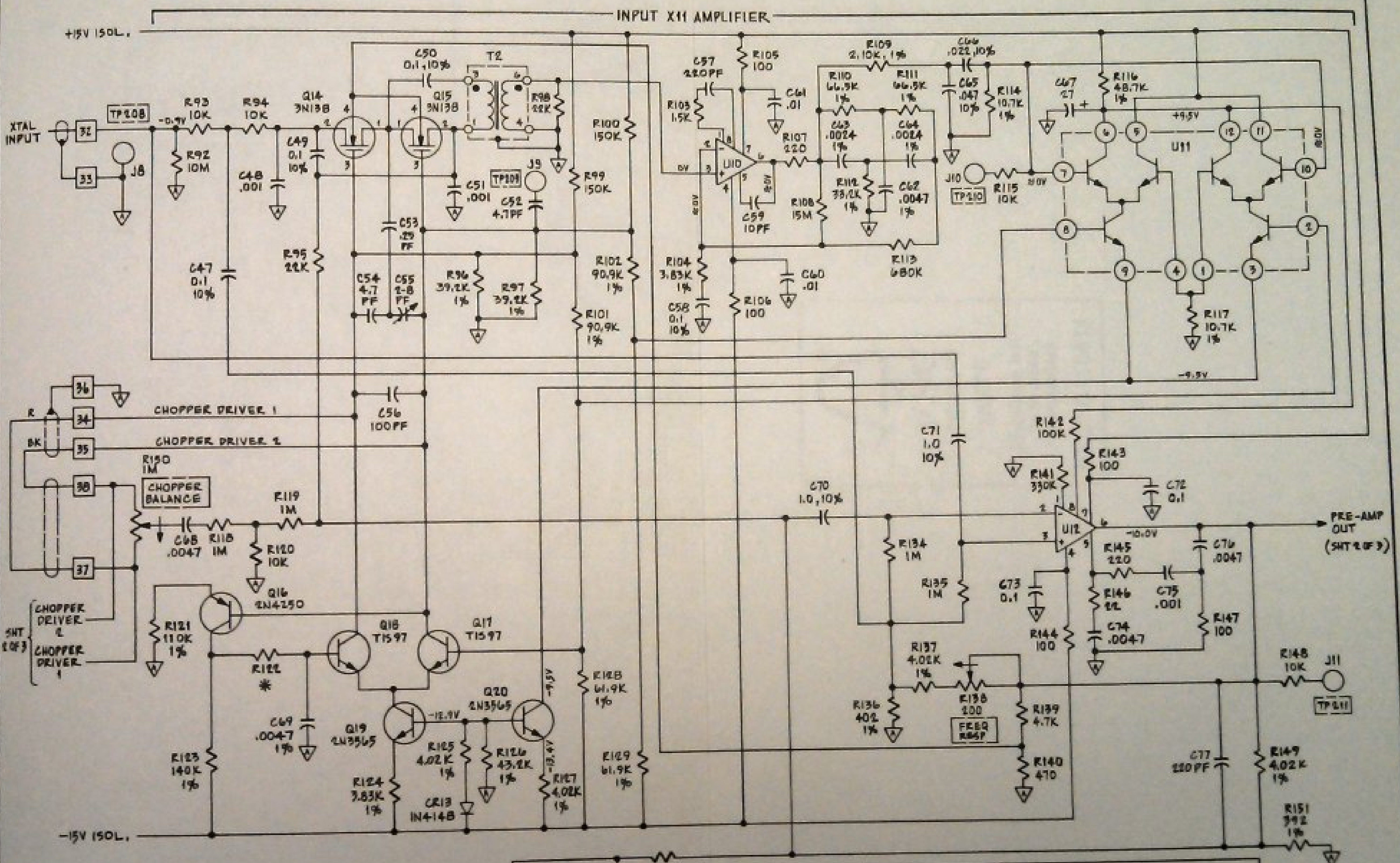
YO	8-8-73	
RHB	3-7-74	

PACIFIC MEASUREMENTS INCORPORATED

HORIZONTAL AMPLIFIER

12455 A

SHEET 2 OF 2



NOTES:
1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE ±5% 1/4W. CAPACITOR VALUES ARE IN MICROFARADS.
2. * DENOTES FACTORY SELECTED

REF DESIG	TYPE
U12	725C
U11	CA3026
U10	709C

ASSEMBLY 12744 REFERENCE DESIGNATORS ARE ABBREVIATED PREFIX WITH A2

LIST OF MATERIAL

NEXT ASSY

10-1-73

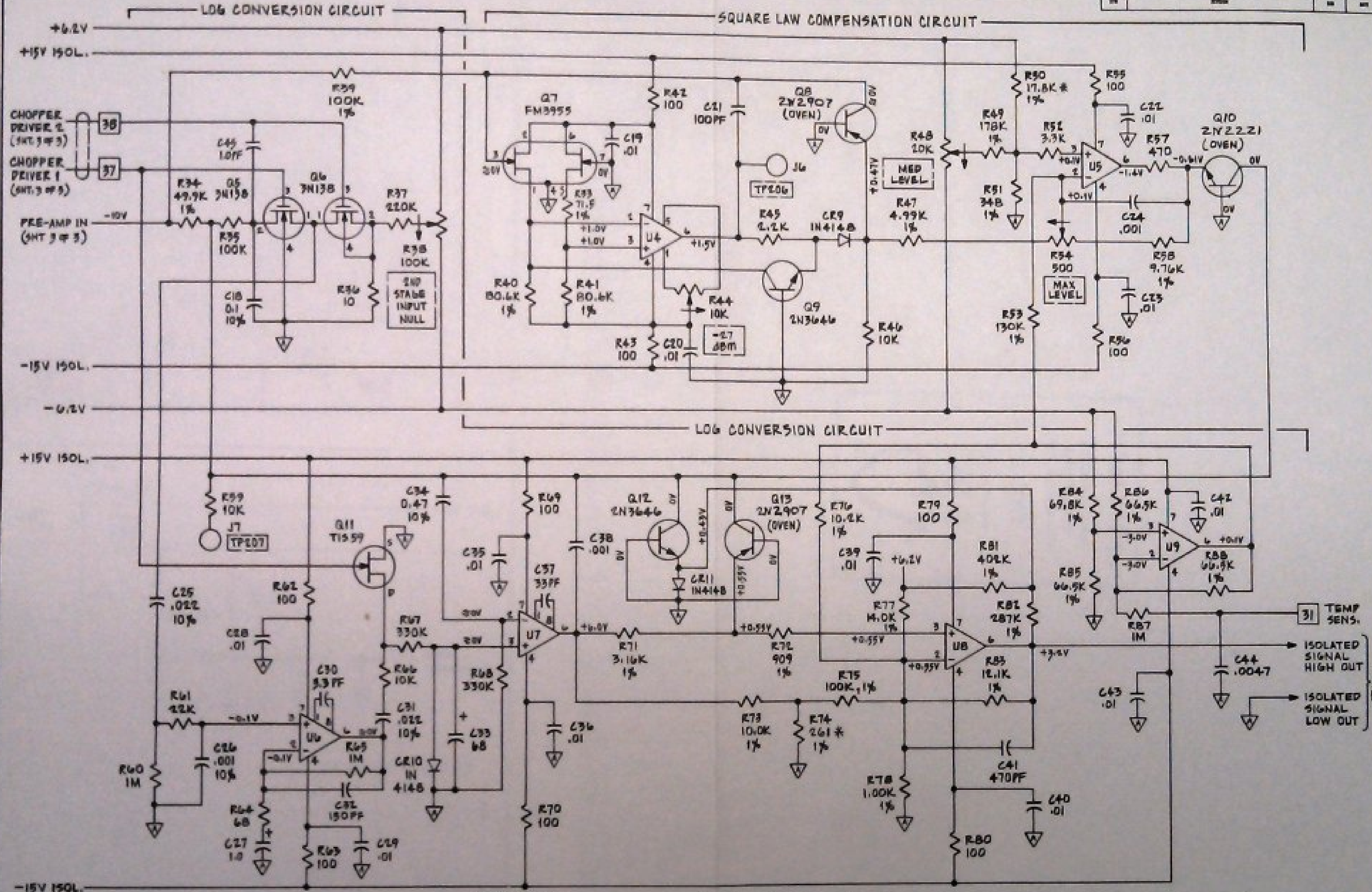
RHB 5-10-74

PACIFIC MEASUREMENTS INCORPORATED

REFERENCE CHANNEL

12746 C

SHEET OF 3



NOTE:
1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE ±5% 1/4W. CAPACITOR VALUES ARE IN MICROFARADS.
2. * DENOTES FACTORY SELECTED.

REF DESIG	TYPE
U6, U7	LM301A
U4, U5, U8, U9	741C

LIST OF MATERIAL

NEXT ASSY

PACIFIC MEASUREMENTS INCORPORATED

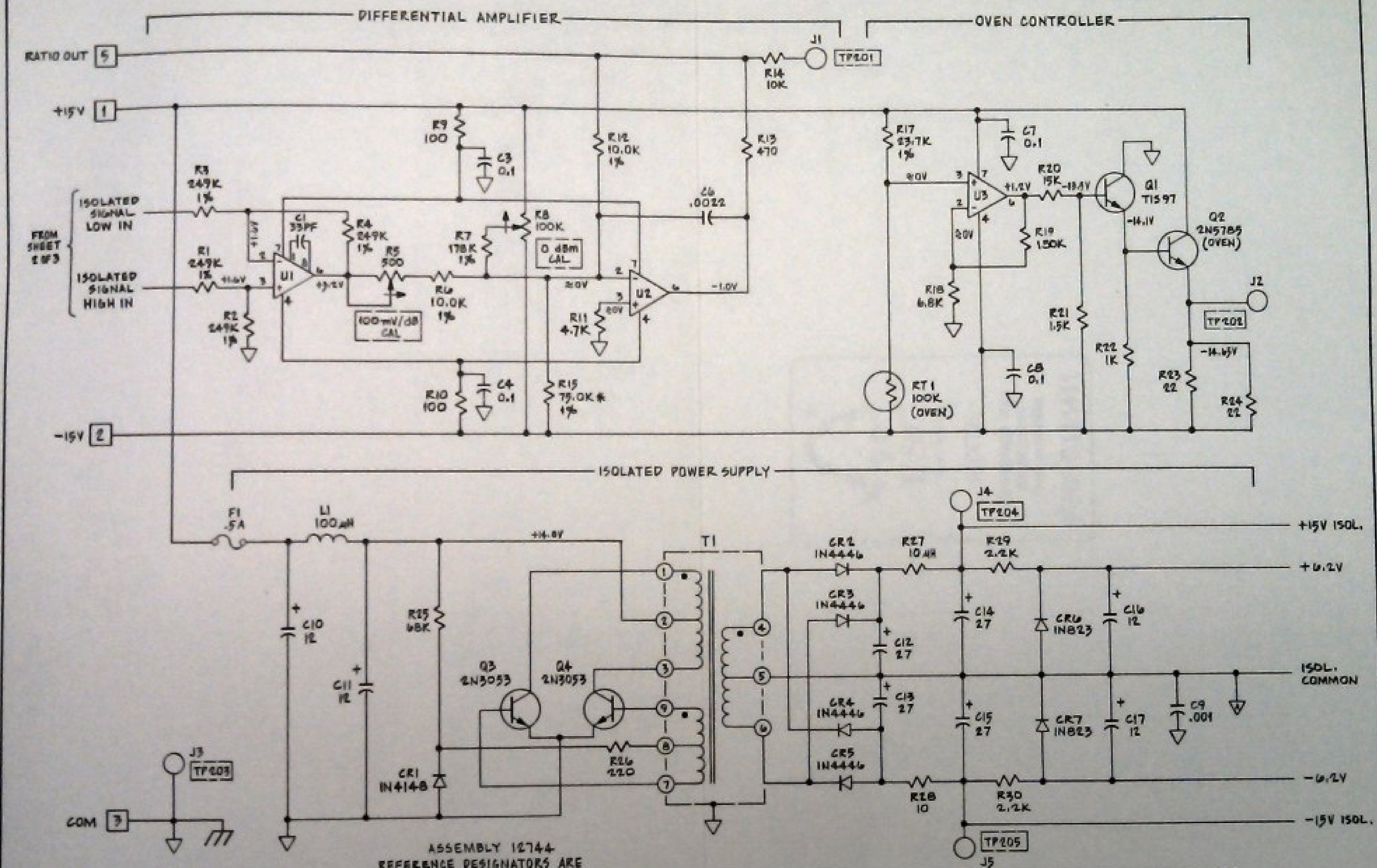
REFERENCE CHANNEL

10-1-73

RHB 5-10-74

12746 B

SHEET 2 OF 3



ASSEMBLY 12744
REFERENCE DESIGNATORS ARE ABBREVIATED PREFIX WITH A2

NOTES:
1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE ±5% 1/4W. CAPACITOR VALUES ARE IN MICROFARADS.
2. * DENOTES FACTORY SELECTED.

REF DESIG	TYPE
U2 U3	741C
U1	LM301A

LIST OF MATERIAL

NEXT ASSY

PM PACIFIC MEASUREMENTS INCORPORATED

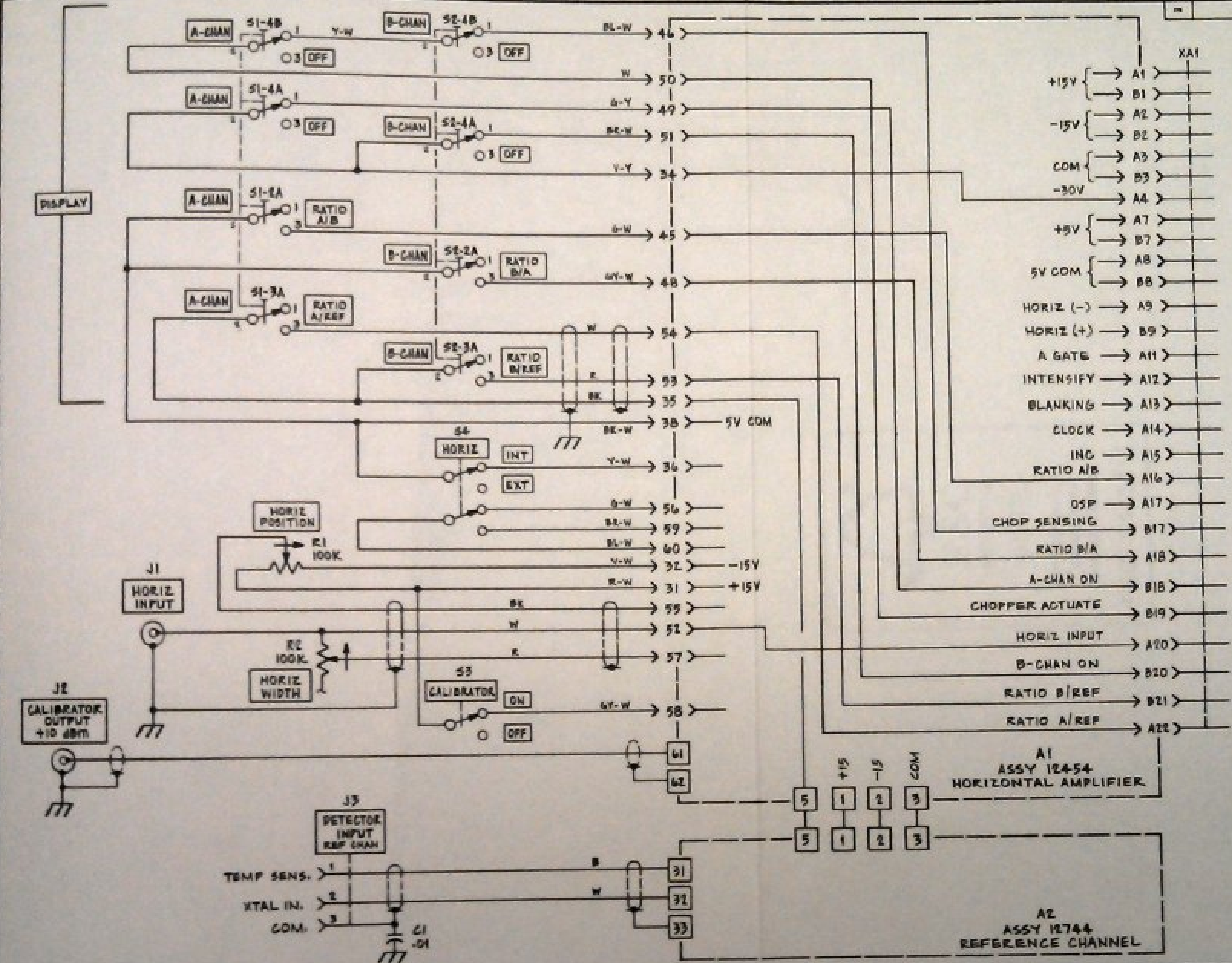
10-1-73

RHB 5-10-74

REFERENCE CHANNEL

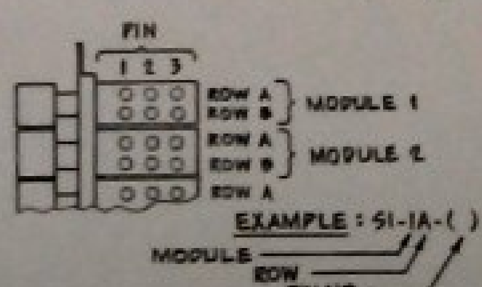
12746 C

SHEET 3 OF 3



NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE ±5% 1/4W. CAPACITOR VALUES ARE IN MICROFARADS.
2. TERMINAL NUMBERING FOR SWITCHES S1 AND S2 ARE FOR REFERENCE ONLY. RELATIVE LOCATION OF TERMINALS IS SHOWN IN DIAGRAM AT RIGHT. SWITCH IS SHOWN VIEWED FROM RIGHT-SIDE WITH BUTTON OUT-POSITION.
3. POTENTIOMETER ARROW INDICATES CW ROTATION.



LIST OF MATERIAL

NEXT ASSY

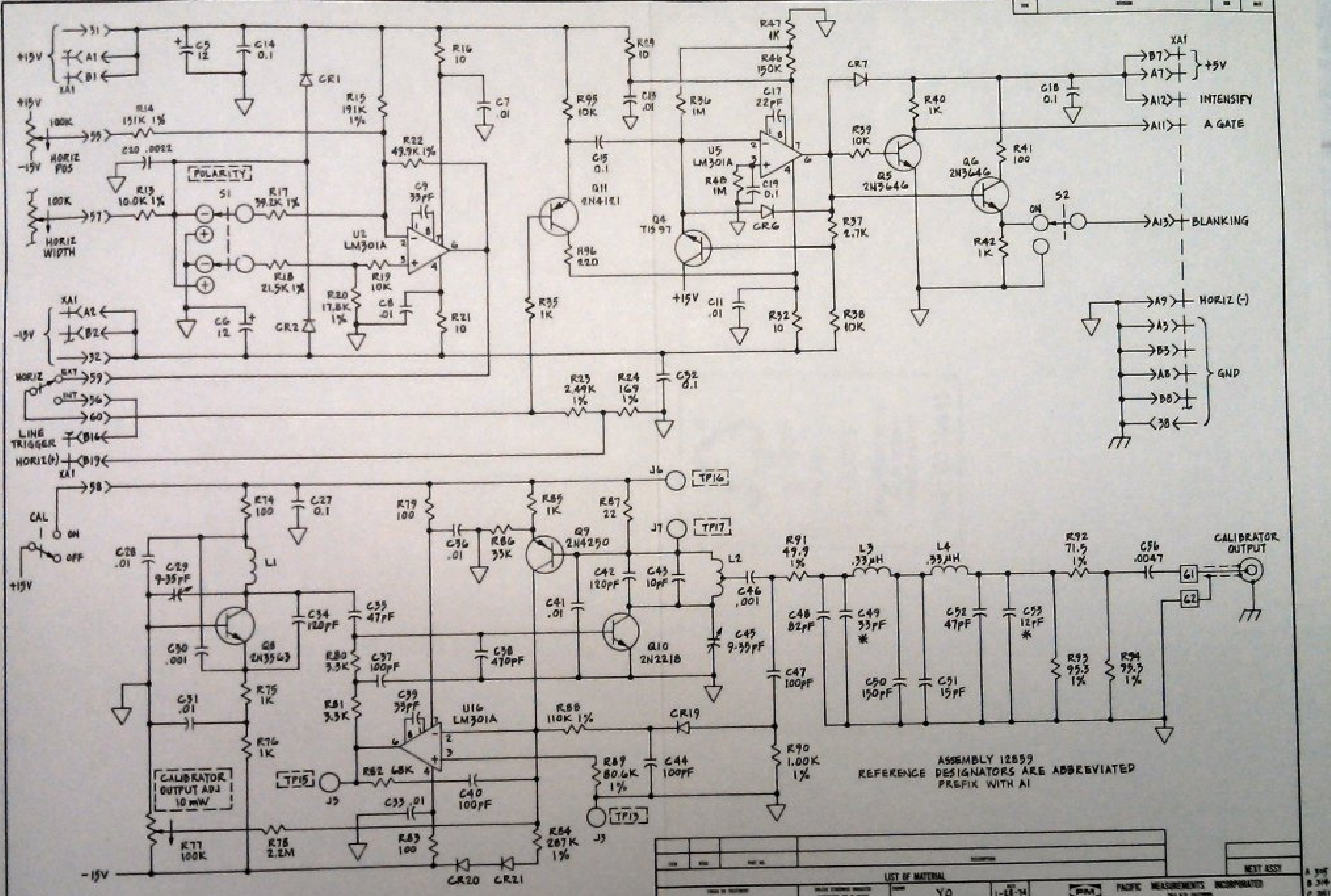
PACIFIC MEASUREMENTS INCORPORATED

HORIZ/MEMORY/LOG AMP
MODEL 1038-H13

1-8-74
5-10-74

12753

SHEET OF



ASSEMBLY 12859
REFERENCE DESIGNATORS ARE ABBREVIATED
PREFIX WITH A1

NOTES:
1. UNLESS SPECIFIED OTHERWISE, RESISTOR VALUES ARE IN OHMS AND ARE ±5% ¼WATT. CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL DIODES ARE 1N4148.
3. * DENOTES FACTORY SELECTED.

LIST OF MATERIAL

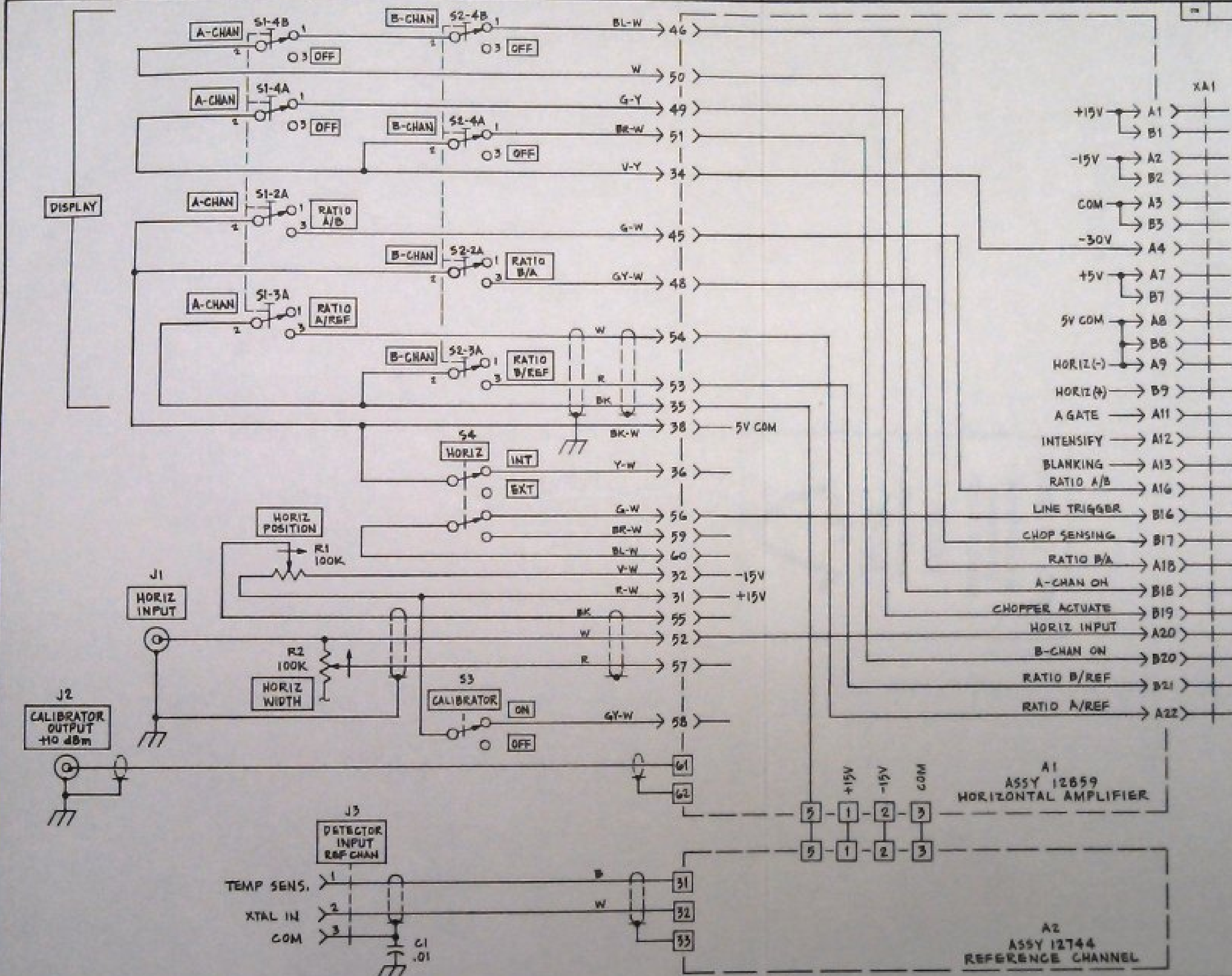
YO 1-28-74
RHB 3-7-74

PACIFIC MEASUREMENTS INCORPORATED

HORIZONTAL AMPLIFIER

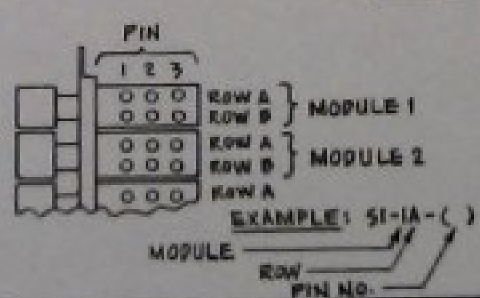
12860 E

NEXT ASSY



NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE ±5% 1/4W. CAPACITOR VALUES ARE IN MICROFARADS.
2. TERMINAL NUMBERING FOR SWITCHES S1 AND S2 ARE FOR REFERENCE ONLY. RELATIVE LOCATION OF TERMINALS IS SHOWN IN DIAGRAM AT RIGHT. SWITCH IS SHOWN VIEWED FROM RIGHT-SIDE WITH BUTTON OUT-POSITION.
3. POTENTIOMETER ARROW INDICATES CW ROTATION.



LIST OF MATERIAL

NEXT ASSY

YO

RHB

PACIFIC MEASUREMENTS INCORPORATED

HORIZONTAL / LOG AMP
MODEL 1038-H12

12879

SECTION 8

REPLACEABLE PARTS LIST

CIRCUIT REFERENCE	PART NO.	DESCRIPTION
		CHASSIS 12550 (1038-H12) 12551 (1038-H13)
C1	10000-11	Ceramic .01 µF ±20% 100 V
J1	10048	BNC UG1094/U
J2	11413	Type N UG1095A/U
J3	12564	3 Cond. Audio
R1	11676-1	Variable 100 KΩ ±20% 1/2 W
R2	11676-1	Variable 100 KΩ ±20% 1/2 W
S1	13118	Pushbutton 4 Station
S2	13118	Pushbutton 4 Station
S3	12714	Slide DPDT
S4	12714	Slide DPDT
		HORIZONTAL AMPLIFIER PC BOARD ASSEMBLY 12454 (1038-H13) 12859 (1038-H12)
		*Denotes parts not used in 12859
*A1C1	10001-15	Ceramic 150 pF ±5% 1000 V
*A1C2	10585-2	Ceramic 330 pF ±5% 1000 V
*A1C3	10000-11	Ceramic .01 µF ±20% 100 V
*A1C4	10000-11	Ceramic .01 µF ±20% 100 V
A1C5	10787-2	Tantalum 12 µF ±20% 35 V
A1C6	10787-2	Tantalum 12 µF ±20% 35 V
A1C7	10000-11	Ceramic .01 µF ±20% 100 V
A1C8	10000-11	Ceramic .01 µF ±20% 100 V
A1C9	10001-5	Ceramic 33 pF ±5% 1000 V
*A1C10	10001-5	Ceramic 33 pF ±5% 1000 V
A1C11	10000-11	Ceramic .01 µF ±20% 100 V
A1C12	10001-3	Ceramic 10 pF ±5% 1000 V
A1C13	10000-11	Ceramic .01 µF ±20% 100 V
A1C14	10000-10	Ceramic 0.1 µF +80%-20% 100 V
A1C15	10007-7	Mylar 0.1 µF ±10% 200 V
*A1C16	10001-5	Ceramic 33 pF ±5% 1000 V
A1C17	10001-4	Ceramic 22 pF ±5% 1000 V
A1C18	10000-10	Ceramic 0.1 µF +80%-20% 100 V
A1C19	10000-10	Ceramic 0.1 µF +80%-20% 100 V
A1C20	10000-5	Ceramic .0022 µF ±20% 500V
*A1C21	10000-11	Ceramic .01 µF ±20% 100 V
*A1C22	10001-6	Ceramic 47 pF ±5% 1000 V
*A1C23	10001-6	Ceramic 47 pF ±5% 1000 V
*A1C24	10000-11	Ceramic .01 µF ±20% 100 V
*A1C25	10001-13	Ceramic 12 pF ±5% 1000 V
*A1C26	10000-12	Ceramic 150 pF ±20% 1000 V
A1C27	10000-10	Ceramic 0.1 µF ±80%-20% 100 V
A1C28	10000-11	Ceramic .01 µF ±20% 100 V
A1C29	10630-2	Variable 9-35 pF NPO
A1C30	10000-4	Ceramic .001 µF ±20% 1000 V
A1C31	10000-11	Ceramic .01 µF ±20% 100 V
A1C32	10000-10	Ceramic 0.1 µF +80%-20% 100 V
A1C33	10000-11	Ceramic .01 µF ±20% 100 V
A1C34	10001-16	Ceramic 120 pF ±5% 1000 V
A1C35	10001-6	Ceramic 47 pF ±5% 1000 V
A1C36	10000-11	Ceramic .01 µF ±20% 100 V
A1C37	10000-1	Ceramic 100 pF ±20% 1000 V
A1C38	10585-3	Ceramic 470 pF ±5% 1000 V
A1C39	10001-5	Ceramic 33 pF ±5% 1000 V
A1C40	10000-1	Ceramic 100 pF ±20% 1000 V
A1C41	10000-11	Ceramic .01 µF ±20% 100 V
A1C42	10001-16	Ceramic 120 pF ±5% 1000 V

CIRCUIT REFERENCE	PART NO.	DESCRIPTION
A1C43	10001-3	Ceramic 10 pF ±5% 1000 V
A1C44	10001-7	Ceramic 100 pF ±5% 1000 V
A1C45	10630-2	Variable 9-35 pF NPO
A1C46	10000-4	Ceramic .001 µF ±20% 1000 V
A1C47	10001-7	Ceramic 100 pF ±5% 1000 V
A1C48	10001-17	Ceramic 82 pF ±5% 1000 V
A1C49	--	Factory Selected Value
A1C50	10001-15	Ceramic 150 pF ±5% 1000 V
A1C51	10001-8	Ceramic 15 pF ±5% 1000 V
A1C52	10001-6	Ceramic 47 pF ±5% 1000 V
A1C53	--	Factory Selected Value
*A1C54	10001-3	Ceramic 10 pF ±5% 1000 V
*A1C55	10001-3	Ceramic 10 pF ±5% 1000 V
A1CR1	10043	1N4148
A1CR2	10043	1N4148
*A1CR3	10043	1N4148
*A1CR4	10043	1N4148
*A1CR5	10043	1N4148
A1CR6	10043	1N4148
A1CR7	10043	1N4148
*A1CR8	10043	1N4148
*A1CR9	10043	1N4148
*A1CR10	10043	1N4148
*A1CR11	10043	1N4148
*A1CR12	10043	1N4148
*A1CR13	10043	1N4148
*A1CR14	10043	1N4148
*A1CR15	10043	1N4148
*A1CR16	10043	1N4148
*A1CR17	10043	1N4148
*A1CR18	10043	1N4148
A1CR19	10043	1N4148
A1CR20	10043	1N4148
A1CR21	10043	1N4148
*A1J1	10140-1	Test Jack, Red
*A1J2	10140-2	Test Jack, Yellow
A1J3	10140-3	Test Jack, Black
*A1J4	10140-2	Test Jack, Yellow
A1J5	10140-2	Test Jack, Yellow
A1J6	10140-2	Test Jack, Yellow
A1J7	10140-2	Test Jack, Yellow
A1L1	12722	Coil, RF
A1L2	12723	Coil, RF W/Center Tap
A1L3	10631-11	Coil, RF .33 µH ±10%
A1L4	10631-11	Coil, RF .33 µH ±10%
*A1Q1	10018	2N3646
*A1Q2	10019	2N3565
*A1Q3	11119	2N4250
A1Q4	11507	TIS97
A1Q5	10018	2N3646
A1Q6	10018	2N3646
*A1Q7	10018	2N3646
A1Q8	10021	2N3563
A1Q9	11119	2N4250
A1Q10	11531	2N2218
A1Q11	10398	2N4121
*A1R1	10015-60	Metal Film 19.6 KΩ ±1% 1/8 W
*A1R2	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
*A1R3	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
*A1R4	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
*A1R5	10013-51	Carbon Film 150 KΩ ±5% 1/4 W
*A1R6	10013-13	Carbon Film 100 Ω ±5% 1/4 W

CIRCUIT REFERENCE	PART NO.	DESCRIPTION
*A1R7	10013-27	Carbon Film 1.5 KΩ ±5% 1/4 W
*A1R8	10013-51	Carbon Film 150 KΩ ±5% 1/4 W
*A1R9	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
*A1R10	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
*A1R11	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
*A1R12	10013-35	Carbon Film 6.8 KΩ ±5% 1/4 W
A1R13	10015-7	Metal Film 10.0 KΩ ±1% 1/8 W
A1R14	10015-108	Metal Film 191 KΩ ±1% 1/8 W
A1R15	10015-108	Metal Film 191 KΩ ±1% 1/8 W
A1R16	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A1R17	10015-61	Metal Film 39.2 KΩ ±1% 1/8 W
A1R18	10015-15	Metal Film 21.5 KΩ ±1% 1/8 W
A1R19	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A1R20	10015-9	Metal Film 17.8 KΩ ±1% 1/8 W
A1R21	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A1R22	10015-133	Metal Film 49.9 KΩ ±1% 1/8 W
A1R23	11485-11	Metal Film 2.50 KΩ ±0.1% 1/8 W
A1R24	12449-1	Metal Film 171.2 Ω ±0.1% 1/8 W
*A1R25	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
*A1R26	10013-41	Carbon Film 22 KΩ ±5% 1/4 W
*A1R27	10013-31	Carbon Film 3.3 KΩ ±5% 1/4 W
*A1R28	12449-11	Metal Film 87.04 KΩ ±0.1% 1/8 W
A1R29	10013-1	Carbon Film 10 Ω ±5% 1/4 W
*A1R30	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
*A1R31	12449-8	Metal Film 30.58 KΩ ±0.1% 1/8 W
A1R32	10013-1	Carbon Film 10 Ω ±5% 1/4 W
*A1R33	12449-11	Metal Film 87.04 KΩ ±0.1% 1/8 W
*A1R34	12449-8	Metal Film 30.58 KΩ ±0.1% 1/8 W
A1R35	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A1R36	10013-61	Carbon Film 1 MΩ ±5% 1/4 W
A1R37	10013-30	Carbon Film 2.7 KΩ ±5% 1/4 W
A1R38	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A1R39	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A1R40	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A1R41	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A1R42	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
*A1R43	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
*A1R44	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
*A1R45	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A1R46	10013-51	Carbon Film 150 KΩ ±5% 1/4 W
A1R47	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A1R48	10013-61	Carbon Film 1 MΩ ±5% 1/4 W
*A1R49	12449-5	Metal Film 7.621 KΩ ±0.1% 1/8 W
*A1R50	12449-7	Metal Film 15.252 KΩ ±0.1% 1/8 W
*A1R51	12449-8	Metal Film 30.58 KΩ ±0.1% 1/8 W
*A1R52	12449-10	Metal Film 61.25 KΩ ±0.1% 1/8 W
*A1R53	12449-12	Metal Film 122.68 KΩ ±0.1% 1/8 W
*A1R54	10015-102	Metal Film 249 KΩ ±1% 1/8 W
*A1R55	10015-45	Metal Film 499 KΩ ±1% 1/8 W
*A1R56	10015-45	Metal Film 499 KΩ ±1% 1/8 W
*A1R57	10015-45	Metal Film 499 KΩ ±1% 1/8 W
*A1R58	10015-45	Metal Film 499 KΩ ±1% 1/8 W
*A1R59	10015-45	Metal Film 499 KΩ ±1% 1/8 W
*A1R60	10015-45	Metal Film 499 KΩ ±1% 1/8 W
*A1R61	10015-45	Metal Film 499 KΩ ±1% 1/8 W
*A1R62	10013-68	Carbon Film 3.9 MΩ ±5% 1/4 W
*A1R63	12449-4	Metal Film 2.681 KΩ ±0.1% 1/8 W
*A1R64	12449-2	Metal Film 681.0 Ω ±0.1 % 1/8 W
*A1R65	10015-15	Metal Film 21.5 KΩ ±1% 1/8 W
*A1R66	10013-9	Carbon Film 47 Ω ±5% 1/4 W
*A1R67	12449-3	Metal Film 1.8311 KΩ ±0.1% 1/8 W
*A1R68	12449-18	Metal Film 7.50 KΩ ±0.1% 1/8 W
*A1R69	12449-21	Metal Film 10.0 KΩ ±0.1% 1/8 W
*A1R70	12449-18	Metal Film 7.50 KΩ ±0.1% 1/8 W
*A1R71	12449-6	Metal Film 13.617 KΩ ±0.1% 1/8 W
*A1R72	12449-9	Metal Film 37.647 KΩ ±0.1% 1/8 W
*A1R73	10013-9	Carbon Film 47 Ω ±5% 1/4 W
A1R74	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A1R75	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A1R76	10013-25	Carbon Film 1 KΩ ±5% 1/4 W

CIRCUIT REFERENCE	PART NO.	DESCRIPTION
A1R77	10046-10	Variable Comp 100 KΩ ±20% 1/4 W
A1R78	10013-65	Carbon Film 2.2 MΩ ±5% 1/4 W
A1R79	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A1R80	10013-31	Carbon Film 3.3 KΩ ±5% 1/4 W
A1R81	10013-31	Carbon Film 3.3 KΩ ±5% 1/4 W
A1R82	10013-47	Carbon Film 68 KΩ ±5% 1/4 W
A1R83	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A1R84	10015-85	Metal Film 287 KΩ ±1% 1/8 W
A1R85	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A1R86	10013-43	Carbon Film 33 KΩ ±5% 1/4 W
A1R87	10013-5	Carbon Film 22 Ω ±5% 1/4 W
A1R88	10015-54	Metal Film 110 KΩ ±1% 1/8 W
A1R89	10015-183	Metal Film 80.6 KΩ ±1% 1/8 W
A1R90	10015-19	Metal Film 1.00 KΩ ±1% 1/8 W
A1R91	10015-3	Metal Film 49.9 Ω ±1% 1/8 W
A1R92	10015-143	Metal Film 71.5 Ω ±1% 1/8 W
A1R93	10015-144	Metal Film 95.3 Ω ±1% 1/8 W
A1R94	10015-144	Metal Film 95.3 Ω ±1% 1/8 W
A1R95	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A1R96	10013-17	Carbon Film 220 Ω ±5% 1/4 W
A1S1	12430	Switch, Slide DPDT
A1S2	12430	Switch, Slide DPDT
*A1U1	11627	LM301A (National Semiconductor)
A1U2	11627	LM301A (National Semiconductor)
*A1U3	11627	LM301A (National Semiconductor)
*A1U4	11627	LM301A (National Semiconductor)
A1U5	11627	LM301A (National Semiconductor)
*A1U6	11270-1	SN7400N
*A1U7	12480	711C
*A1U8	11270-8	SN7473N
*A1U9	11270-11	SN7493N
*A1U10	11270-11	SN7493N
*A1U11	11270-8	SN7473N
*A1U12	11118	CA3039 (RCA)
*A1U13	11118	CA3039 (RCA)
*A1U14	11627	LM301A (National Semiconductor)
*A1U15	11627	LM301A (National Semiconductor)
*A1U16	11627	LM301A (National Semiconductor)

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CIRCUIT REFERENCE	PART NO.	DESCRIPTION
A2C1	10001-5	Ceramic 33 pF ±5% 1000 V
A2C2	--	Not Used
A2C3	11501-2	Ceramic 0.1 μF ±20% 50 V
A2C4	11501-2	Ceramic 0.1 μF ±20% 50 V
A2C5	--	Not Used
A2C6	10000-5	Ceramic .0022 μF ±5% 500 V
A2C7	10000-10	Ceramic 0.1 μF +80% - 20% 100 V
A2C8	10000-10	Ceramic 0.1 μF +80% - 20% 100 V
A2C9	10000-4	Ceramic .001 μF ±20% 1000 V
A2C10	10787-2	Tantalum 12 μF ±20% 15 V
A2C11	10787-2	Tantalum 12 μF ±20% 15 V
A2C12	10787-3	Tantalum 27 μF ±20% 25 V
A2C13	10787-3	Tantalum 27 μF ±20% 25 V
A2C14	10787-3	Tantalum 27 μF ±20% 25 V
A2C15	10787-3	Tantalum 27 μF ±20% 25 V
A2C16	10787-2	Tantalum 12 μF ±20% 15 V
A2C17	10787-2	Tantalum 12 μF ±20% 15 V
A2C18	10007-7	Mylar 0.1 μF ±10% 200 V
A2C19	10000-11	Ceramic .01 μF ±20% 100 V
A2C20	10000-11	Ceramic .01 μF ±20% 100 V
A2C21	10000-1	Ceramic 100 pF ±20% 1000 V
A2C22	10000-11	Ceramic .01 μF ±20% 100 V
A2C23	10000-11	Ceramic .01 μF ±20% 100 V
A2C24	10000-4	Ceramic .001 μF ±20% 1000 V
A2C25	10007-5	Mylar .022 μF ±10% 200 V

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
A2C26	10007-1	Mylar .001 µF ±10% 200 V
A2C27	10787-5	Tantalum 1.0 µF ±20% 15 V
A2C28	10000-11	Ceramic .01 µF ±20% 100 V
A2C29	10000-11	Ceramic .01 µF ±20% 100 V
A2C30	10001-12	Ceramic 3.3 pF ±5% 1000 V
A2C31	10007-5	Mylar .022 µF ±10% 200 V
A2C32	10000-12	Ceramic 150 pF ±20% 1000 V
A2C33	10787-4	Tantalum 68 µF ±20% 15 V
A2C34	10007-9	Mylar 0.47 µF ±10% 200 V
A2C35	10000-11	Ceramic .01 µF ±20% 100 V
A2C36	10000-11	Ceramic .01 µF ±20% 100 V
A2C37	10001-5	Ceramic 33 pF ±5% 1000 V
A2C38	10000-4	Ceramic .001 µF ±20% 1000 V
A2C39	10000-11	Ceramic .01 µF ±20% 100 V
A2C40	10000-11	Ceramic .01 µF ±20% 100 V
A2C41	10000-3	Ceramic 470 pF ±20% 1000 V
A2C42	10000-11	Ceramic .01 µF ±20% 100 V
A2C43	10000-11	Ceramic .01 µF ±20% 100 V
A2C44	10000-6	Ceramic .0047 µF ±20% 500 V
A2C45	11501-4	Ceramic 1.0 pF ±10% 100V
A2C46	--	Not Used
A2C47	10007-7	Mylar 0.1 µF ±10% 200 V
A2C48	10000-4	Ceramic .001 µF ±20% 1000 V
A2C49	10007-7	Mylar 0.1 µF ±10% 200 V
A2C50	10007-7	Mylar 0.1 µF ±10% 200 V
A2C51	10000-4	Ceramic .001 µF ±20% 1000 V
A2C52	10001-2	Ceramic 4.7 pF ±5% 1000 V
A2C53	--	Factory Selected
A2C54	10001-2	Ceramic 4.7 pF ±5% 1000 V
A2C55	10630-1	Variable Ceramic NPO 2-8 pF
A2C56	10000-1	Ceramic 100 pF ±20% 1000 V
A2C57	10000-2	Ceramic 220 pF ±20% 1000 V
A2C58	10007-7	Mylar 0.1 µF ±10% 200 V
A2C59	10001-3	Ceramic 10 pF ±5% 1000 V
A2C60	10000-11	Ceramic .01 µF ±20% 100 V
A2C61	10000-11	Ceramic .01 µF ±20% 100 V
A2C62	10909-5	Mica .0047 µF ±1% 500 V
A2C63	10909-4	Mica .0024 µF ±1% 500 V
A2C64	10909-4	Mica .0024 µF ±1% 500 V
A2C65	10007-6	Mylar .047 µF ±10% 200 V
A2C66	10007-5	Mylar .022 µF ±10% 200 V
A2C67	10787-3	Tantalum 27 µF ±20% 15 V
A2C68	10000-6	Ceramic .0047 µF ±20 % 500 V
A2C69	10909-5	Mica .0047 µF ±1% 500 V
A2C70	10011-2	Mylar 1.0 µF ±10% 100 V
A2C71	10011-2	Mylar 1.0 µF ±10% 100 V
A2C72	11501-2	Ceramic 0.1 µF ±20% 50 V
A2C73	11501-2	Ceramic 0.1 µF ±20% 50 V
A2C74	10000-6	Ceramic .0047 µF ±20% 500 V
A2C75	10000-4	Ceramic .001 µF ±20% 1000 V
A2C76	10000-6	Ceramic .0047 µF ±20% 500 V
A2C77	10001-2	Ceramic 220pF ±5% 1000 V
A2CR1	10043	1N4148
A2CR2	11715	1N4446
A2CR3	11715	1N4446
A2CR4	11715	1N4446
A2CR5	11715	1N4446
A2CR6	10045	1N823
A2CR7	10045	1N823
A2CR8	--	Not Used
A2CR9	10043	1N4148
A2CR10	10043	1N4148
A2CR11	10043	1N4148
A2CR12	--	Not Used
A2CR13	10043	1N4148

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
A2J1	10140-2	Test Jack, Yellow
A2J2	10140-2	Test Jack, Yellow
A2J3	10140-3	Test Jack, Black
A2J4	10140-1	Test Jack, Red
A2J5	10140-4	Test Jack, Blue
A2J6	10140-2	Test Jack, Yellow
A2J7	10140-2	Test Jack, Yellow
A2J8	10140-3	Test Jack, Black
A2J9	10140-2	Test Jack, Yellow
A2J10	10140-2	Test Jack, Yellow
A2J11	10140-2	Test Jack, Yellow
A2L1	10920-1	Coil, RF 100 µH ±10%
A2Q1	11507	T1S97
A2Q2	12439	2N5785
A2Q3	10206	2N3053
A2Q4	10206	2N3053
A2Q5	10896	3N138
A2Q6	10896	3N138
A2Q7	11432	2N3955
A2Q8	13533	2N2907
A2Q9	10018	2N3646
A2Q10	13534	2N2221
A2Q11	11585	T1S59
A2Q12	10018	2N3646
A2Q13	13533	2N2907
A2Q14	10896	3N138
A2Q15	10896	3N138
A2Q16	11119	2N4250
A2Q17	11507	T1S97
A2Q18	11507	T1S97
A2Q19	10019	2N3565
A2Q20	10019	2N3565
A2R1	10015-102	Metal Film 249 KΩ ±1% 1/8 W
A2R2	10015-102	Metal Film 249 KΩ ±1% 1/8 W
A2R3	10015-102	Metal Film 249 KΩ ±1% 1/8 W
A2R4	10015-102	Metal Film 249 KΩ ±1% 1/8 W
A2R5	10046-1	Variable Comp 500 Ω ±20% 1/4 W
A2R6	10015-7	Metal Film 10.0 KΩ ±1% 1/8 W
A2R7	10015-213	Metal Film 178 KΩ ±1% 1/8 W
A2R8	10046-10	Variable Comp 100 KΩ ±20% 1/4 W
A2R9	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R10	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R11	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A2R12	10015-7	Metal Film 10.0 KΩ ±1% 1/8 W
A2R13	10013-21	Metal Film 470 Ω ±5% 1/4 W
A2R14	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A2R15	10015-114	Metal Film 75.0 K ±1% 1/8 W
A2R16	--	Not Used
A2R17	10015-28	Metal Film 23.7 KΩ ±1% 1/8 W
A2R18	10013-35	Carbon Film 6.8 KΩ ±5% 1/4 W
A2R19	10013-51	Carbon Film 150 KΩ ±5% 1/4 W
A2R20	10013-39	Carbon Film 15 KΩ ±5% 1/4 W
A2R21	10013-27	Carbon Film 1.5 KΩ ±5% 1/4 W
A2R22	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A2R23	10013-5	Carbon Film 22 Ω ±5% 1/4 W
A2R24	10013-5	Carbon Film 22 Ω ±5% 1/4 W
A2R25	10013-47	Carbon Film 68 KΩ ±5% 1/4 W
A2R26	10013-17	Carbon Film 220 Ω ±5% 1/4 W
A2R27	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A2R28	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A2R29	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A2R30	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A2R31	--	Not Used
A2R32	--	Not Used
A2R33	10015-143	Metal Film 71.5 Ω ±1% 1/8 W
A2R34	10015-133	Metal Film 49.9 KΩ ±1% 1/8 W

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
A2R35	10013-49	Carbon Film 100 K ±5% 1/4 W
A2R36	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A2R37	10013-53	Carbon Film 220 KΩ ±5% 1/4 W
A2R38	10046-10	Variable Comp 100 KΩ ±20% 1/4 W
A2R39	10015-13	Metal Film 100 KΩ ±1% 1/8 W
A2R40	10015-183	Metal Film 80.6 KΩ ±1% 1/8 W
A2R41	10015-183	Metal Film 80.6 KΩ ±1% 1/8 W
A2R42	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R43	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R44	10046-8	Variable Comp 10 KΩ ±20% 1/4 W
A2R45	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A2R46	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A2R47	10015-65	Metal Film 4.99 KΩ ±1% 1/8 W
A2R48	11711-3	Variable Comp 20 KΩ ±20% 1/4 W
A2R49	10015-213	Metal Film 178 KΩ ±1% 1/8 W
A2R50	--	Factory Selected
A2R51	10015-170	Metal Film 348 Ω ±1% 1/8 W
A2R52	10013-31	Carbon Film 3.3 KΩ ±5% 1/4 W
A2R53	10015-209	Metal Film 130 KΩ ±1% 1/8 W
A2R54	10046-1	Variable Comp 500 Ω ±20% 1/4 W
A2R55	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R56	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R57	10013-21	Carbon Film 470 Ω ±5% 1/4 W
A2R58	10015-58	Metal Film 9.76 KΩ ±1% 1/8 W
A2R59	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A2R60	10013-61	Carbon Film 1 MΩ ±5% 1/4 W
A2R61	10013-41	Carbon Film 22 KΩ ±5% 1/4 W
A2R62	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R63	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R64	10013-11	Carbon Film 68 Ω ±5% 1/4 W
A2R65	10013-61	Carbon Film 1 MΩ ±5% 1/4 W
A2R66	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A2R67	10013-55	Carbon Film 330 KΩ ±5% 1/4 W
A2R68	10013-55	Carbon Film 330 KΩ ±5% 1/4 W
A2R69	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R70	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R71	10015-31	Metal Film 3.16 KΩ ±1% 1/8 W
A2R72	10015-71	Metal Film 909 Ω ±1% 1/8 W
A2R73	10015-7	Metal Film 10.0 KΩ ±1% 1/8 W
A2R74	- -	Factory Selected
A2R75	10015-13	Metal Film 100 KΩ ±1% 1/8 W
A2R76	10015-73	Metal Film 10.2 KΩ ±1% 1/8 W
A2R77	10015-99	Metal Film 14.0 KΩ ±1% 1/8 W
A2R78	10015-19	Metal Film 1.00 KΩ ±1% 1/8 W
A2R79	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R80	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R81	10015-63	Metal Film 402 KΩ ±1% 1/8 W
A2R82	10015-85	Metal Film 287 KΩ ±1% 1/8 W
A2R83	10015-96	Metal Film 12.1 KΩ ±1% 1/8 W
A2R84	10015-120	Metal Film 69.8 KΩ ±1% 1/8 W
A2R85	10015-191	Metal Film 66.5 KΩ ±1% 1/8 W
A2R86	10015-191	Metal Film 66.5 KΩ ±1% 1/8 W
A2R87	10013-61	Carbon Film 1 MΩ ±5% 1/4 W
A2R88	10015-191	Metal Film 66.5 KΩ ±1% 1/8 W
A2R89	--	Not Used
A2R90	--	Not Used
A2R91	--	Not Used
A2R92	10013-73	Carbon Film 10 MΩ ±5% 1/4 W
A2R93	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A2R94	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A2R95	10013-41	Carbon Film 22 KΩ ±5% 1/4 W
A2R96	10015-61	Metal Film 39.2 KΩ ±1% 1/8 W
A2R97	10015-61	Metal Film 39.2 KΩ ±1% 1/8 W
A2R98	10013-41	Carbon Film 22 KΩ ±5% 1/4 W
A2R99	10013-51	Carbon Film 150 KΩ ±5% 1/4 W
A2R100	10013-51	Carbon Film 150 KΩ ±5% 1/4 W
A2R101	10015-91	Metal Film 90.9 KΩ ±1% 1/8 W
A2R102	10015-91	Metal Film 90.9 KΩ ±1% 1/8 W
A2R103	10013-27	Carbon Film 1.5 KΩ ±5% 1/4 W
A2R104	10015-32	Metal Film 3.83 KΩ ±1% 1/8 W

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
A2R105	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R106	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R107	10031-17	Carbon Film 220 Ω ±5% 1/4 W
A2R108	10142-2	Carbon Film 15 MΩ ±5% 1/4 W
A2R109	10015-84	Metal Film 2.10 KΩ ±1% 1/8 W
A2R110	10015-191	Metal Film 66.5 KΩ ±1% 1/8 W
A2R111	10015-191	Metal Film 66.5 KΩ ±1% 1/8 W
A2R112	10015-188	Metal Film 33.2 KΩ ±1% 1/8 W
A2R113	10013-59	Carbon Film 680 KΩ ±5% 1/4 W
A2R114	10015-22	Metal Film 10.7 KΩ ±1% 1/8 W
A2R115	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A2R116	10015-41	Metal Film 48.7 KΩ ±1% 1/8 W
A2R117	10015-22	Metal Film 10.7 KΩ ±1% 1/8 W
A2R118	10013-61	Carbon Film 1 MΩ ±5% 1/4 W
A2R119	10013-61	Carbon Film 1 MΩ ±5% 1/4 W
A2R120	10013-37	Carbon Film 10 K ±5% 1/4 W
A2R121	10015-54	Metal Film 110KΩ ±1% 1/8 W
A2R122	--	Factory Selected
A2R123	10015-179	Metal Film 140KΩ ±1% 1/8 W
A2R124	10015-32	Metal Film 3.83 KΩ ±1% 1/8 W
A2R125	10015-80	Metal Film 4.02 KΩ ±1% 1/8 W
A2R126	10015-40	Metal Film 43.2 KΩ ±1% 1/8 W
A2R127	10015-80	Metal Film 4.02 KΩ ±1% 1/8 W
A2R128	10015-25	Metal Film 61.9 KΩ ±1% 1/8 W
A2R129	10015-25	Metal Film 61.9 KΩ ±1% 1/8 W
A2R130	10046-10	Variable Comp 100 KΩ ±20% 1/4 W
A2R131	10015-133	Metal Film 49.9 KΩ ±1% 1/8 W
A2R132	10013-53	Carbon Film 220KΩ±5% 1/4 W
A2R133	10015-70	Metal Film 681 Ω ±1% 1/8 W
A2R134	10013-61	Metal Film 1 MΩ ±1% 1/4 W
A2R135	10013-61	Metal Film 1 MΩ ±1% 1/4 W
A2R136	10015-159	Metal Film 402 Ω ±1% 1/8 W
A2R137	10015-80	Metal Film 4.02 KΩ ±1% 1/8 W
A2R138	10046-6	Variable Comp 200 Ω ±20% 1/4 W
A2R139	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A2R140	10013-21	Carbon Film 470 Ω ±5% 1/4 W
A2R141	10013-55	Carbon Film 330 KΩ ±5% 1/4 W
A2R142	10013-49	Carbon Film 100 KΩ ±5% 1/4 W
A2R143	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R144	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R145	10013-17	Carbon Film 220 Ω ±5% 1/4 W
A2R146	10013-5	Carbon Film 22 Ω ±5% 1/4 W
A2R147	10013-13	Carbon Film 100 Ω ±5% 1/4 W
A2R148	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A2R149	10015-80	Metal Film 4.02 KΩ ±1% 1/8 W
A2R150	10046-13	Variable Comp 1 MΩ ±20% 1/4 W
A2R151	10015-158	Metal Film 392 Ω ±1% 1/8 W
A2RT1	10209	Thermistor 100 KΩ
A2T1	12468	Transformer
A2T2	12260	Transformer, Transistor
A2U1	11627	LM301A (National Semiconductor)
A2U2	11539	741C
A2U3	11539	741C
A2U4	11539	741C
A2U5	11539	741C
A2U6	11627	LM301A (National Semiconductor)
A2U7	11627	LM301A (National Semiconductor)
A2U8	11539	741C
A2U9	11539	741C
A2U10	10769	709C
A2U11	11117	CA3026 (RCA)
A2U12	12445	725C

PART NO. CROSS REFERENCE

PM PART NO.	MFGR. CODE	MFGR. PART NO.
10000-1	56289	5GA-T10
10000-2	56289	5GA-T22
10000-3	56289	5GA-T47
10000-4	56289	5GA-D10
10000-5	56289	5GA-D22
10000-6	56289	5GAB-D47
10000-10	91418	Type TA 0.1 μF
10000-11	72989	805-000-X5VD-103Z
10000-12	56289	5GA-T15
10001-2	56289	10TCC-V47
10001-3	56289	10TCC-Q10
10001-4	56289	10TCC-Q22
10001-5	56289	10TCC-Q33
10001-6	56289	10TCC-Q47
10001-7	56289	10TCC-T10
10001-8	56289	10TCC-Q15
10001-11	56289	10TCC-Q25
10001-12	56289	10TCC-V33
10001-13	56289	10TCC-Q12
10001-15	56289	10TCC-T15
10001-16	56289	10TCC-T12
10001-17	56289	10TCC-Q82
10007-1	01002	75F1R2A 102
10007-5	01002	75F1R2A 223
10007-6	01002	75F1R2A 473
10007-7	01002	75F1R2A 104
10007-9	01002	75F1R2A 474
10011-2	27556	ZA1652K
10013-1	73445	B803104NB 100
10013-5	73445	B803104NB 220
10013-9	73445	B803104NB 470
10013-11	73445	B803104NB 680
10013-13	73445	B803104NB 101
10013-17	73445	B803104NB 221
10013-21	73445	B803104NB 471
10013-25	73445	B803104NB 102
10013-27	73445	B803104NB 152
10013-29	73445	B803104NB 222
10013-30	73445	B803104NB 272
10013-31	73445	B803104NB 332
10013-33	73445	B803104NB 472
10013-35	73445	B803104NB 682
10013-37	73445	B803104NB 103
10013-39	73445	B803104NB 153
10013-41	73445	B803104NB 223
10013-43	73445	B803104NB 333
10013-47	73445	B803104NB 683
10013-49	73445	B803104NB 104
10013-51	73445	B803104NB 154
10013-53	73445	B803104NB 224
10013-55	73445	B803104NB 334
10013-57	73445	B803104NB 474
10013-59	73445	B803104NB 684
10013-61	73445	B803104NB 105

PART NO. CROSS REFERENCE

PM PART NO.	MFGR. CODE	MFGR. PART NO.
10013-65	01121	CB 2255
10013-68	01121	CB 3955
10013-73	01121	CB 1065
10015-3	91637	RN55D 49.9 Ω 1%
10015-7	91637	RN55D 10.0 KΩ 1%
10015-9	91637	RN55D 17.8 KΩ 1%
10015-13	91637	RN55D 100 KΩ 1%
10015-15	91637	RN55D 21.5 KΩ 1%
10015-19	91637	RN55D 1.00 KΩ 1%
10015-22	91637	RN55D 10.7 KΩ 1%
10015-25	91637	RN55D 61.9 KΩ 1%
10015-28	91637	RN55D 23.7 KΩ 1%
10015-31	91637	RN55D 3.16 KΩ 1%
10015-32	91637	RN55D 3.83 KΩ 1%
10015-34	91637	RN55D 162 KΩ 1%
10015-37	91637	RN55D 25.5 KΩ 1%
10015-40	91637	RN55D 43.2 KΩ 1%
10015-41	91637	RN55D 48.7 KΩ 1%
10015-45	91637	RN55D 499 KΩ 1%
10015-54	91637	RN55D 110 KΩ 1%
10015-58	91637	RN55D 9.76 KΩ 1%
10015-60	91637	RN55D 19.6 KΩ 1%
10015-61	91637	RN55D 39.2 KΩ 1%
10015-63	91637	RN55D 402 KΩ 1%
10015-65	91637	RN55D 4.99 KΩ 1%
10015-70	91637	RN55D 681 Ω 1%
10015-71	91637	RN55D 909 Ω 1%
10015-73	91637	RN55D 10.2 KΩ 1%
10015-74	91637	RN55D 2.00 KΩ 1%
10015-80	91637	RN55D 4.02 KΩ 1%
10015-84	91637	RN55D 2.10 KΩ 1%
10015-85	91637	RN55D 287 KΩ 1%
10015-91	91637	RN55D 90.9 KΩ 1%
10015-96	91637	RN55D 121 KΩ 1%
10015-99	91637	RN55D 14.0 KΩ 1%
10015-101	91637	RN55D 20.5 KΩ 1%
10015-102	91637	RN55D 249 KΩ 1%
10015-108	91637	RN55D 191 KΩ 1%
10015-114	91637	RN55D 75.0 KΩ 1%
10015-120	91637	RN55D 69.8 KΩ 1%
10015-133	91637	RN55D 49.9 KΩ 1%
10015-143	91637	RN55D 71.5 Ω 1%
10015-144	91637	RN55D 95.3 Ω 1%
10015-159	91637	RN55D 402 Ω 1%
10015-170	91637	RN55D 348 Ω 1%
10015-183	91637	RN55D 80.6 KΩ 1%
10015-188	91637	RN55D 33.2 KΩ 1%
10015-191	91637	RN55D 66.5 KΩ 1%
10015-209	91637	RN55D 130 KΩ 1%
10015-213	91637	RN55D 178 Ω 1%
10018	07263	2N3646
10019	07263	2N3565
10021	07263	2N3563

PART NO. CROSS REFERENCE

PART NO.	MFGR. CODE	MFGR. PART NO.
10023	07263	2N3644
10043	09214	1N4148
10045	07910	1N823
10046-1	71450	X201R501B
10046-6	71450	X201R201B
10046-8	71450	X201R103B
10046-10	71450	X201R104B
10046-13	71450	X201R105B
10048	02660	31-221-1050
10140-1	74970	105852
10140-2	74970	105857
10140-3	74970	105853
10140-4	74970	105860
10142-2	01121	CB1565
10142-4	01121	CB2265
10206	07263	2N3053
10209	90634	51RD21
10398	07263	2N4121
10585-2	56289	CO28B102 F331J
10585-3	56289	CO28B102 G471J
10630-1	72982	538-011 A 2-8
10630-2	72982	538-001 D9-35 pF
10631-11	99800	9230-08
10769	04713	MC1709CB
10787-2	12954	D12GSB 20K
10787-3	12954	D27GSC 15K
10787-4	12954	D68GSC 15K
10787-5	12954	D1ROGSA 15K
10787-6	12954	D2R7GSA 15K
10896	02735	3N138
10909-4	04062	DM 19F 242F-500V 1%
10909-5	04062	DM 19F 472F-500V 1%
10920-1	99800	2890-42
11117	02735	CA3026
11118	02735	CA3039
11119	07263	2N4250
11270-1	01295	SN7400N
11270-8	01295	SN7473N
11270-11	01295	SN7493N
11413	02660	82-5377
11432	27014	2N3955
11485-11	14298	REA C2, 2500 Ω 0.1%
11485-15	14298	REA C2, 10.00 KΩ 0.1%
11501-2	72982	8131-050-651-104M

PART NO. CROSS REFERENCE

PART NO.	MFGR. CODE	MFGR. PART NO.
11501-4	72982	8131-050-651-100
11507	01295	TIS 97
11531	04713	2N2218
11539	07263	U5B7741393
11585	01295	TIS 59
11627	27014	LM301AH
11676-1	01121	WA1G012S104 MZ
11711-3	73138	66 WR
11715	09214	1N4446
12260	81095	SP-66
12430	95146	MSS-2220
12439	02735	2N5785
12445	27014	LM725 CH
12449-1	14298	EE 1/8 C2 171.2 Ω 0.1%
12449-2	14298	EE 1/8 C2 681.0 Ω 0.1%
12449-3	14298	EE 1/8 C2 1.831 KΩ 0.1%
12449-4	14298	EE 1/8 C2 2.681 KΩ 0.1%
12449-5	14298	EE 1/8 C2 7.621 KΩ 0.1%
12449-6	14298	EE 1/8 C2 13.617 KΩ 0.1%
12449-7	14298	EE 1/8 C2 15.252 KΩ 0.1%
12449-8	14298	EE 1/8 C2 30.58 KΩ 0.1%
12449-9	14298	EE 1/8 C2 37.647 KΩ 0.1%
12449-10	14298	EE 1/8 C2 61.25 KΩ 0.1%
12449-11	14298	EE 1/8 C2 87.04 KΩ 0.1%
12449-12	14298	EE 1/8 C2 122.68 KΩ 0.1%
12449-18	14298	EE 1/8 C2 7.50 KΩ 0.1%
12468	28821	12468
12476	71590	009-605
12480	27014	LM711CH
12564	82389	57HA3F
12673	83330	8655
12714	83330	8634
12722	28821	12722
12723	28821	12723
13118	71590	13118
13533	04713	2N2907
13534	04713	2N2221

FEDERAL SUPPLY CODE FOR MANUFACTURERS

The following five-digit code numbers are listed in numerical sequence along with the manufacturer's name and address to which the code has been assigned.

The Federal Supply Code has been taken from Cataloging Handbook H 4-2, Code to Name.

00303	Shelly Associates Inc. El Segundo, California.
00656	Aerovox Corp. New Bedford, Massachusetts
00779	AMP Inc. Harrisburg, Pennsylvania
01002	General Electric Co. Capacitor Dept. Hudson Falls, New York
01121	Allen-Bradley Co. Milwaukee, Wisconsin
01295	Texas Instruments, Inc. Semiconductor Components Div. Dallas, Texas
01961	Pulse Engineering Inc. Santa Clara, California
02114	Ferroxcube Corp. of America Saugerties, New York
02660	Amphenol-Borg Elect. Corp. Broadview, Illinois
02735	Radio Corp. of America Semiconductor and Materials Div. Somerville, New Jersey
04062	Elmenco Products Co. New York, N.Y.
04713	Motorola, Inc. Semiconductor Products Div. Phoenix, Arizona
07263	Fairchild Camera and Inst. Corp. Semiconductor Div. Mountain View, California
07910	Continental Device Corp. Hawthorne, California
09214	General Electric Co. Semiconductor Products Dept. Auburn, New York
09353	C and K Components Inc. Newton, Massachusetts
11711	General Instruments Inc. Semiconductor Div. Newark, New Jersey
12674	Syncro Corp. Hicksville, Ohio
12954	Dickson Electronics Corp. Scottsdale, Arizona
14298	American Components, Inc. Conshohocken, Pennsylvania
18324	Signetics Corp. Sunnyvale, Calif.
24931	Speciality Connector Co. Inc. Indianapolis, Indiana
25088	Siemens America Corp. Iselin, New Jersey
27014	National Semiconductor Corp. Santa Clara, California
27556	IMB Electronic Products Santa Fe Springs, California
28480	Hewlett-Packard Co. Palo Alto, California
28821	Pacific Measurements Inc. Palo Alto, California
56289	Sprague Electric Co. North Adams, Massachusetts
71034	Bliley Electric Co. Erie, Pa.
70903	Belden Mfg. Co. Chicago, Illinois
71400	Bussman Mfg. Div. of McGraw-Edison Co. St. Louis, Missouri
71450	CTS Corp. Elkhart, Indiana
72982	Erie Tech. Products Inc. Erie, Pennsylvania
73138	Beckman Instruments Inc. Helipot Division Fullerton, California
73445	Amperex Electronic Corp. Hicksville, New York.

74970	E. F. Johnson Co. Waseca, Minnesota
75915	Littlefuse Inc. Des Plaines, Illinois
76854	Oak Mfg. Co. Crystal Lake, Illinois
76493	J. W. Miller Company Compton, Calif.
76541	Monsanto Commercial Products Co. Cupertino, Calif.
79727	Continental-Wirt Electronics Corp. Philadelphia, Pa.
82389	Switchcraft Inc. Chicago, Illinois
83594	Burroughs Corp. Electronic Components Div. Plainfield, New Jersey
84171	Arco Electronics Inc. Great Neck, New York
90634	Gulton Industries Inc. Metuchen, New Jersey
91418	Radio Materials Co. Chicago, Illinois
91637	Dale Electronics Inc. Columbus, Nebraska
91929	Honeywell Inc. Microswitch Div. Freeport, Illinois
94144	Raytheon Co. Components Div. Quincy, Massachusetts
99800	Delavan Electronics Corp. East Aurora, New York.

ADDITIONAL FEDERAL SUPPLY CODE FOR MANUFACTURERS

07126	Digitran Co. Pasadena, Calif.
17856	Siliconix Santa Clara, Calif.
19447	Electro-Technique Inc. Oceanside, Calif.
22526	Berg Electronics Corp. York Expressway New Cumberland, Pa. 17070
32284	Rotron Manufacturing Co. Inc. Woodstock, New York
71590	Centralab Electronics Milwaukee, Wisconsin
75042	International Resistance Co. Philadelphia, Pa.
81095	Traid Transformer Corp Venice, California
81483	International Rectifier Corp. El Segundo, Calif.
83330	H. H. Smith, Inc. Brooklyn, New York
83701	Electronic Devices, Inc. Yonkers, New York 10710
95146	Alco Electronics Lawrence, Mass.
99392	STM Corp. Oakland, Calif. 94601
22045	Jordan Electric Van Nuys, Calif.