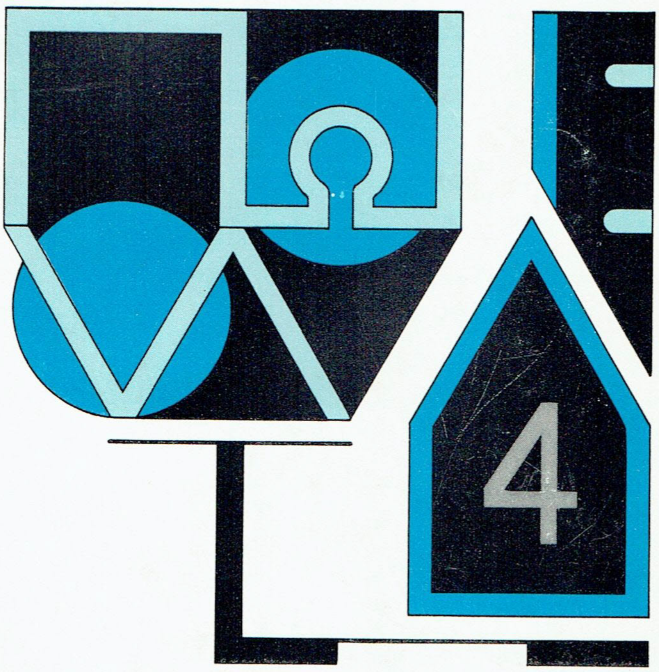
INSTRUCTION MANUAL

4800
DIGITAL VOLTMETER



DANA®

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INSTRUCTION MANUAL

MODEL 4800

DIGITAL VOLTMETER

DANA LABORATORIES, INC.
2401 CAMPUS DRIVE
IRVINE, CALIFORNIA 92664

DANA

TELEPHONE (714) 833-1234
TELETYPE 910-595-1136
TELEX 678-341

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1.1 INTRODUCTION.

1.2 The Model 4800 Digital Voltmeter (figure 1.1) is a four-digit instrument with a fifth decade providing 100% overrange. The basic instrument is equipped for dc and dc/dc ratio measurements on five ranges. With the addition of the optional Model 21 AC Converter, a-c and ac/dc ratio measurements on five ranges are available. The Model 50 Preamp/Ohms Converter, also optional, adds a 10 mV range plus ohms and ohms/dc ratio measurements on nine ranges. Complete measurement capability is tabulated in Table 1.1.

Table 1.1 - Measurement Capability

Range	FUNCTION			
	DC & DC/DC RATIO (Basic 4800)	MV & MV/DC RATIO (Model 12 Preamp)	Ohms & Ohms/DC RATIO (Model 50 Preamp/ Ohms)	AC & AC/DC RATIO (Model 21 AC Conv.)
10 mV		X		
.1V	X	X		X
1V	X			X
10V	X			X
100V	X			X
1000V	X			X
1Ω			X	
10Ω			X	
.1 KΩ			X	
1 KΩ			X	
10 KΩ			X	
100 KΩ			X	
1000 KΩ			X	
10 MΩ			X	
100 MΩ			X	

1.3 Range can be selected manually or automatically (autorange). In AUTO range, the proper range for a particular measurement is selected automatically (full scale is defined as "10000" on any range). The instrument "up-ranges" at 200% of full scale and "downranges" at 10% of full scale. Polarity selection is also automatic and is displayed on the readout.

1.4 Two operating modes are provided. In Single Read mode, a measurement is held (displayed) until a single reading is commanded by a front panel pushbutton switch (or externally, see paragraph 1.15). The new measurement is then held until the switch is again activated. In Periodic mode, measurements are made automatically at the rate of approximately three and one-third per second.

1.5 The basic Model 4800 includes an analog output voltage that is proportional to the parameter being measured. The voltage, at 20 volts maximum, is available at a rear panel connector.

1.6 Also included as standard equipment is a solid-state isolated BCD output. TTL-compatible output levels of the reading, function, range, etc., plus a print command are provided. An additional line enables a new reading to be commanded externally. An optional isolated remote programming unit (Model 70) allows all operating commands to be made externally.

1.7 OPTIONS.

1.8 All optional accessories having model numbers are plug-in circuit boards that may be added at any time. A calibrated accessory board can be installed without affecting the d-c calibration of the basic instrument. An instrument shipped without PCB accessories will not be

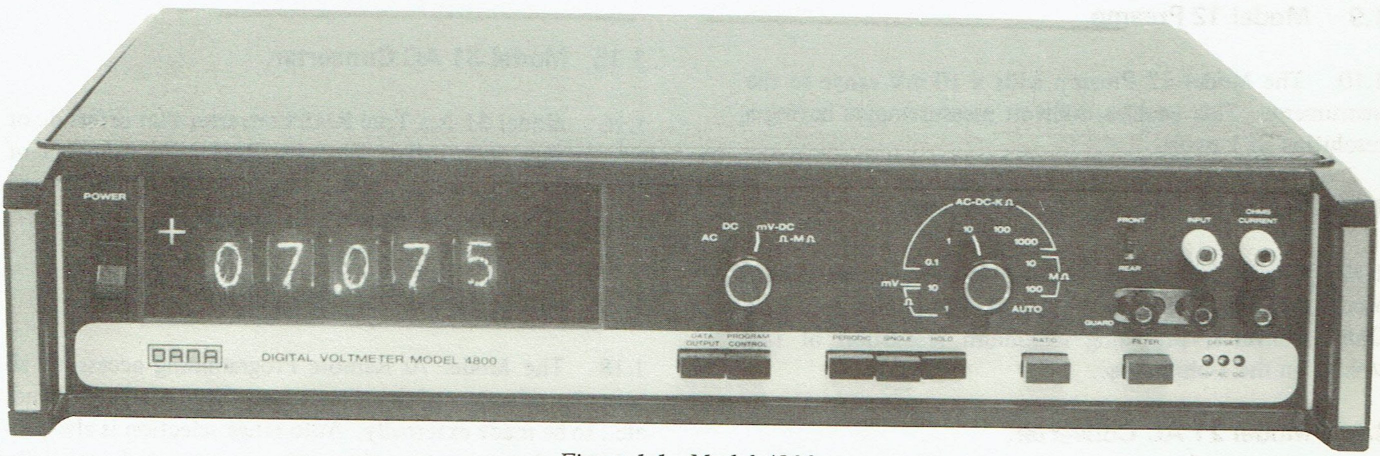


Figure 1.1 - Model 4800

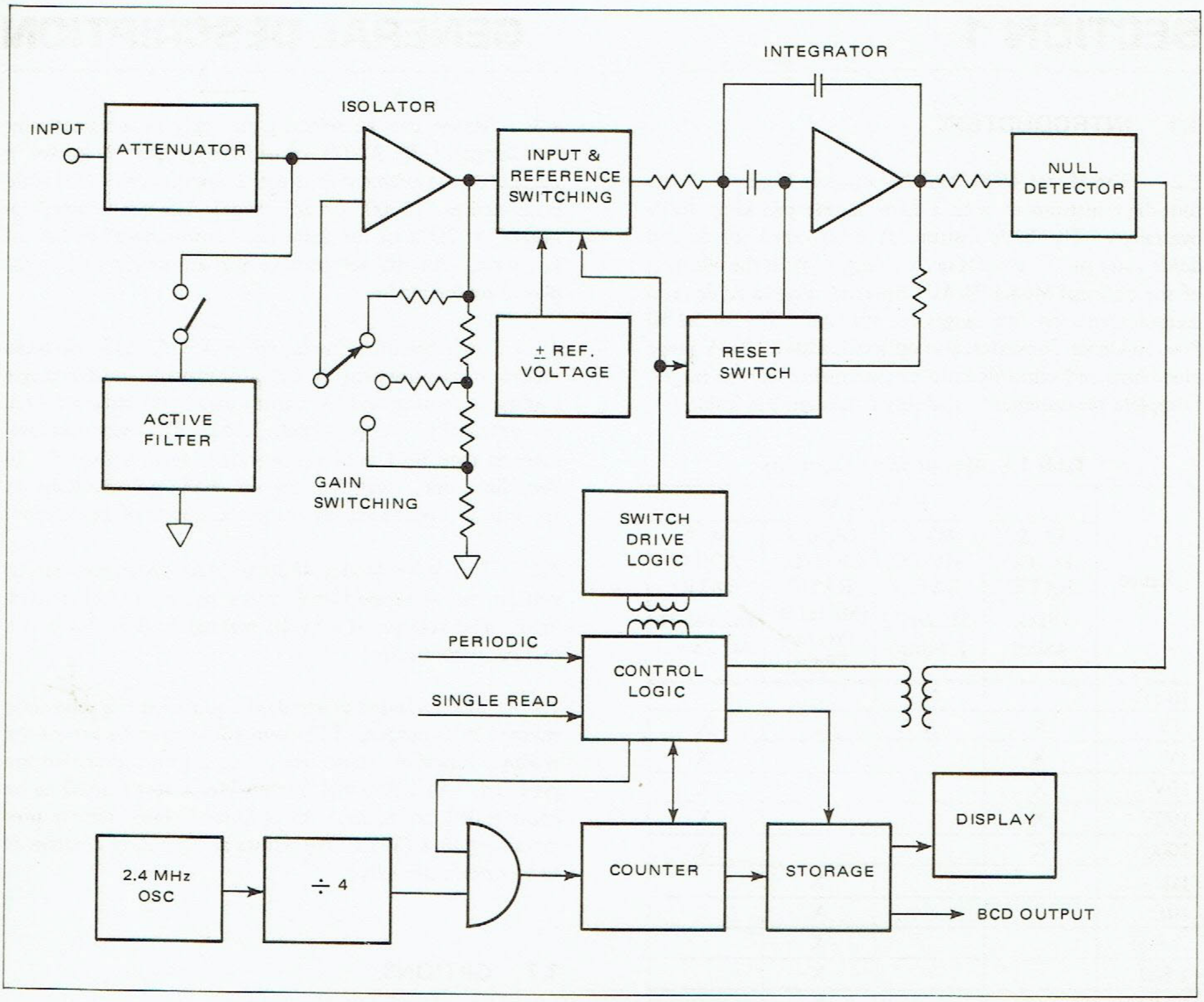


Figure 1.2 - Block Diagram - DC Measurement

equipped with a Function Switching PCB assembly. This board must be added when accessory boards are installed.

1.9 Model 12 Preamp.

1.10 The Model 12 Preamp adds a 10 mV range to the instrument. This enables millivolt measurements having a resolution of 1 μvolt.

1.11 Model 50 Preamp/Ohms Converter.

1.12 The Model 50 Preamp/Ohms Converter combines the Model 12 Preamp with a nine-range ratiometric four-wire Ohms Converter providing maximum resolution of 100 μohms on the 1-ohm range.

1.13 Model 21 AC Converter.

1.14 Model 21 is a Distortion Insensitive AC Converter that makes accurate a-c measurements in the presence of up to 5% total harmonic distortion. It can measure the RMS value of distorted sine waves with little degradation of accuracy.

1.15 Model 31 AC Converter.

1.16 Model 31 is a True RMS Converter that offers dc or ac coupling and makes accurate RMS measurements of sinusoidal and non-sinusoidal inputs. The converter can accept full scale input signals with crest factors up to 7 to 1.

1.17 Model 70 Remote Programming.

1.18 The Model 70 Remote Programming accessory allows the selection of function, range, filter, read command, etc., to be made externally. Auto range selection is also provided and appropriate timeouts are generated internally when ranging takes place. Remote Programming "overrides" all manual control settings to prevent erratic selections. Complete isolation of the programming unit is achieved by the use of photo-couplers and pulse transformers.

1.19 Rack-Mounting Flanges (403402).

1.20 Rack-Mounting Flanges are used where the instrument is to be installed in a relay-rack or cabinet.

1.21 High-Voltage Probe (641).

1.22 The High-Voltage Probe extends the voltage range of the instrument up to 10,000 volts (or 7500V rms). It is an insulated probe containing a 1000:1 voltage divider.

1.23 Current Shunt Set (651).

1.24 The Current Shunt Set consists of six precision shunt assemblies with values selected to produce a voltage drop that, measured in millivolts, has a numerical value equal to the current flow in milliamps or microamps.

1.25 ELECTRICAL DESCRIPTION.

1.26 A block diagram of the Model 4800 is shown in figure 1.2. A dc input signal is applied through the attenuator (voltage divider) to the Isolator amplifier. Ranging is accomplished by the voltage division of the attenuator combined with the gain of the Isolator. The Isolator output is a ten-volt full scale (20 volts in overrange) analog voltage representing the input.

1.27 For optional AC measurements, the signal is first applied to the Model 21 AC Converter (not shown) where it is scaled, rectified, and filtered. The resulting d-c voltage is then applied to the attenuator and measured as DC.

1.28 To measure resistance, the Model 50 Ohms Converter is used. The Ohms Converter generates a current that is applied to the unknown resistance. A voltage, representing a ratio E_X/E_{FS} of the voltage drop across the unknown resistor (E_X) to the voltage drop across a "full-scale" resistor (E_{FS}) is measured as a dc ratio and displayed in ohms.

1.29 The analog output of the Isolator is converted to its digital equivalent by the Integrator using the dual-slope technique. Figure 1.3 shows a simplified Integrator circuit and the dual slope produced.

1.30 I_S and I_R, shown as current generators, represent current derived from the signal (I_S) and the reference current generated within the instrument (I_R). Both constant currents, they are applied to integrator capacitor C_i as the appropriate switch is closed.

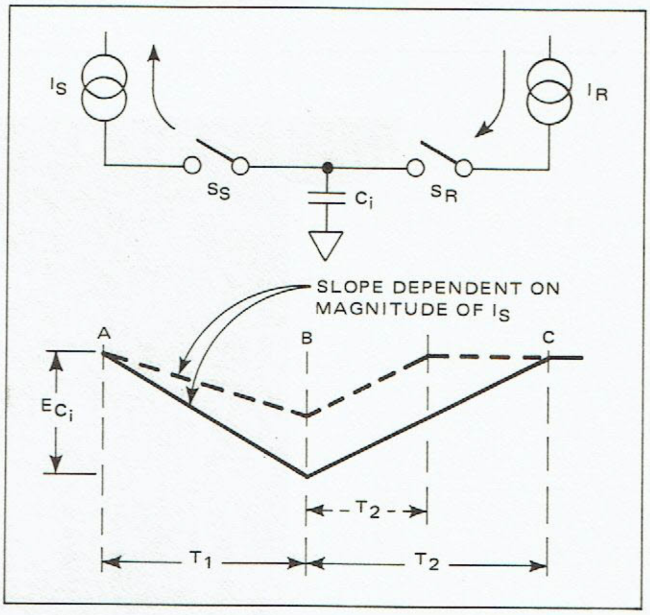


Figure 1.3 - Simplified Integrator Circuit

1.31 Period T1 is the signal integration period. At time A, S_S closes and C_i (initially uncharged) begins to charge. T1 is a fixed period. At time B, S_S opens and S_R closes starting the reference integration period (T2). C_i charges at a constant rate. The time required to charge the capacitor to zero is proportional to the voltage across the capacitor at the end of the signal integration period; therefore, it is proportional to the input.

1.32 A counter operates during the integration period at a rate of 600 kHz. The counter output is stored in Storage IC's. The counter is stopped when the reference integration ramp reaches zero by a pulse from the Null Detector. The contents of the Storage circuits are then displayed and routed to the BCD output circuitry.

1.33 The Control Logic (figure 1.2) generates control signals that operate the Integrator switches, counter, and Storage circuits at the appropriate time.

1.34 MECHANICAL DESCRIPTION.

1.35 A top view of the Model 4800 is shown in figure 1.4. The instrument shown is equipped with optional accessories (PC Boards) for the measurement of Ohms and AC. The AC option consists of two boards: the AC Converter and the Scaling Amplifier. The accessory boards plus the Digitizer, Isolator, and Function Switching board all plug into the "motherboard" called the Logic and Interconnection assembly. This board also carries much of the instrument logic. Connectors on the motherboard are identified in the figure.

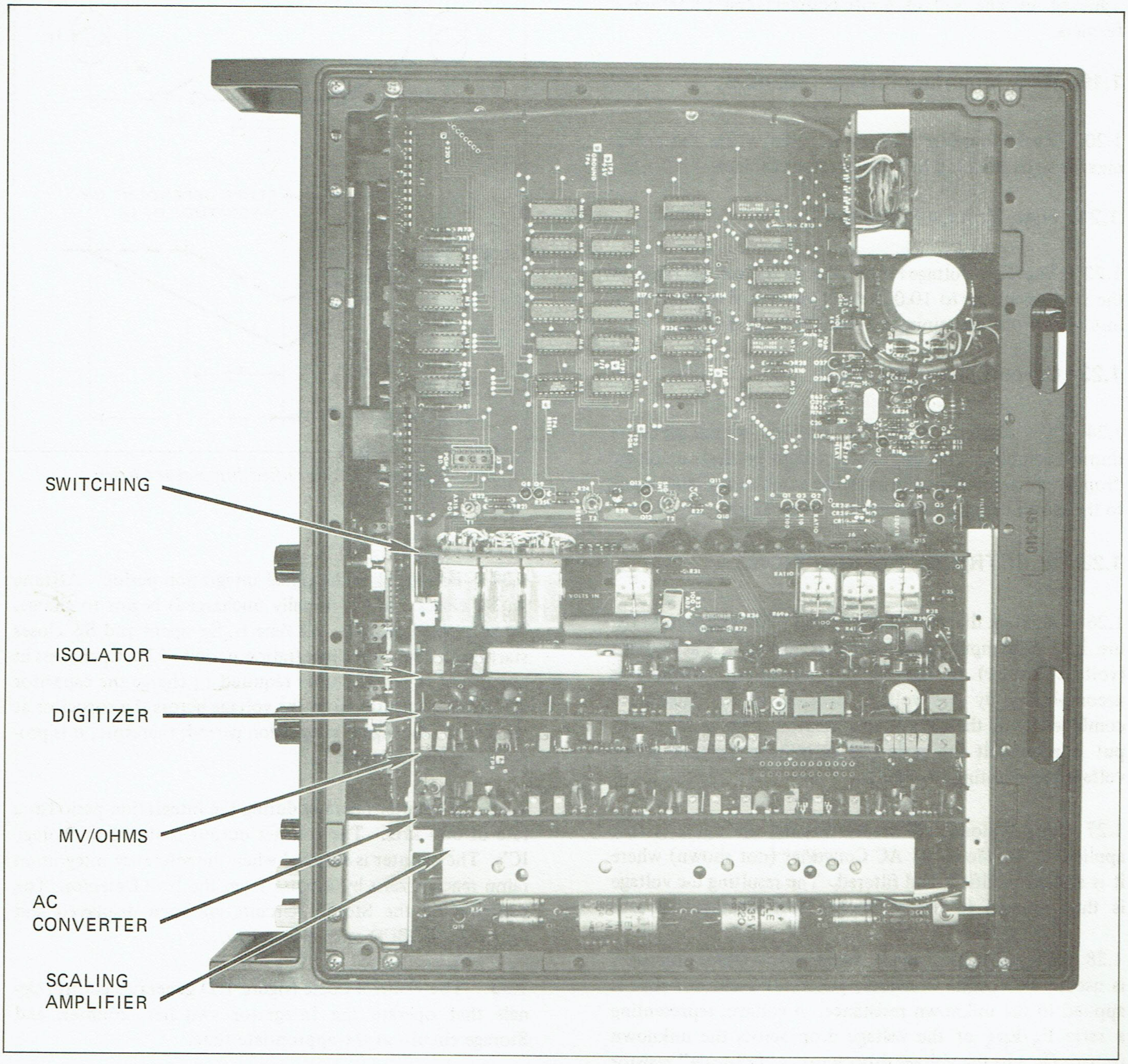


Figure 1.4 - Printed Circuit Board Locations

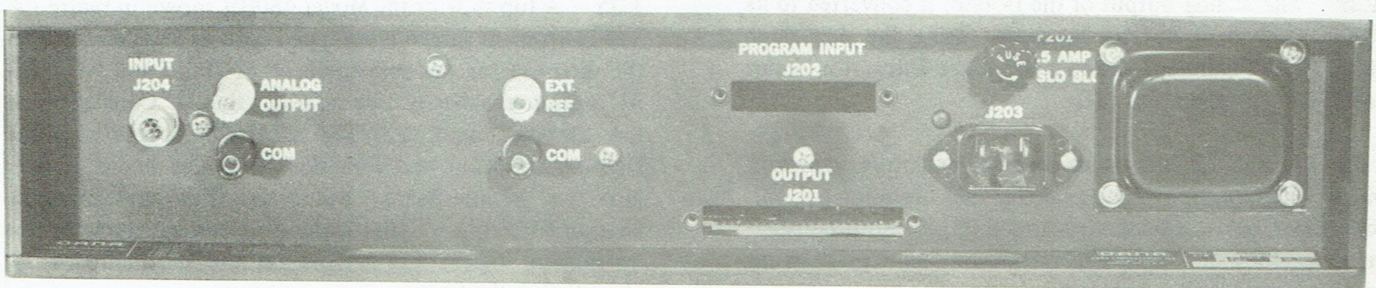


Figure 1.5 - Rear Panel

1.36 The Function Switching board is used only when either or both of the options (AC and Ohms) are installed. With no options installed, the Function Switching board is replaced with the Switching Bypass board. The Switching Bypass merely connects the + Input (from input connector) directly to the Isolator input and the – Input to ground.

1.37 At the rear edge of the Interconnection and Logic Assembly is a PCB connector that extends to the rear panel and serves as the BCD output connector J201 (figure 1.5). If the optional Model 70 Remote Program board is installed, it is mounted on stand-offs above the Interconnection and Logic board with the PROGRAM INPUT connector (J202) available at the rear panel above the BCD OUTPUT connector.

1.38 The POWER input connector J203, the power transformer, and power transistors for the power supply are mounted on the rear panel of the instrument. Other power supply components are mounted on the Interconnection and Logic assembly. Also mounted on the rear panel, in addition to J201 and J202, is the rear INPUT connector J204, the ANALOG OUTPUT connector and common, the EXTernal REFerence connector and common, and the line fuse F201.

1.39 A dimensional outline of the Model 4800 is shown in figure 1.6.

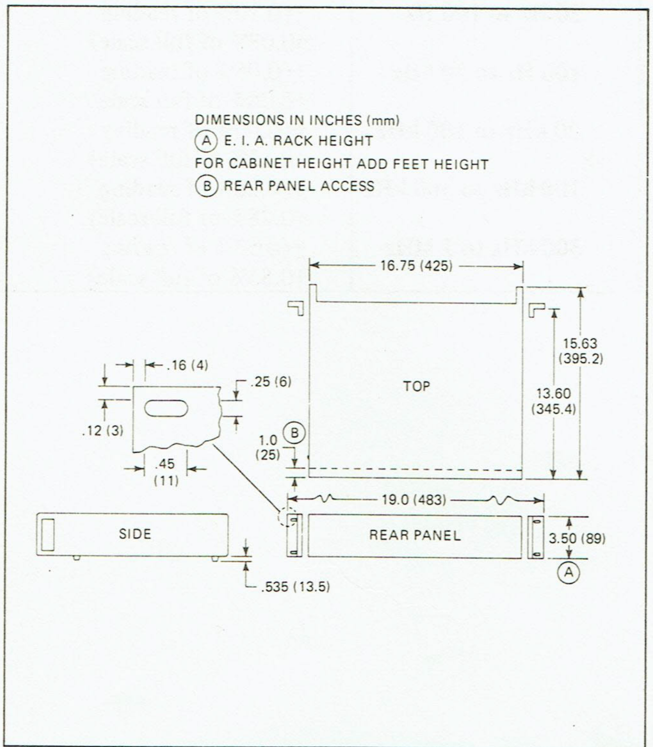


Figure 1.6 - Dimensions

1.40 SPECIFICATIONS.

1.41 Specifications are listed in Table 1.2. Test procedures for verification of specifications are given in Section 3.

Table 1.2 - Specifications

GENERAL	
Maximum Common Mode Voltage:	500V peak ac or dc
Maximum Power Requirement:	40 watts, 115V ± 10%, 50 to 400 Hz
Operating Temperature:	0^{o} to 50^{o}C
Warmup:	30 minutes to full accuracy
Dimensions:	3-1/2 x 16-3/4 x 15-5/8 inches (87.5 mm x 418 mm x 394 mm)
Weight:	16 pounds (approx.) net, 18 pounds (approx.) shipping
Guarantee:	12 months, faulty workmanship or component failure

mV/DC, DC/DC, AC/DC, Ω/DC RATIO	
Full Scale Display: (ratio x 10)	mV/DC ratio range +10.000:1 DC/DC & AC/DC ratio ranges +.10000:1, +1.0000, +10.000:1, +100.00:1, +1000.0:1 Ω/DC ratio ranges 1.0000:1, 10.000:1, 100.00:1, 1.0000k:1, 10.000k:1, 100.00k:1, 1.0000m:1, 10.000m:1, 100.00m:1
Overrange:	100% on all ranges
Accuracy DC/DC:	90 days, 25^{o}C ± 5^{o}C (add 0.01% of reading to get 6 month specification) ±[0.01% of reading +0.01 (10V/ref input) % of full scale]
Reference Input:	Impedance: 1000 megohms NMR: 15 dB at line frequency Settling time: 250 ms to 0.01%

Table 1.2 - Specifications (Continued)

DC VOLTAGE	
Full Scale Display:	±.10000, ±1.0000, ±10.000, ±100.00, ±1000.0V
Overrange:	100% on all ranges, ±1000V maximum input
Resolution:	10 microvolts on 0.1V range
Accuracy:	24 hours, 23°C ± 1°C ±(0.005% of reading +0.005% of full scale) 90 days, 25°C ± 5°C ±(0.01% of reading +0.01% of full scale) 6 months, 25°C ± 5°C ±(0.02% of reading +0.01% of full scale)
Temperature Coefficient:	0°C to 50°C 1, 10, 100, 1000 Volt Ranges ±(0.001% of reading +0.001% of full scale)/°C 0.1 Volt Range ±(0.001% of reading +0.002% of full scale)/°C
Input Resistance:	0.1, 1, 10 Volt Ranges 10,000 megohms 100, 1000 Volt Ranges 10 megohms ± .1%
Normal Mode Noise Rejection:	At or near line frequency Filter in: 100 dB (100,000 to 1) Filter out: 48 dB (250 to 1)
Common Mode Noise Rejection:	DC to 61 Hz (with 100Ω unbalance in either lead) Filter in: 140 dB (10,000,000 to 1) Filter out: 120 dB (1,000,000 to 1)
Settling Time:	To 0.01% from full scale step Filter in: 250 ms Filter out: 5 ms

DISTORTION INSENSITIVE AC VOLTAGE	
Full Scale Display:	.10000, 1.0000, 10.000, 100.00, 1000.0V
Overrange:	100% on all ranges, 1000V rms maximum input ($2x10^7$ maximum volt - Hz product)
Resolution:	10 microvolts on 0.1V range
Accuracy:	90 days, 23°C ± 5°C 1V, 10V, 100V, and 1000V ranges
30 Hz to 50 Hz	±(0.13% of reading +0.02% of full scale)
50 Hz to 100 Hz	±(0.08% of reading +0.02% of full scale)
100 Hz to 20 kHz	±(0.03% of reading +0.02% of full scale)
20 kHz to 100 kHz	±(0.04% of reading +0.03% of full scale)
100 kHz to 300 kHz	±(0.26% of reading +0.08% of full scale)
300 kHz to 1 MHz	±(0.51% of reading +0.11% of full scale)
	0.1 volt range
30 Hz to 50 Hz	±(0.15% of reading +0.08% of full scale)
50 Hz to 100 Hz	±(0.10% of reading +0.08% of full scale)
100 Hz to 20 kHz	±(0.05% of reading +0.08% of full scale)
20 kHz to 100 kHz	±(0.06% of reading +0.13% of full scale)
100 kHz to 300 kHz	±(0.28% of reading +0.28% of full scale)
300 kHz to 1 MHz	±(0.53% of reading +0.53% of full scale)

Table 1.2 - Specifications (Continued)

DISTORTION INSENSITIVE AC VOLTAGE (continued)	
Accuracy: (continued)	6 months, 23°C ± 5°C 1V, 10V, 100V, and 1000V ranges
30 Hz to 50 Hz	±(0.14% of reading +0.02% of full scale)
50 Hz to 100 Hz	±(0.09% of reading +0.02% of full scale)
100 Hz to 20 kHz	±(0.04% of reading +0.02% of full scale)
20 kHz to 100 kHz	±(0.05% of reading +0.03% of full scale)
100 kHz to 300 kHz	±(0.27% of reading +0.08% of full scale)
300 kHz to 1 MHz	±(0.52% of reading +0.11% of full scale)
	0.1 volt range
30 Hz to 50 Hz	±(0.16% of reading +0.08% of full scale)
50 Hz to 100 Hz	±(0.11% of reading +0.08% of full scale)
100 Hz to 20 kHz	±(0.06% of reading +0.08% of full scale)
20 kHz to 100 kHz	±(0.07% of reading +0.13% of full scale)
100 kHz to 300 kHz	±(0.29% of reading +0.28% of full scale)
300 kHz to 1 MHz	±(0.54% of reading +0.53% of full scale)
Input Impedance:	1 megohm minimum in series with .22 μF, shunted by less than 100 pF
Settling Time:	350 msec to 0.1% from full scale step
Maximum Input Voltage:	See Figure 1.7

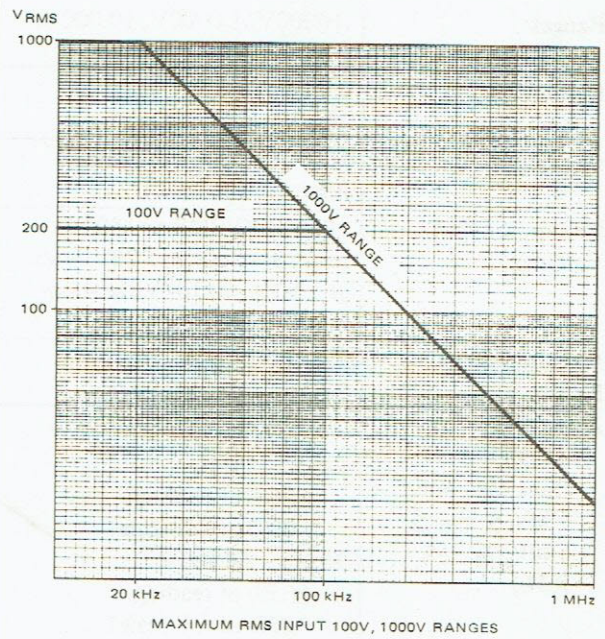


Figure 1.7 - Maximum RMS Input Voltage

SYSTEMS INTERFACE	
Electrical Output:	Included in basic instrument
Information:	5 digits, polarity, range, function filter in/out
Print Command:	Level change from TTL "1" state to a "0" state (1 = +2.4V to +5.0V) (0 = 0.0V to +0.5V)
Output Levels:	Series 7400 TTL output levels; 1-2-4-8 positive true code
Remote Programming:	With addition of Option 70 Programming
Programmability:	Single line command for any function, any range, and filter
Selection:	TTL logic levels applied to appropriate pin

Table 1.2 - Specifications (Continued)

TRUE RMS AC VOLTAGE	
Ranges:	.10000V, 1.0000V, 10.000V, 100.00V, 1000.0V RMS
Resolution:	0.01% of range 10 μV on .1V range
Overrange:	100%, (within maximum input voltage limit)
Maximum Input Voltage:	1000V DC/RMS or 1500V peak, decreasing to 20V RMS at 1 MHz. 2×10^7V Hz maximum on any range
Maximum Crest Factor:	7:1 at full-scale 22:1 at 10% of full-scale
Accuracy: AC Mode (Sinewave input, 1 MV $\leq V_{in} \leq$ 500V, $\leq$ 75% R.H.)	90 days, 23°C ± 5°C 20 Hz – 30 Hz ±(.6% of reading +.03% of full-scale) 30 Hz – 50 Hz ±(.3% of reading +.03% of full-scale) 50 Hz – 100 Hz ±(.1% of reading +.03% of full-scale) .1V range 100 Hz – 20 kHz ±(.15% of reading +.04% of full-scale) 20 kHz – 100 kHz ±(1% of reading +.2% of full-scale) 1, 10, 100, 1000V range 100 Hz – 20 kHz ±(.07% of reading +.03% of full-scale) 20 kHz – 50 kHz ±(.1% of reading +.1% of full-scale) 50 kHz – 100 kHz ±(.2% of reading +.2% of full-scale) 1V range 100 kHz – 300 kHz ±(5% of reading +1% of full-scale) 10, 100, 1000V range 100 kHz – 300 kHz ±(3% of reading +.5% of full-scale)

TRUE RMS AC VOLTAGE (continued)	
Accuracy: (cont) AC & DC Mode	1, 10, 100, 1000V range Add ±.02% of full-scale to AC Specification .1V range Add ±(.03% of reading +.015% of full-scale) to AC Specification
Temperature Coefficient:	0°C to 50°C AC coupled (to 20 kHz) 1, 10, 100, 1000V range ±(.004% of reading +.003% of full-scale) .1V range ±(.008% of reading +.003% of full-scale) DC coupled (to 20 kHz) 1, 10, 100, 1000V range ±(.004% of reading +.005% of full-scale)/°C .1V range ±(.01% of reading +.02% of full-scale)/°C
Input Impedance: (Front Input)	AC Mode 1M ± .1% in series with .22 μF, shunted by less than 100 pF to common DC Mode 1M ± .1%, shunted by less than 100 pF to common
Common Mode Rejection: With 100Ω unbalance in either lead. DC to 60 Hz	Range — CMR .1V — 140 dB 1V — 120 dB 10V — 100 dB 100V — 80 dB 1000V — 60 dB
Settling Time: (to .1% of range with "Filter" in)	0 to Full Scale Step 300 msec Full Scale Step to 10% FS Step 400 msec

Table 1.2 - Specifications (Continued)

TRUE 4-WIRE OHMS	
Full Scale Display:	1.0000, 10.000, 100.00, 1.0000k, 10.000k, 100.00k, 1.0000M, 10.000M, 100.00M ohms
Overrange:	100% on all ranges; ±30 VDC or 30V peak AC maximum input
Resolution:	100 microhms on 1 ohm range
Accuracy:	90 days, 25°C ± 5°C (Multiply % of reading error by 1.5 to get 6 month specification) 10, 100, 1k, 10k, 100k, 1M ohm ranges ±(0.01% of reading +0.01% of full scale) 1 ohm range ±(0.01% of reading +0.05% of full scale) 10M ohm range ±(0.05% of reading +0.01% of full scale) 100M ohm range ±(0.20% of reading +0.01% of full scale) 6 months, 25°C ± 5°C 10, 100, 1k, 10k, 100k, 1M ohm ranges ±(0.015% of reading +0.01% of full scale) 1 ohm range ±(0.015% of reading +0.05% of full scale) 10M ohm range ±(0.075% of reading +0.01% of full scale) 100M ohm range ±(0.30% of reading +0.01% of full scale)
Normal Mode Noise Rejection:	Same as DC Voltage
Settling Time:	To rated accuracy from full scale step 20 ms (200 ms 100 M range)
Current Through Unknown:	Range: 1 ohm — 10.1 mA 10 ohm — 10.1 mA 100 ohm — 1.01 mA 1 kilohm — .101 mA 10 kilohm — 1 mA 100 kilohm — 0.1 mA 1 megohm — 10 µA 10 megohm — 1 µA 100 megohm — 0.1 µA

MILLIVOLTS DC	
Full Scale Display:	10.000 mV, .10000V
Overrange:	100% on both ranges, ±150V maximum input
Resolution:	1 microvolt on 10 mV range
Accuracy: **10 mV range***	24 hours, 25°C ± 1°C ±(0.005% of reading +0.01% of full scale) 90 days, 23°C ± 5°C ±(0.01% of reading +0.03% of full scale) 6 months, 25°C ± 5°C ±(0.02% of reading +0.03% of full scale) *accuracy of 0.1V range same as DC Volts
Temperature Coefficient:	0°C to 50°C 0.1V range ±(0.001% of reading +0.001% of full scale)/°C 10 mV range ±(0.001% of reading +0.005% of full scale)/°C
Input Resistance:	10,000 megohms
Noise Rejection:	Same as DC Voltage
Settling Time:	Same as DC Voltage

2.1 UNPACKING AND INSPECTION.

2.2 The Model 4800 DVM is packed in a molded plastic-foam form within a cardboard carton for shipment. The plastic form holds the DVM securely in the carton and absorbs any reasonable external shock normally encountered in transit. Prior to unpacking, examine the exterior of the shipping carton for any signs of damage. Carefully remove the DVM from the carton and inspect the exterior of the instrument for any signs of damage. If damage is found, notify the carrier immediately.

2.3 Included with the instrument in the packing container are the instruction manual, power cord, and rear input and BCD output mating connectors. With instruments equipped with remote programming, a mating connector for that accessory is included.

2.4 BENCH OPERATION.

2.5 Each Model 4800 is equipped with a tilt bail or "kickstand" to enable the front of the instrument to be elevated for convenient bench use. The tilt bail is attached to the two front supporting "feet" at the bottom of the instrument. For use, the bail is pulled down to its supporting position.

2.6 RACK MOUNTING.

2.7 The instrument can be mounted in a standard 19-inch rack with the optional rack-mounting flanges (403402, includes attaching hardware). To install the flanges, proceed as follows:

a. With instrument on its side, remove four Phillips-head screws holding bottom cover. Remove cover. Remove screws holding feet (and bail) in place. Replace bottom cover.

b. Place one of the supplied screws through each of the two holes in the mounting flange (figure 2.1). Thread a securing nut onto each screw just enough to attach it to the screw (approximately one turn).

c. Place the mounting flange onto the mounting slot in the instrument side panel so that the securing nuts fit entirely into the slot. Be sure the rack-mount slots on the flange are toward the front of the instrument.

d. Tighten screws. The securing nuts will rotate and hold the flange securely in place.

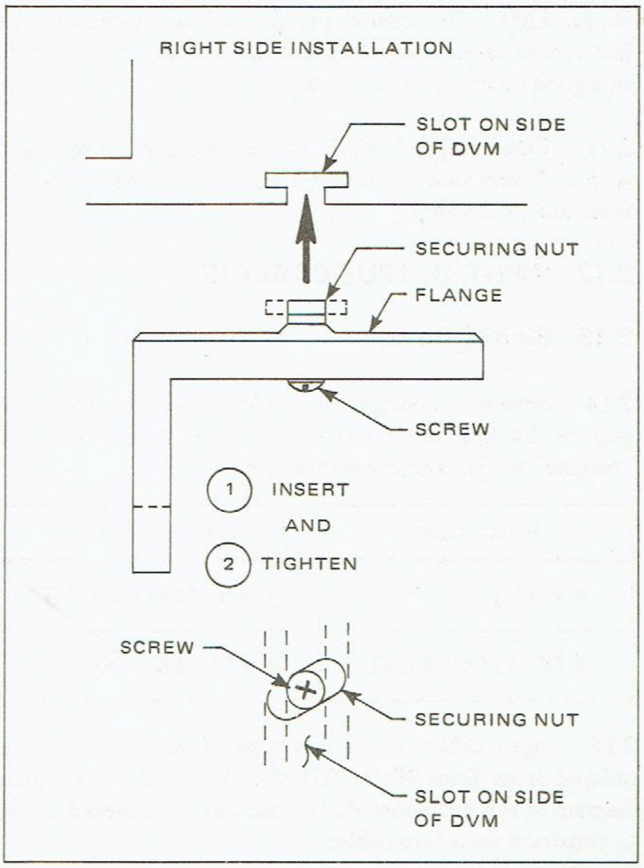


Figure 2.1 - Rack Mount Installation

2.8 POWER CONNECTIONS.

2.9 Power requirements for domestic units are 115V ± 10%, 50 to 400 Hz. Power consumption is 40 watts maximum. Instruments for export, designated as Models 4800E, are equipped with a special transformer with an attached jumper matrix. The matrix has numbered pairs of terminals that are jumpered according to the line voltage (figure 2.2).

Line Voltage	Jumpers across terminal(s):
100V	2, 3, and 6
120V	1, 3, and 7
200V	5 and 6
220V	4 and 6
240V	4 and 7

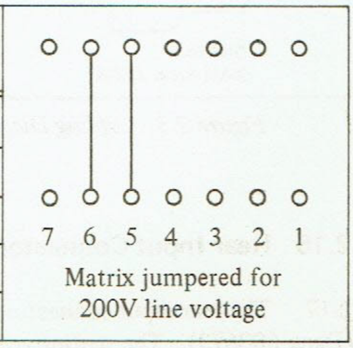


Figure 2.2 - Line Voltage Jumpers – Export Models Only

2.10 A standard power cable having a three-pin plug is supplied with the instrument. It connects to POWER connector J203. The ground pin (round) is attached to the instrument case. It is important that this pin be connected to a good quality earth ground.

2.11 Fuse receptacle F201 on the rear panel is equipped with a .5 amp fuse in domestic units. In export units, the fuse value is .25 amp.

2.12 INPUT/OUTPUT CABLING.

2.13 Binding Posts.

2.14 Several connectors on the Model 4800 consist of a pair of binding posts spaced so as to accept standard "banana" plugs. The connectors are:

Front Panel	Rear Panel
± INPUT	± ANALOG OUTPUT
± OHMS CURRENT	± REFerence INput

2.15 Input cables to fit this type of connector can be ordered from Dana (P/N 402190). Figure 2.3 is a wiring diagram of this cable included for assistance to users desiring to construct their own cables.

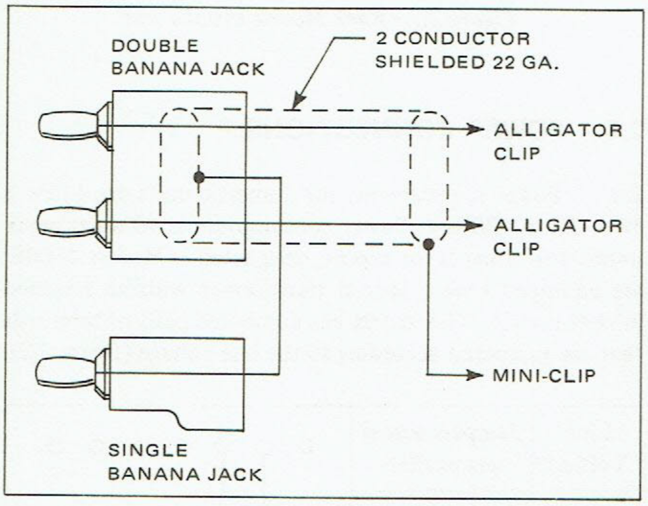


Figure 2.3 - Cabling Diagram, Binding Posts

2.16 Rear Input Connector.

2.17 The rear input connector J204 is a Viking TKR7-101 (Dana 600673). The mating connector is TKP7-100 (Dana 600616) and is supplied with the basic instrument. The instrument accepts inputs applied to this connector or inputs applied to the front-panel binding posts depending on the position of the FRONT/REAR switch. It is recommended that the cable for the mating connector be constructed as shown in figure 2.4 using two two-conductor shielded cables. Other configurations may be desirable depending on the ohms measuring method to be used (see paragraph 2.60).

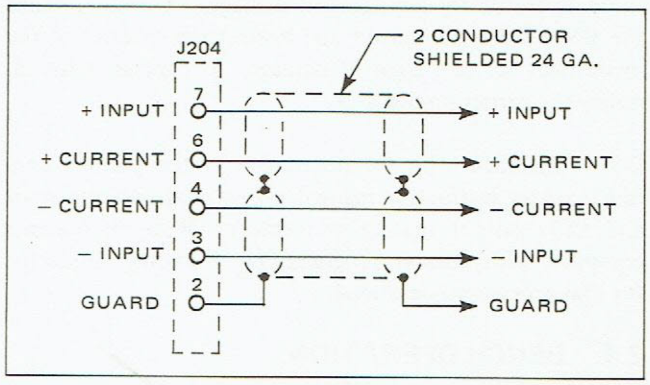


Figure 2.4 - Cabling Diagram, Rear Input

2.18 PRINTER OUTPUT.

2.19 Outputs are delivered to PRINTER OUTPUT connector J201 in the form of positive-true TTL logic levels:

False: 0 to +.5V
True: +2.4V to +5.0V
Fanout: 2 min.
Maximum capacitive load: 500 pF

2.20 J201 is a double-edged PCB connector (extension of Interconnection and Logic board) with pins A1 through A22 on the top edge and pins B1 through B22 on the bottom edge. Pin assignments of J201 are shown in figure 2.5. All outputs are referenced to data output ground, pin A12. This ground may be "floated" at up to 200V (peak) from power ground.

NOTE

Figure 2.5 shows the pin numbering when a Viking mating connector is supplied. On certain instruments, a Cinch connector was supplied. Pin numbering for the Cinch connector is shown in figure 2.6. Signal descriptions and relative positions of the pins are identical, only pin numbers are different.

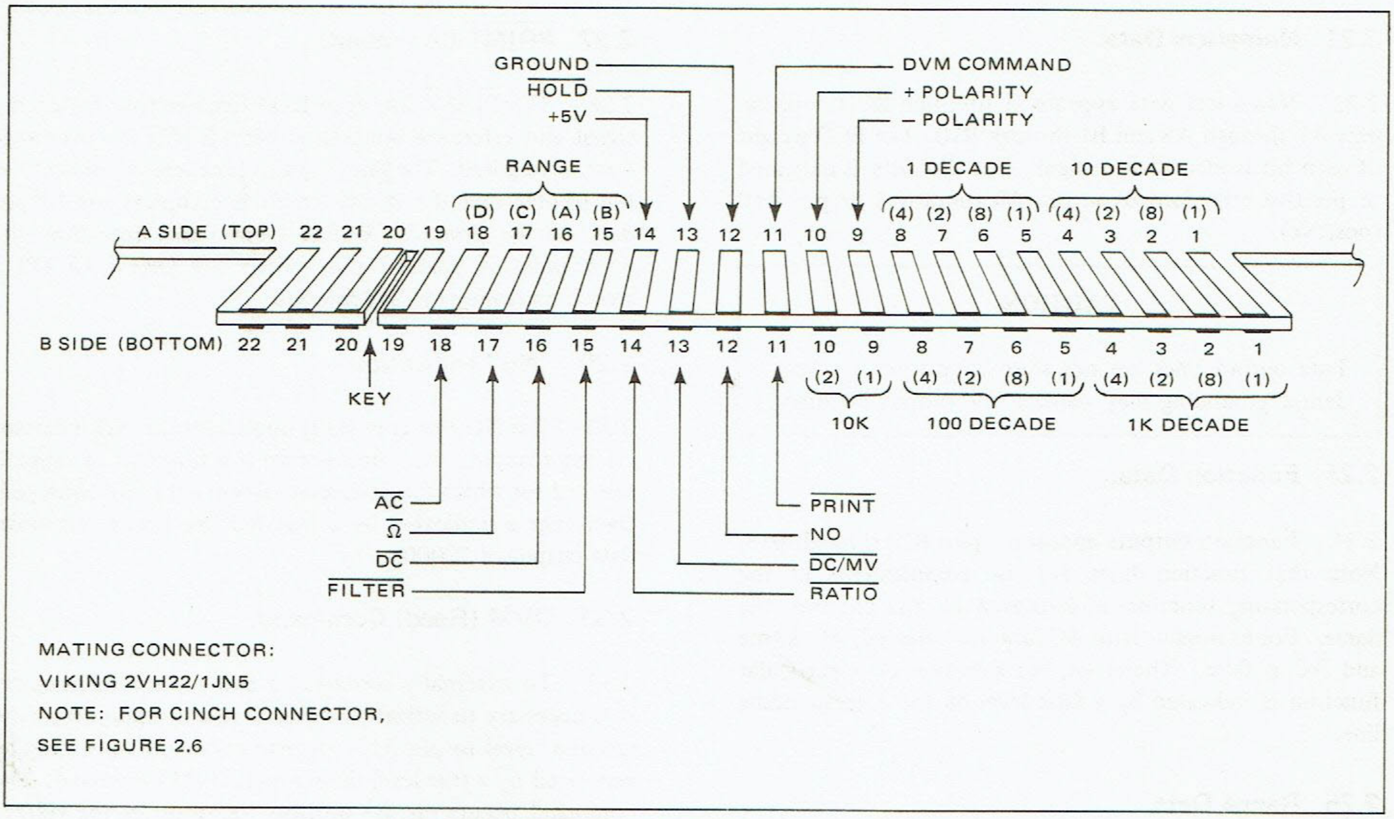


Figure 2.5 - PRINTER OUTPUT Connector J201 (Viking)

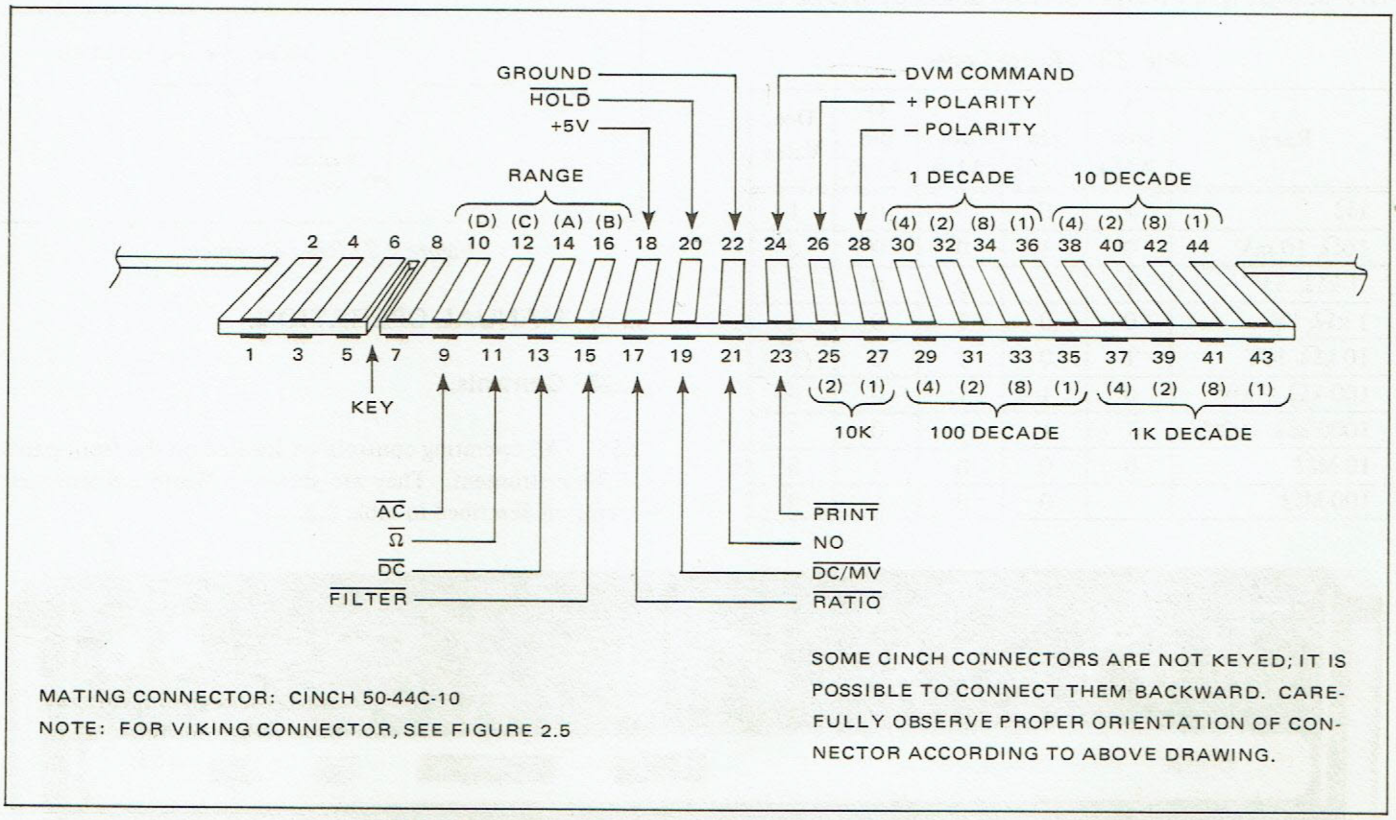


Figure 2.6 - PRINTER OUTPUT Connector J201 (Cinch)

2.21 Numerical Data.

2.22 Numerical data appears in four-line BCD code on pins A1 through A8 and B1 through B10. The BCD weight of each bit is identified in figure 2.5. Polarity is indicated in positive true format on pin A9 (negative) or pin A10 (positive).

> **CAUTION**
>
> True output lines are not short-circuit proof. Accidental grounding may damage the output circuitry.

2.23 Function Data.

2.24 Function outputs appear on pins B13 through B18. Note that function lines are the complements of the corresponding function as indicated by the bar over the name. For example: with AC function selected, AC is true and $\overline{\text{AC}}$ is false. Therefore, the selection of a particular function is indicated by a false level on the corresponding line.

2.25 Range Data.

2.26 Range data appears in four-line BCD code on pins A15 through A18. Range codes are described in table 2.1.

Table 2.1 - Range Codes

Range	A (pin A16)	B (pin A15)	C (pin A17)	D (pin A18)	Dec. Value
1Ω	1	0	0	0	1
10Ω, 10 mV	0	1	0	0	2
.1 kΩ, .1V	1	1	0	0	3
1 kΩ, 1V	0	0	1	0	4
10 kΩ, 10V	1	0	1	0	5
100 kΩ, 100V	0	1	1	0	6
1000 kΩ, 1000V	1	1	1	0	7
10 MΩ	0	0	0	1	8
100 MΩ	1	0	0	1	9

2.27 $\overline{\text{PRINT}}$ Command.

2.28 The $\overline{\text{PRINT}}$ line (pin B11) remains true during the signal and reference integration periods plus the overrange time, if required. The line drops to false level to indicate to the printer that the measurement is complete and output data can be printed. During front panel operation, the print pulse is enabled only when the DATA OUTPUT switch on front panel is depressed.

2.29 "No" Indication.

2.30 The NO line (pin B12) duplicates the NO indicator on the readout. The line is true if a function or range is selected for which the particular instrument is not equipped. Overrange is indicated by a true NO line plus a numerical data output of 20000.

2.31 DVM (Read) Command.

2.32 To externally command a new measurement cycle, it is necessary to activate the $\overline{\text{HOLD}}$ line by applying a false (ground) level to pin A13. A read command must then be generated by a true level on pin A11, DVM Command. The command occurs on the positive transition of the voltage level on this line. Specifications of the command signal are shown in figure 2.7.

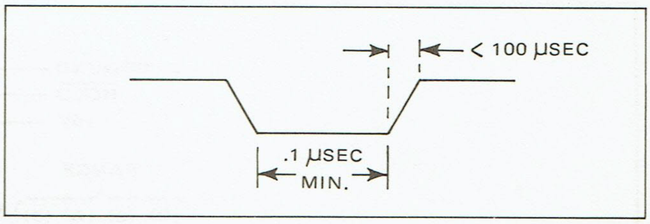


Figure 2.7 - Read Command

2.33 MANUAL OPERATION.

2.34 Controls.

2.35 All operating controls are located on the front panel of the instrument. They are shown in figure 2.8 and their operation described in table 2.2.

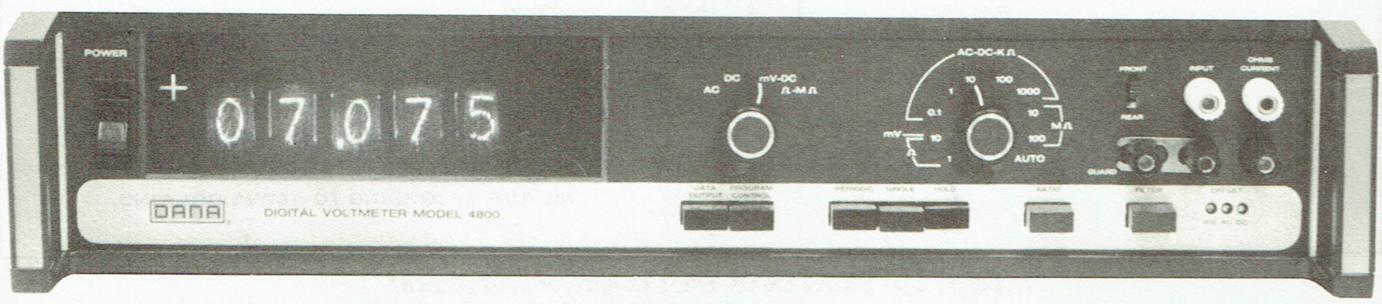


Figure 2.8 - Front Panel

Table 2.2 - Operating Controls

Control	Position	Function
Power (rocker switch)	ON (up)	Applies power to instrument
	OFF (down)	Removes power from instrument
Function Select (rotary switch)	AC	Selects the measurement of AC voltages on the .1, 1, 10, 100, and 1000 volt ranges (max. input, 1000V RMS)
	DC	Selects the measurement of DC voltages on the .1, 1, 10, 100, and 1000 volt ranges (max. input, 1000V)
	mV - DC	Selects the measurement of DC voltages on the 10 mV range plus the five d-c ranges (above)
	Ω - MΩ	Selects the measurement of resistance on the 1 and 10 ohm ranges; on the .1, 1, 10, 100, and 1000 kilohms ranges; or on the 10 or 100 Megohm ranges
Range Select (rotary switch)	AUTO	Selects Auto Range in which the optimum range is selected automatically by internal circuits. Uprange occurs at 200% of full scale; downrange occurs at 10% of full scale
	Other Positions	Enables manual selection of fixed ranges. Ranges permissible for each function are inscribed on the panel
DATA OUTPUT (pushbutton)	Depressed	Enables the print pulse causing BCD data at P201 to be recorded by printer, or other output device. (Output data is present at P201 regardless of the position of this switch.)
PROGRAM CONTROL (pushbutton)	Depressed	Enables the selection of range, function, and mode to be made externally through the remote programming connector and disables all front panel controls
PERIODIC (pushbutton)	Depressed	Selects the Periodic mode of operation in which the instrument automatically takes readings at the rate of 3-1/3 per second (approx.)
HOLD (pushbutton)	Depressed	Selects the HOLD mode in which each reading is held until a new reading is commanded by depression of the SINGLE switch or by an external read command
SINGLE (momentary-contact pushbutton)	Depressed	Commands a new reading to be taken in HOLD mode. Only one reading is taken and held until SINGLE is again depressed (NOTE: DVM will not Auto Range in Single Read mode unless program option installed)
RATIO (pushbutton)	Depressed	Selects a ratio measurement in which the readout represents the ratio of the input to an external d-c reference voltage (applied at terminals on the rear panel) multiplied by 10: $E_{in}/E_{Ref} \times 10$
FILTER (pushbutton)	Depressed	Adds an active three-pole filter across the input circuit when measuring any function but AC. In AC mode, filter is switched in automatically
FRONT/REAR (slide switch)	Front	Selects signal at front set of input terminals for measurement
	Rear	Selects signal at rear set of input terminals for measurement

2.36 Display.

2.37 The display consists of five numerical readout tubes with polarity and function indicators as shown in figure 2.9. Maximum usable readout with overrange is 19999. A one-digit increase (from 19999) results in an overload condition indicated by a readout of 20000 and illumination of the NO indicator.

Figure 2.9 - Readout

2.38 The NO indicator also illuminates when a function or range is selected for which the instrument is not equipped.

2.39 REMOTE PROGRAMMING.

2.40 The instrument accepts commands made through PROGRAM INPUT connector J202 on the rear panel of the instrument. Pin assignments of J202 are shown in figure 2.10. Commands are made by a switch closure from the appropriate pin to ground or by standard TTL logic levels: 0 to .5V, false; +2.4 to +5.0V, true (with respect to ground, pin B3). Either open collector or standard TTL output circuits may be used.

> **NOTE**
>
> Figure 2.10 shows the pin numbering when a Viking mating connector is supplied. On certain instruments, a Cinch connector was supplied. Pin numbering for the Cinch connector is shown in figure 2.11. Command requirements and relative position of the pins are identical; only the pin numbers are different.

2.41 External Program Control.

2.42 A contact closure to ground or a false logic level applied to pin B5 disables all front panel operating controls. Operation of the instrument is then under control of the remote program input. This line duplicates the PROGRAM CONTROL switch on the front panel.

2.43 Function Programming.

2.44 The desired function is selected by applying a ground or false logic level to the appropriate pin:

Table 2.3 - Function Programming

$\overline{\text{DC}}$	pin A9
$\overline{\text{DC/MV}}$	pin B6
$\overline{\text{AC}}$	pin A3
$\overline{\text{OHMS}}$	pin A4
$\overline{\text{RATIO}}$	pin A5
$\overline{\text{FILTER}}$	pin A6

2.45 When selecting AC function with Autorange programmed, it is necessary to also select FILTER (pin A6) in order to obtain proper timeout. This is not necessary when a fixed range is programmed. Timeouts are described under "Read Commands", paragraph 2.52.

2.46 RANGE PROGRAMMING.

2.47 Autorange is selected by a ground or false level at pin A8. Fixed ranges are programmed by applying a positive-true BCD code to the four range lines. See table 2.4.

Table 2.4 - Range Programming

Range	Range A pin A10	Range B pin A7	Range C pin B8	Range D pin B7
1 ohm	1	0	0	0
10 ohms, 10 mV	0	1	0	0
.1 Kilohm, .1V	1	1	0	0
1 Kilohm, 1V	0	0	1	0
10 Kilohm, 10V	1	0	1	0
100 Kilohms, 100V	0	1	1	0
1 Megohm, 1000V	1	1	1	0
10 Megohms	0	0	0	1
100 Megohms	1	0	0	1

2.48 Remote (Output Flag).

2.49 This is an output line to pin A1 that remains true (positive) while the instrument is under remote control.

2.50 + Five Volts.

2.51 This voltage, +5 volts ± 5%, from the logic power supply is available at pin B4 for external use. Current output is .1A, maximum.

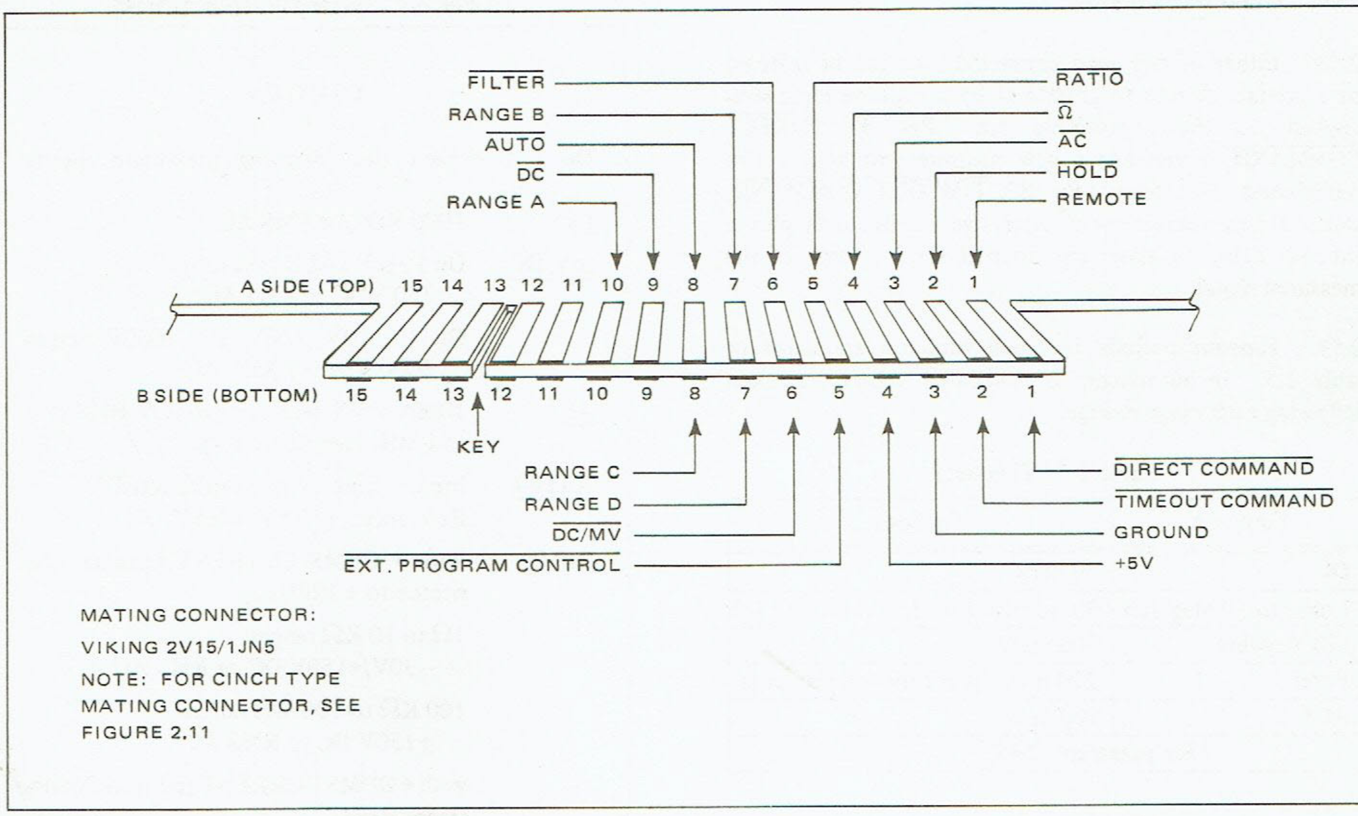


Figure 2.10 - PROGRAM INPUT Connector J202 (Viking)

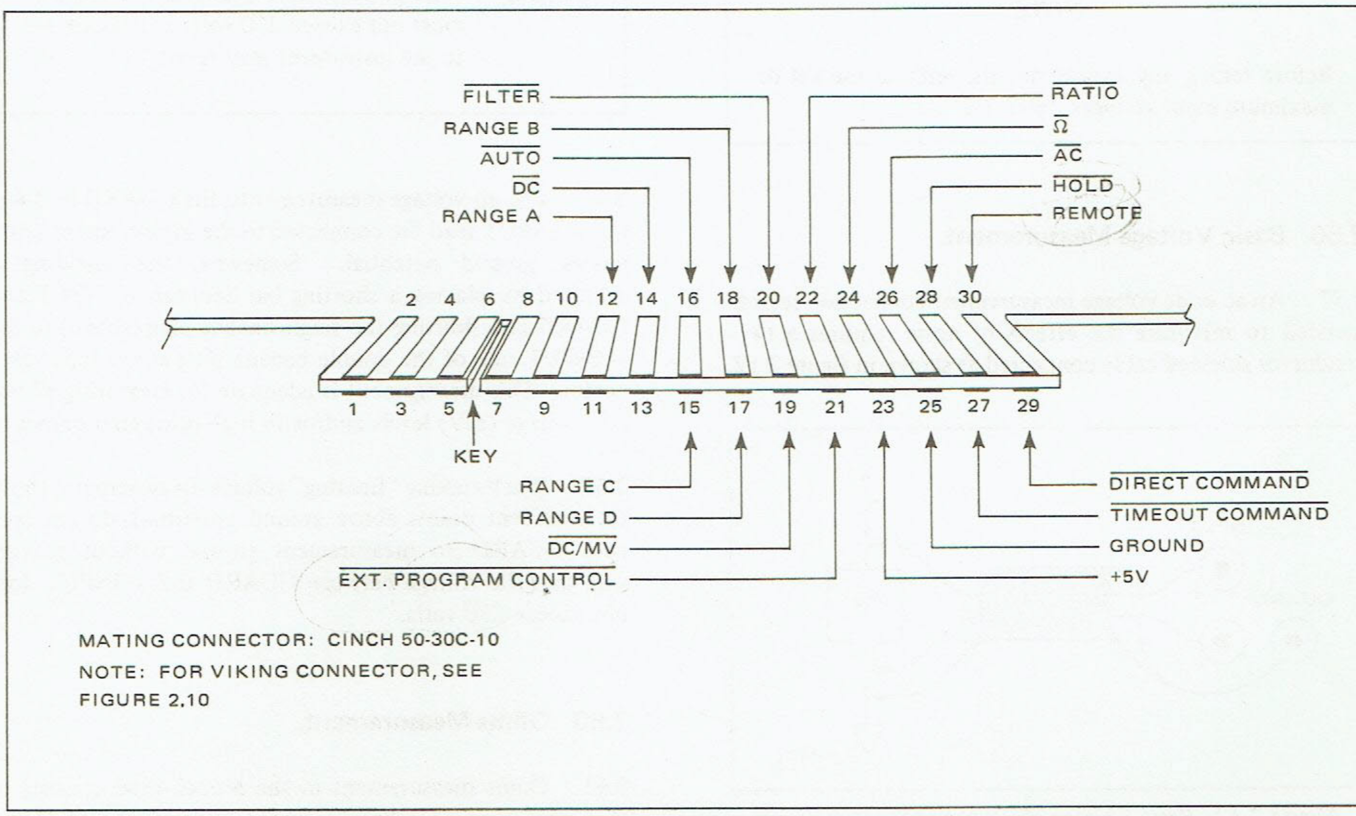


Figure 2.11 - PROGRAM INPUT Connector J202 (Cinch)

2.52 Read Commands.

2.53 Either of two read command lines can be selected by a contact closure to ground or by a negative logic level applied to the appropriate pin. Pin B1, $\overline{\text{DIRECT COMMAND}}$, commands a new measurement after a five millisecond reset delay. Pin B2, $\overline{\text{TIMEOUT COMMAND}}$, starts a new measurement after five milliseconds plus a timeout delay to allow for internal settling time of the measured signal.

2.54 Timeout periods for each function are listed in table 2.5. In autorange, the indicated delays are taken following each range change.

Table 2.5 - Timeouts

Function	Timeout
DC	30 msec
1 ohm to 10 Megohm	30 msec(w-1 out); 300 ms(w-1 in)
100 Megohm	300 msec
Filter	250 msec (plus function timeout)
AC*	500 msec
*See paragraph 2.45	

2.55 MEASUREMENT CONNECTIONS.

NOTE

Before taking any measurements, refer to the list of maximum input voltages, table 2.6.

2.56 Basic Voltage Measurement.

2.57 An ac or dc voltage measurement connection recommended to minimize the effects of noise requires a two-conductor shielded cable connected as shown in figure 2.12.

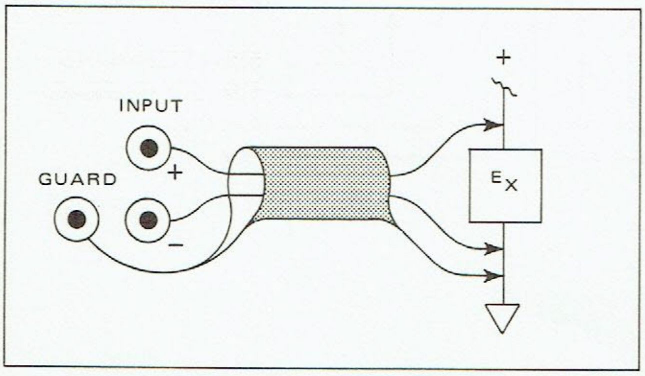


Figure 2.12 - Basic Voltage Measurement Connections

Table 2.6 - Maximum Input Voltage

CAUTION

Do not exceed the following maximum inputs:

DC	1000 VDC or RMS AC
mV/DC	On 10 mV and .1 volt range: 150 VDC or RMS AC On 1V, 10V, 100V, and 1000V ranges: 1000 VDC or RMS AC
AC	1000V RMS decreasing to 20V RMS at 1 MHz (see figure 1.7)
RATIO	Input: same as function selected Reference: +10.5V, −0.5V
OHMS	With + OHMS CURRENT terminal connected to + INPUT: 1Ω to 10 KΩ ranges: −30V/+150V DC or RMS AC 100 KΩ to 100 MΩ ranges: ±150V DC or RMS AC with + OHMS CURRENT terminal floating (from input): ±150V DC or RMS AC
GUARD	Voltage between GUARD and − INPUT must not exceed 250 volts or damage to the instrument may result

2.58 For all voltage measurements, the GUARD lead and the − INPUT lead are connected to the measurement point nearest ground potential. Somewhat less shielding is achieved by placing a shorting bar between − INPUT and GUARD and shorting the single banana plug (shield) to the − INPUT side of the double banana plug at the input connector. This arrangement is adequate for measuring all but low voltage (mV) levels and/or in high-noise environments.

2.59 When making "floating" voltage measurements (both measurement points above ground potential), do not connect GUARD to measurement ground without making sure that the voltage between GUARD and − INPUT does not exceed 250 volts.

2.60 Ohms Measurement.

2.61 Ohms measurement in the Model 4800 consists of the application of a known current through the unknown

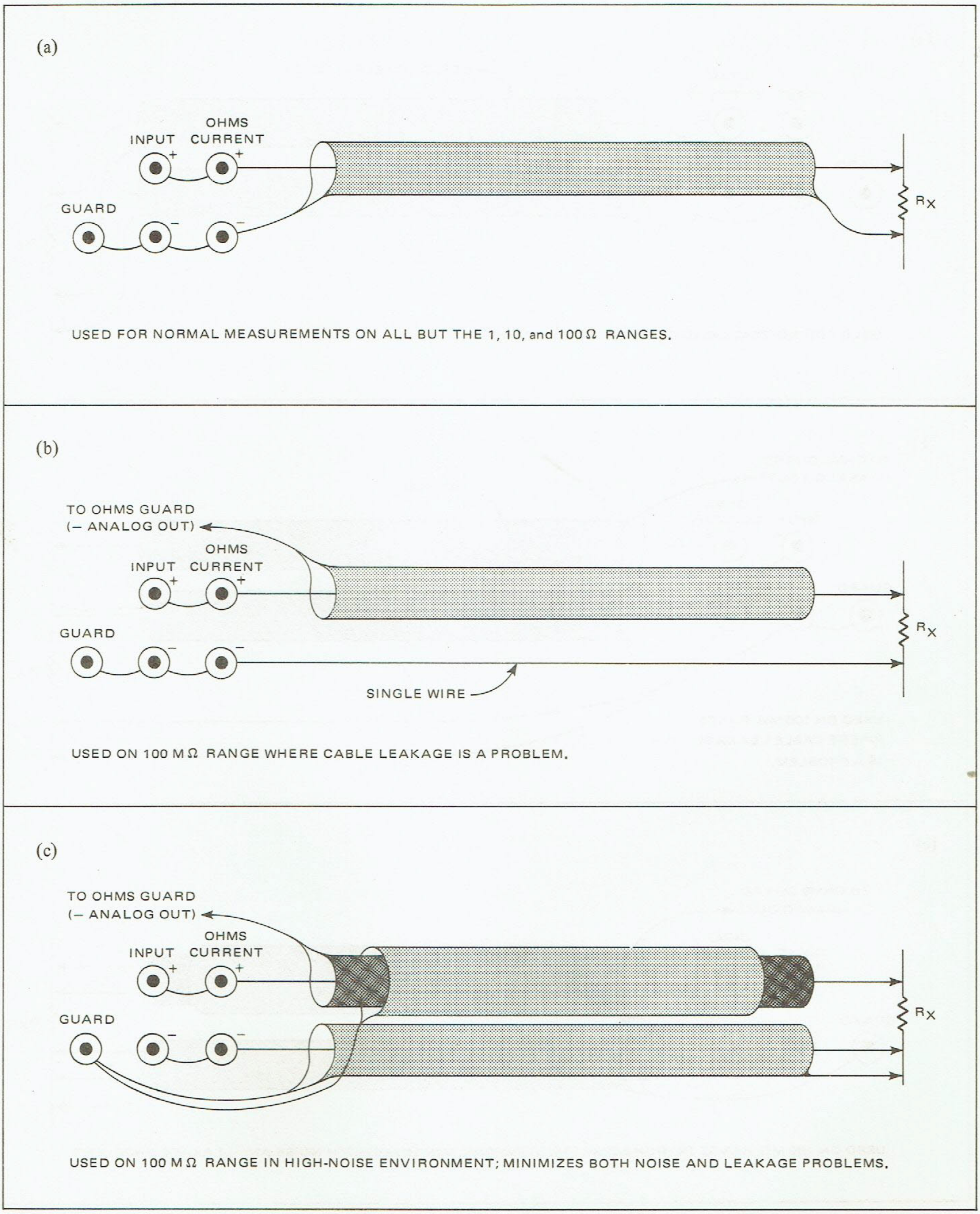


Figure 2.13 - Two Wire Ohms Measurements

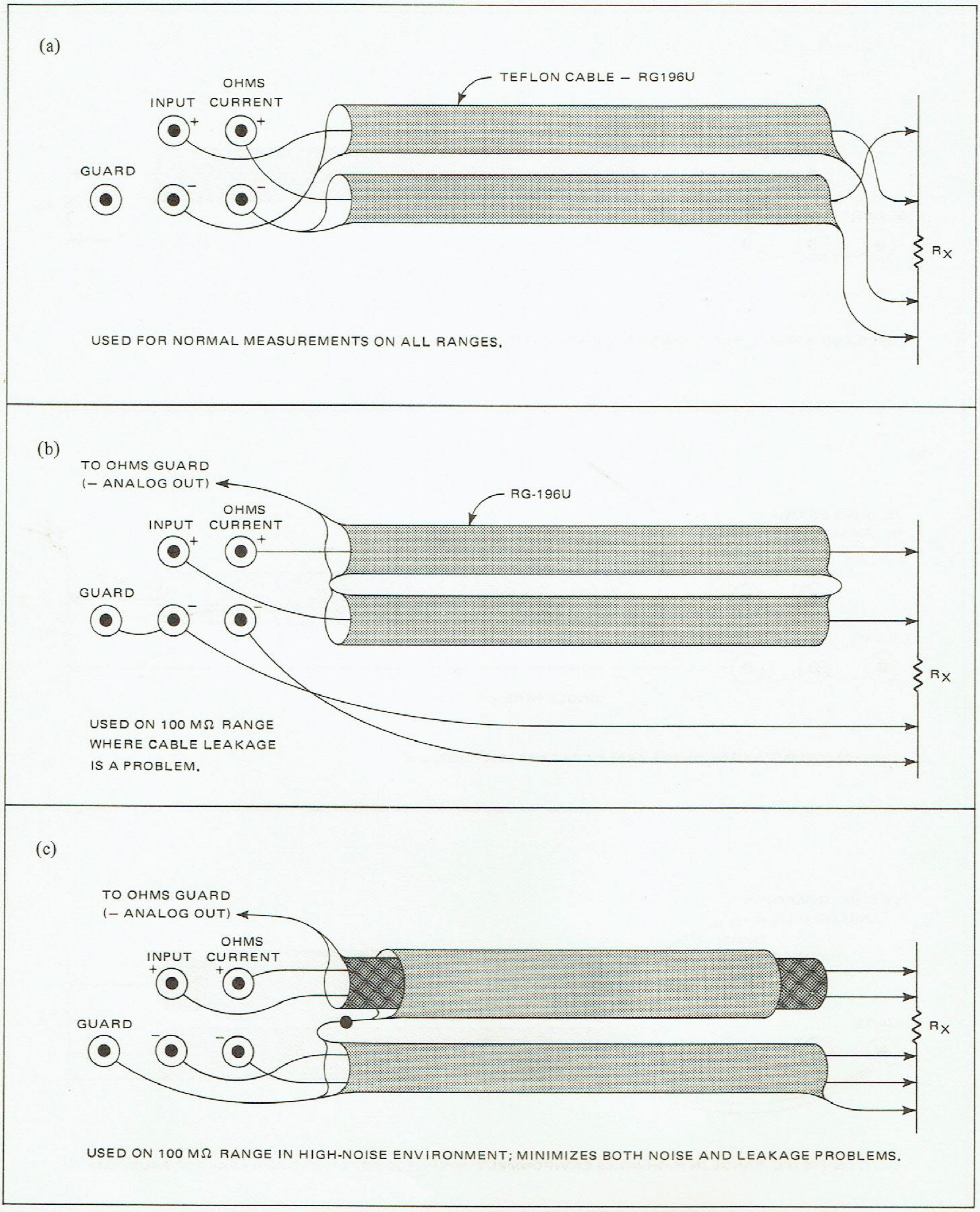


Figure 2.14 - Four Wire Ohms Measurement

resistance (R_X) and measuring the ratio of the voltage drop across R_X to the drop across an internal "full-scale" resistor (E_{RX}/E_{FS}). Current through R_X is applied through leads from the ± OHMS CURRENT terminals. The voltage drop is sensed by the ± INPUT terminals.

2.62 TWO-WIRE MEASUREMENTS.

2.63 Connections for a simple two-wire shielded ohms measurement are shown in figure 2.13a. It consists simply of a single-conductor shielded cable with the conductor serving as both the + CURRENT and + INPUT leads and the shield carrying – CURRENT and – INPUT. While reasonably accurate measurements can be made with this method, shunt leakage problems result from the parallel combinations of R_X and the cable impedance. This causes loss of accuracy, especially at high resistance (100 MΩ range).

2.64 A more accurate two-wire measurement connection is shown in figure 2.13b. The + INPUT and + CURRENT, – INPUT and – CURRENT terminals are again tied together. But now, the positive side is a single-conductor, shielded cable with the shield tied to Ohms Guard. Ohms Guard is the low ANALOG OUTPUT terminal on the rear panel of the Model 4800 when ohms is selected. The negative side is a single wire connected as shown. Guard current is present in the low side, but the leakage problems of the first configuration are eliminated.

2.65 In high noise-level environments, the configuration shown in figure 2.13c is recommended. This method also eliminates error due to shunt leakage, but provides more complete shielding. The positive terminals are tied together and carried in a single-conductor, double-shielded cable with the inner shield tied to Ohms Guard (– ANALOG OUTPUT). The outer shield is tied to GUARD. The negative terminals are tied together and carried in a single-conductor shielded cable with the shield tied to GUARD. This configuration eliminates guard current sensitivity, thereby increasing guarding characteristics.

2.66 FOUR-WIRE MEASUREMENTS.

2.67 In most system applications, the device to be measured is located at a remote location requiring interconnection by cables of lengths from several to possibly hundreds of feet. When measuring low resistance values over long cables, most lead resistance problems can be solved by the use of a four-wire measurement system.

2.68 For high resistance measurements over long cables, other problems are encountered: noise pick-up, leakage resistance, and capacitive loading of the system. These problems can be minimized by proper shielding and the use of ohms guard.

2.69 Figure 2.14a shows a basic shielded four-wire ohms measurement configuration. This method uses two single-conductor shielded teflon cables. The conductors carry the positive sides of the INPUT and CURRENT lines while each shield carries the low side.

2.70 This configuration, although shielded, places the shield capacitance and cable leakage in parallel with R_X. This results in loss of accuracy and slow measurements. In addition, it is very responsive to the triboelectric effect at high resistance measurements.

2.71 Better guarding is achieved by the use of the configuration shown in figure 2.14b. Here again, RG196U teflon dielectric cable (either single-conductor shielded or two-conductor shielded) is used on the positive terminals. The shield(s) are connected to Ohms Guard (low ANALOG OUTPUT terminal). The negative leads are single wires with the – INPUT terminal tied to GUARD.

2.72 This eliminates much of the shunt leakage problem of the previous configuration since guard current now flows through the low side of the measurement circuit. Measurement is much faster since the shield capacity is driven by the guard current.

2.73 A high-noise environment calls for the "super" configuration shown in figure 2.14c. Here, a two-conductor, double-shielded cable is used as the positive leads. The inner shield is tied to Ohms Guard. A two-conductor shielded cable is used as the negative leads. Its shield is tied to GUARD and to the outer shield of the positive cable. The shield is also tied to – CURRENT at the measurement point. This configuration maintains high guarding characteristics while eliminating guard current sensitivity.

2.74 Ratio Measurements.

2.75 Ratio measurements are made by applying a positive d-c voltage to the reference input terminals on the rear panel and an input signal of any function at the front input terminals. For DC/DC, DC-MV/DC, or AC/DC ratios, the reference voltage must be within the range of +.5V to +10.5V. For Ω/DC ratio, the reference voltage must be within +9V to +10.5V. Input signal limitations (numerator) are the same as those given for conventional measurement of the particular function (table 2.6). The readout is the ratio multiplied by ten: $E_{input}/E_{reference} \times 10$. The – INPUT terminal is internally connected to the – REF input terminal.

2.76 ADDING/REMOVING ACCESSORIES.

2.77 The AC, mV, or Ohms/mV accessories may be added or removed at any time in the field without modification to the basic instrument. Note that switching board (403431) is required whenever accessories are used. Access to the accessory mounting connectors is by removal of the top cover and shield as described in paragraph 5.8.

2.78 When an accessory is added or removed from the instrument, a jumper corresponding to the accessory is removed or added to allow proper operation of the NO circuitry. The three jumpers (W1, W2, and W3) are located on the display board, shown partially in figure 2.15. When an accessory is added, the corresponding jumper is removed; conversely, when an accessory is removed, the jumper is added as shown in table 2.7.

Table 2.7 - Accessory Jumpers

Accessory	Jumper
AC	W1
Preamp	W2
Preamp/Ohms	W2, W3

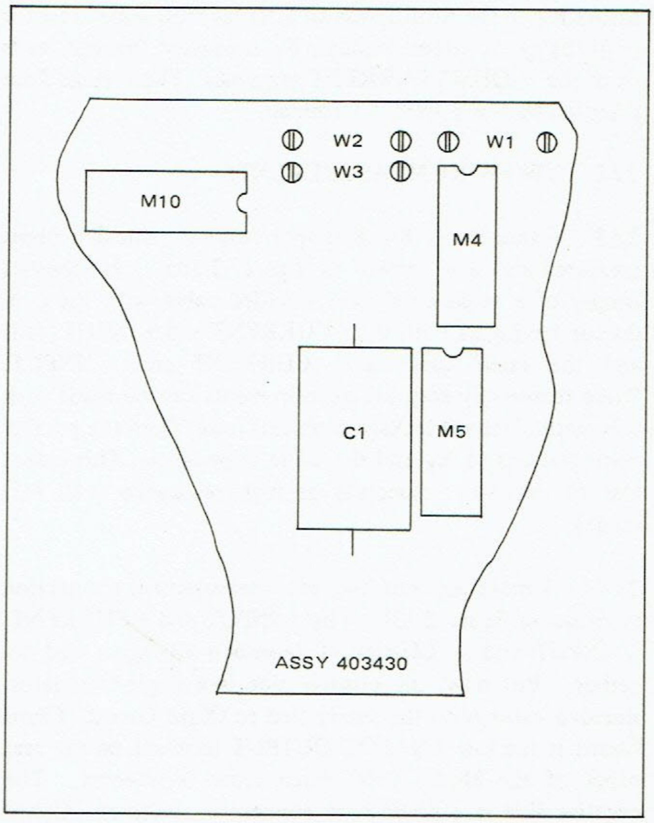


Figure 2.15 - Jumper Location

3.1 GENERAL.

3.2 This procedure is designed to insure that the instrument is operating properly and within its specifications. If any of the readings are not within tolerance, refer to the calibration procedure. If the instrument fails to operate properly, refer to the troubleshooting procedure.

3.3 PREPARATION.

3.4 Allow one hour warmup time for the instrument to reach full accuracy.

3.5 EQUIPMENT.

3.6 A list of equipment is provided in table 3.1.

3.7 PROCEDURE.

3.8 Connect the DVM and test equipment as shown in the figure supplied with each accuracy check. Select the controls and inputs as called out in the tables and monitor the DVM readout for the indicated values.

Table 3.1 - Required Equipment

TYPE	REQUIRED SPECS	SUGGESTED EQUIPMENT
DC Voltage Standard	Adjustable: 0 to 1000V RMS Resolution: 1 μV on 10V range Accuracy: ± .003%	Fluke 332A
Decade Voltage Divider	.005% Accuracy	ESI Model RV622A
AC Laboratory power source	Variable: 0 to 500V RMS & 20 Hz to 100 KHz. Resolution better than 100 PPM. Harmonic distortion of 0.1% or less. Stability of .01%	HP 745/746
Thermal Transfer voltmeter [1]	AC/DC thermal transfer voltmeter. Ranges: 1 to 500V. Accuracy 0.05% or better	Holt Model 6 Thermal Transfer Voltmeter
Standard Resistors [2]	1, 10, 100 Megohms; 1, 10, 100 Kohm; 1, 10, 100 Ohm. All ± .005% except 10 Megohm and 100 Megohm which are ± .01%	ESI SR-1 series standard resistors
1/4W Carbon Resistors	10, 100 Kohm and 100 Ohm	
Capacitor	1 μF (non polar)	
Batteries, 2 required	1.5V cells having screw type binding posts	

[1] Required for instruments equipped with AC Option only

[2] Required for instruments equipped with OHMS Option only

Table 3.2 - DC Range Check (Low Ranges)

DVM		INPUT SIGNAL				
FUNCTION	RANGE	DC VOLTAGE STANDARD	DIVIDER SETTING	NOMINAL READING	TOLERANCE	NOTE
mV/DC	10 mV	10.00000	.00100	10.000	09.999 - 10.001	$23^{o}C \pm 5^{o}C$ (After zeroing)
DC	100 mV	10.00000	.01000	100.00	099.99 - 100.01	
	1V	10.00000	.10000	1.0000	0.9999 - 1.0001	

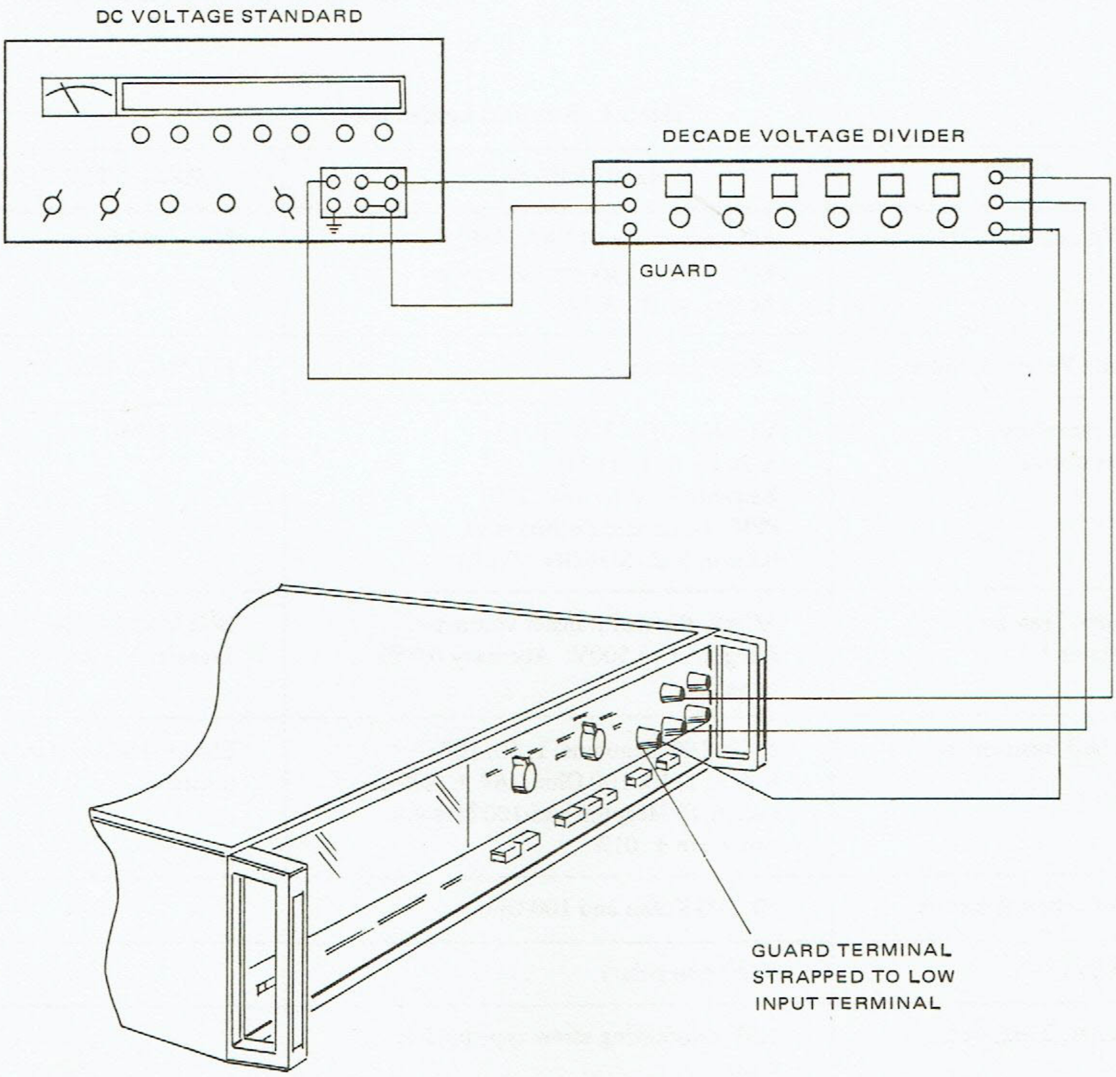


Table 3.3 - DC Range Check (High Ranges)

DVM		INPUT SIGNAL				
FUNCTION	RANGE	DC VOLTAGE STANDARD		NOMINAL READING	TOLERANCE	NOTE
DC	10	10.0000V		10.000	9.999 - 10.001	23°C ± 5°C (After zeroing)
	100	100.000V		100.00	99.99 - 100.01	
	1000	1000.00V		1000.0	999.9 - 1000.1	

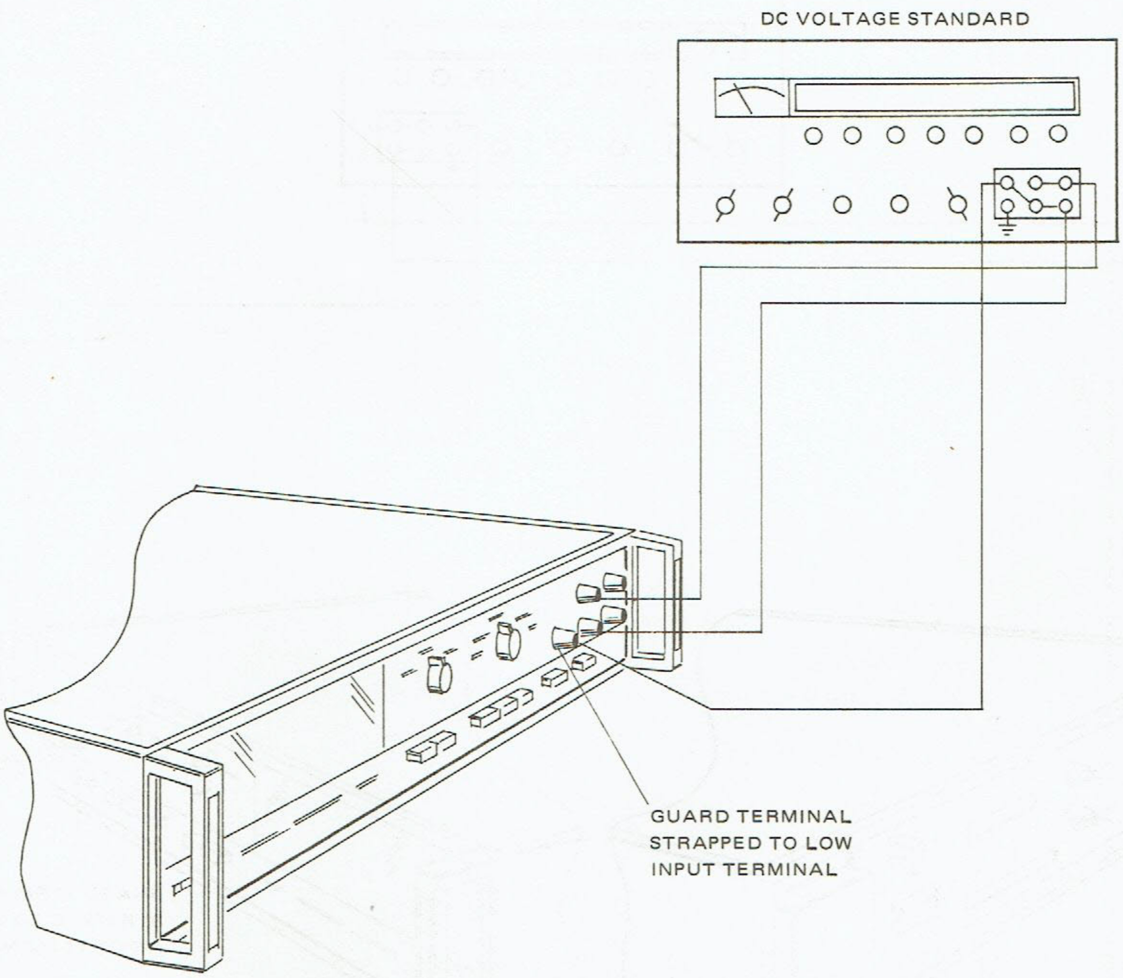


Table 3.4 - Ratio Check

DVM		INPUT SIGNAL		NOMINAL READING	TOLERANCE	NOTE
FUNCTION	RANGE	DC VOLTAGE STANDARD				
DC	10	+ 2.00000V		10.000	9.990 - 10.010	23^{o}C ± 5^{o}C (After zeroing)
RATIO	10	+10.00000V		10.000	9.999 - 10.001	

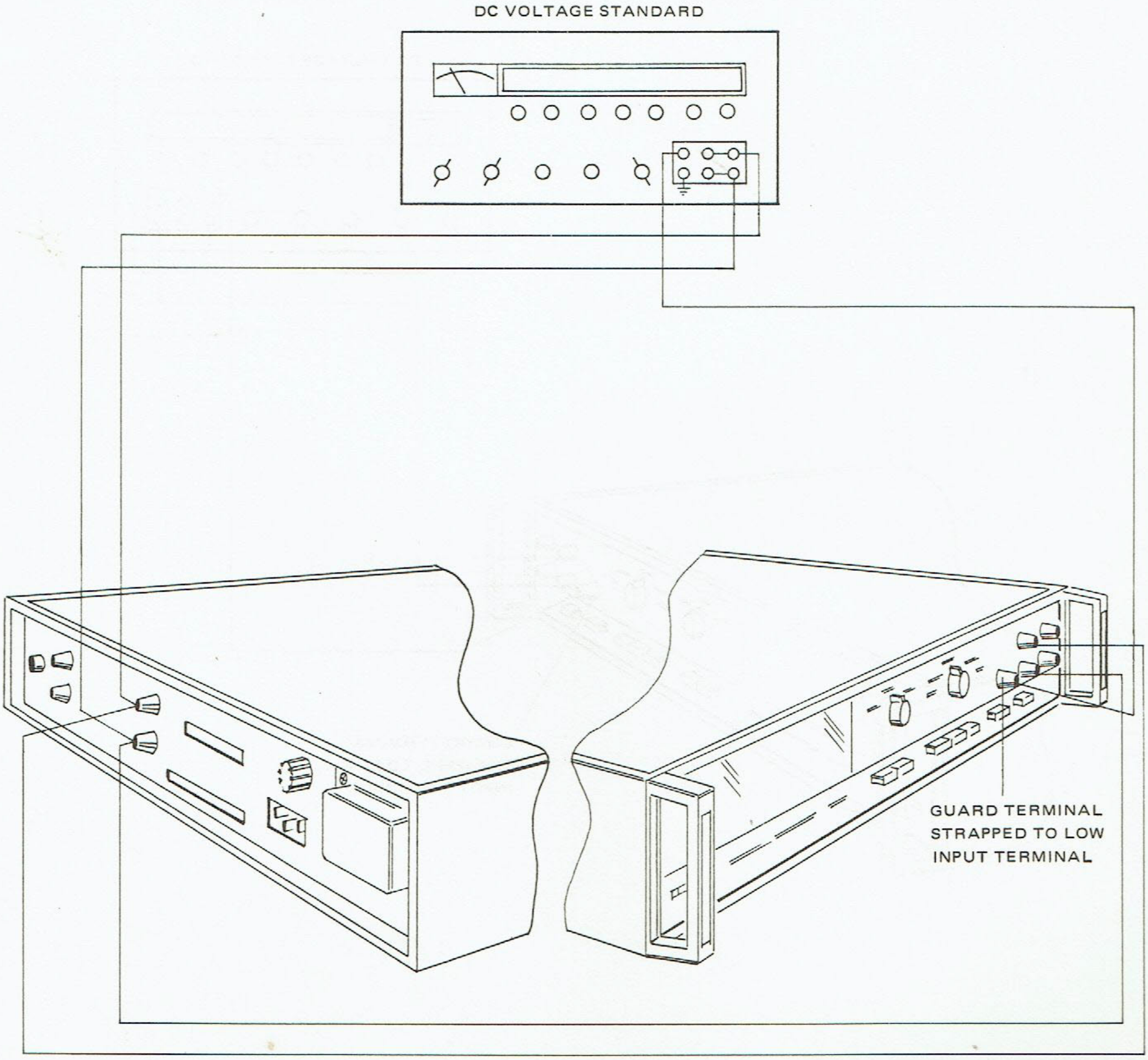


Table 3.5 - DC Linearity Check

DVM		INPUT SIGNAL		NOMINAL READING	TOLERANCE	
FUNCTION	RANGE	DC VOLTAGE STANDARD				
DC	100	90.0000		90.00	89.99 - 90.01	
		80.0000		80.00	79.99 - 80.01	
		70.0000		70.00	69.99 - 70.01	
		60.0000		60.00	59.99 - 60.01	
		50.0000		50.00	49.99 - 50.01	
		40.0000		40.00	39.99 - 40.01	
		30.0000		30.00	29.99 - 30.01	
		20.0000		20.00	19.99 - 20.01	

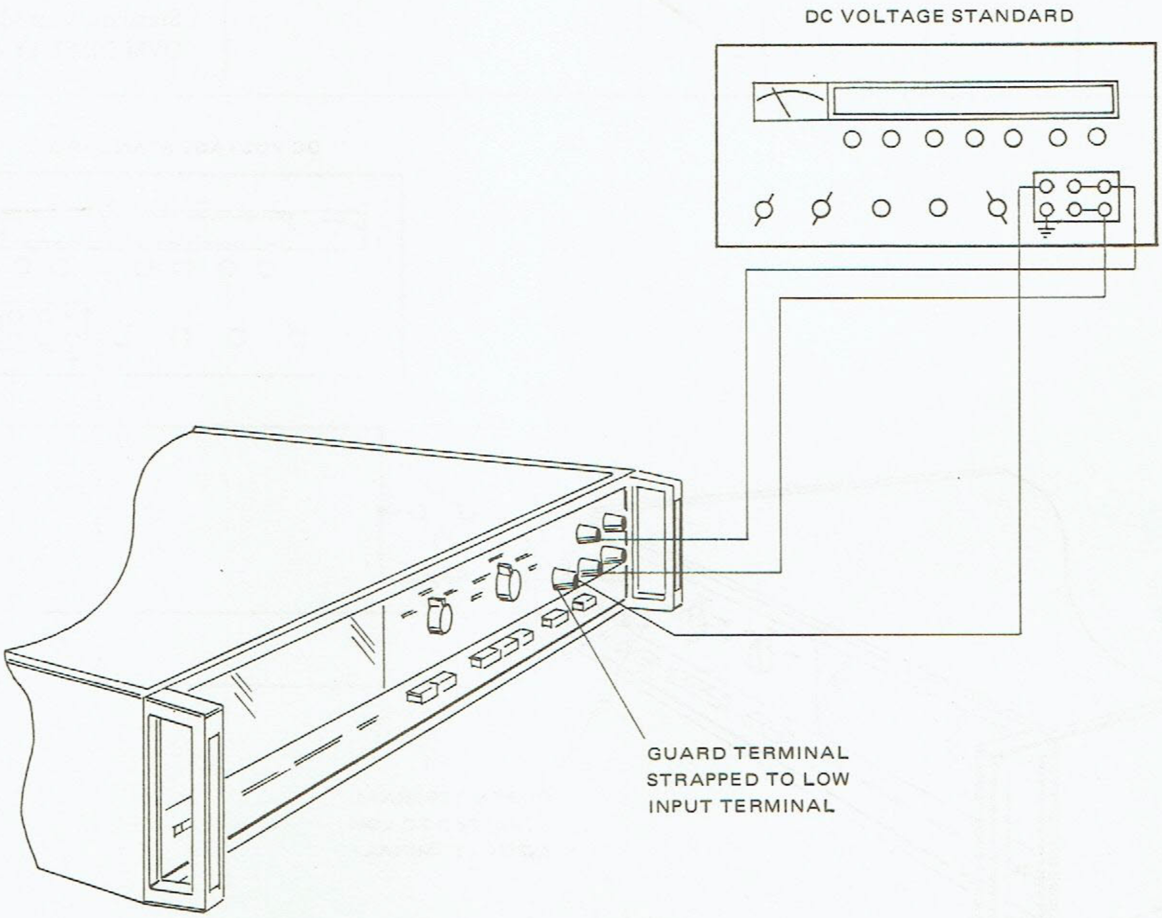


Table 3.6 - DC Input Resistance

DVM		INPUT SIGNAL		DVM DISPLAY	TOLERANCE	NOTE
FUNCTION	RANGE	DC VOLTS*	S1			
DC	0.1	.100000	Closed	.10000		Rs
			Open		.09998 - .10002	100 KΩ
	1	1.000000	Closed	1.0000		
			Open		0.9999 - 1.0001	100 KΩ
	10	10.00000	Closed	10.000		
			Open		9.999 - 10.001	100 KΩ
	100	100.0000	Closed	100.00		
			Open		99.99 - 100.01	1 KΩ
	1000	1000.000	Closed	1000.0		
			Open		999.9 - 1000.1	1 KΩ
						*Adjust the DC Voltage Standard to produce the DVM DISPLAY reading.

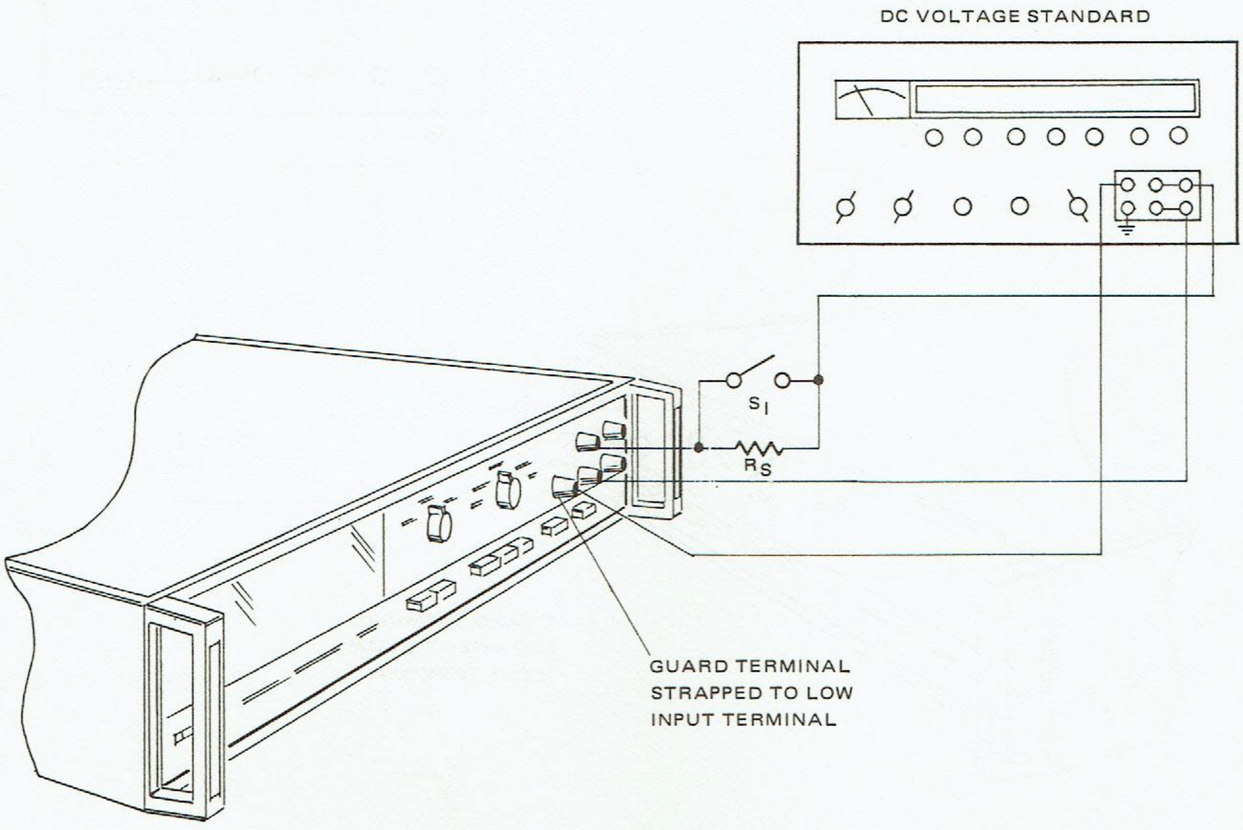


Table 3.7 - DIAC Range Check

DVM		INPUT SIGNAL		NOMINAL READING	TOLERANCE	NOTE
FUNCTION	RANGE	DC VOLTAGE STANDARD	AC			
AC	.1	.100000	0.1V, 10 KHz	.10000	.09986 - .10014	Set thermal transfer voltmeter to same range as the DMM
		.100000	0.1V, 50 KHz	.10000	.09980 - .10020	
	1	1.000000	1.V, 10 KHz	1.0000	0.9994 - 1.0006	
		1.000000	1.V, 50 KHz	1.0000	0.9992 - 1.0008	Adjust the amplitude controls on the AC source to produce a Null on the thermal transfer voltmeter, for each new setting
	10	10.00000	10V, 10 KHz	10.000	09.994 - 10.006	
		10.00000	10V, 50 KHz	10.000	09.992 - 10.008	
	100	100.0000	100V, 10 KHz	100.00	099.94 - 100.06	
		100.0000	100V, 50 KHz	100.00	099.92 - 100.08	
	1000	125.0000	125V, 10 KHz	125.00	0124.7 - 0125.3	
		125.0000	125V, 50 KHz	125.00	0124.6 - 0125.4	
						$23^{o}C \pm 5^{o}C$

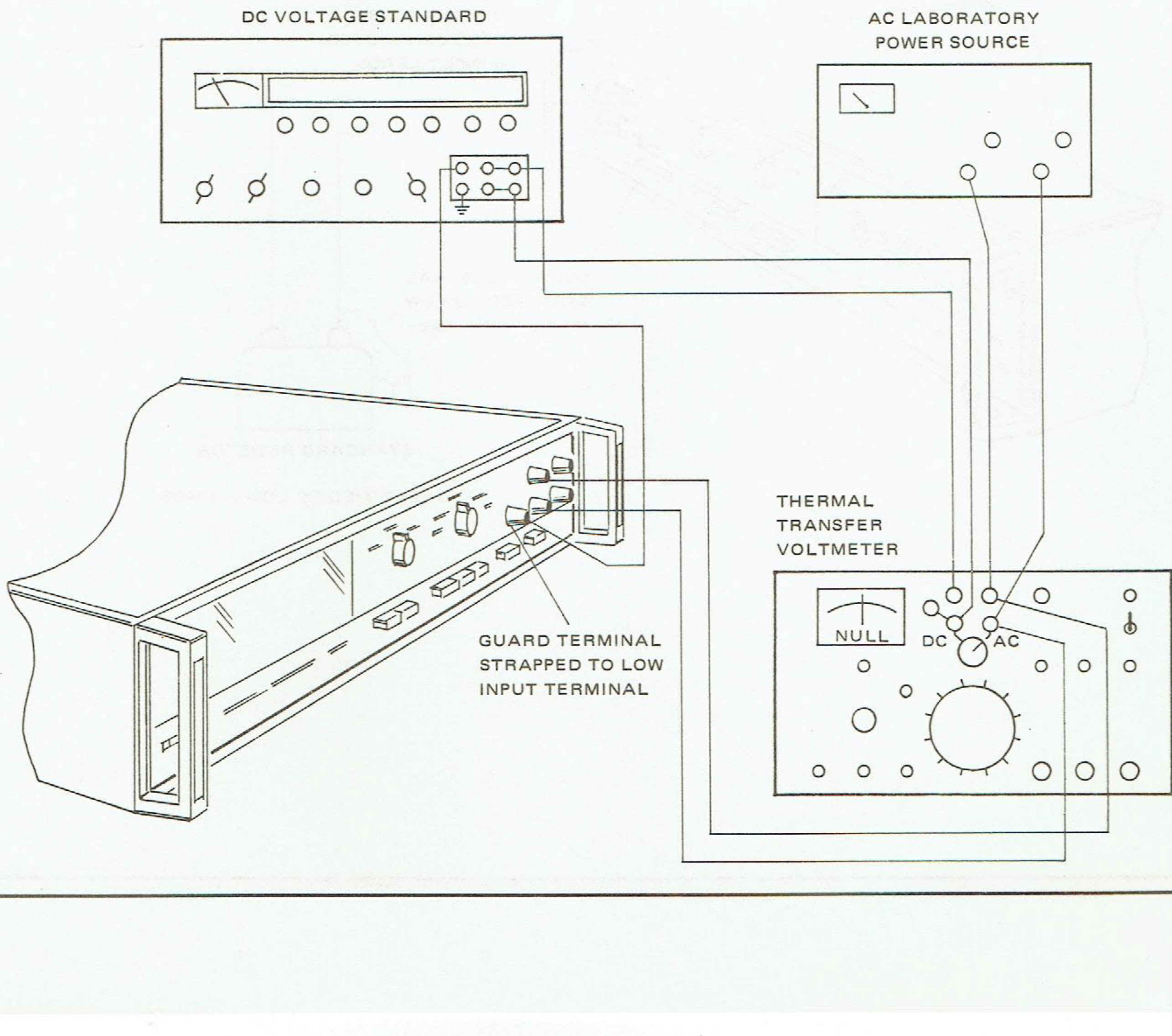


Table 3.8 - Ohms-Megohms Range Check

DVM		INPUT SIGNAL		NOMINAL READING (Same as Standard)	TOLERANCE
FUNCTION	RANGE	NOMINAL STANDARD VALUE	TOLERANCE		
	1Ω	1Ω	.005%		±7 digits
	10Ω	10Ω	.001%		±3 digits
	100Ω	100Ω	.001%		±3 digits
	1 kΩ	1 kΩ	.001%		±3 digits
	10 kΩ	10 kΩ	.001%		±3 digits
	100 kΩ	100 kΩ	.001%		±3 digits
	1 MΩ	1 MΩ	.001%		±3 digits
	10 MΩ	10 MΩ	.005%		±9 digits
	100 MΩ	100 MΩ	.02%		±31 digits

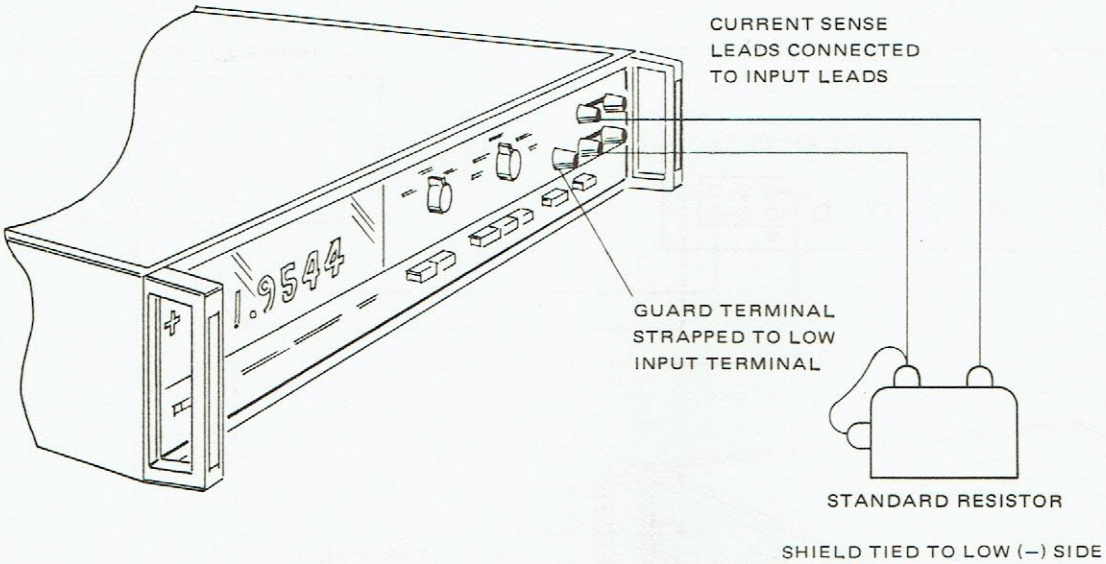


Table 3.9 - Ohms-Megohms Range Check

DVM		INPUT SIGNAL		NOMINAL READING (Same as Standard)	TOLERANCE
FUNCTION	RANGE	NOMINAL STANDARD VALUE	TOLERANCE		
Ω - MΩ	1Ω	1Ω	.005%		±7 digits
	10Ω	10Ω	.001%		±3 digits
	100Ω	100Ω	.001%		±3 digits
	1 kΩ	1 kΩ	.001%		±3 digits
	10 kΩ	10 kΩ	.001%		±3 digits
	100 kΩ	100 kΩ	.001%		±3 digits
	1 MΩ	1 MΩ	.001%		±3 digits
	10 MΩ	10 MΩ	.005%		±9 digits
	100 MΩ	100 MΩ	.02%		±31 digits

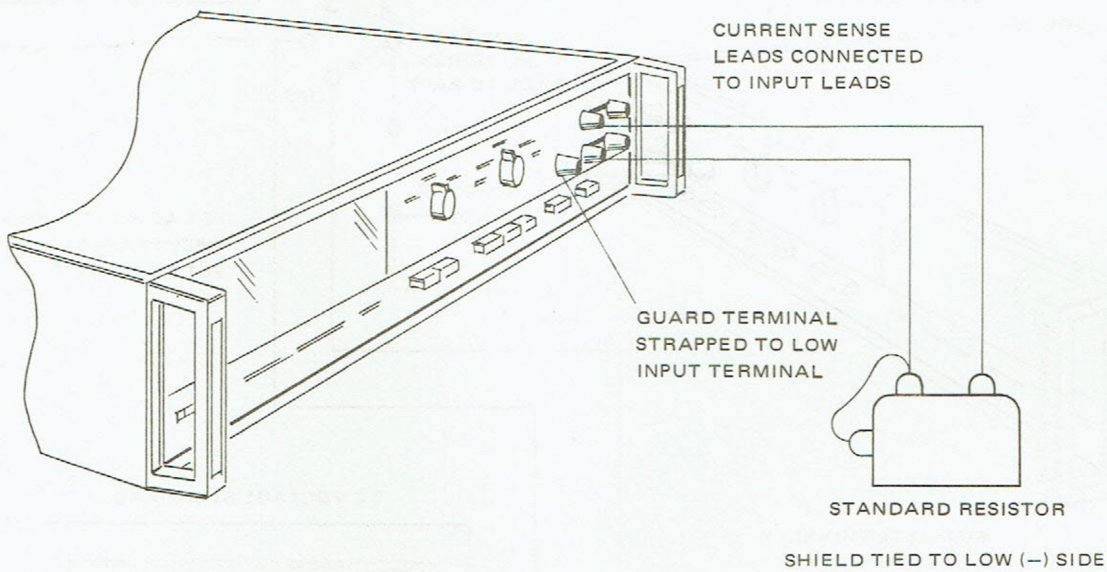


Table 3.10 - Common Mode Rejection (In DC Volts Function)

DVM		INPUT SIGNAL		NOMINAL READING See Note 1	TOLERANCE	NOTE
FUNCTION	RANGE	S1				
DCV FILT. OUT	0.1	Off			±1 digit from nominal	1) With switch S-1 in the off position, record the reading displayed on the DMM's readout in the "nominal reading" boxes of the table. DC: ±5 digits=140 dB AC: ±25 digits=120 dB ±12 digits=126 dB
		DC			±5 digits from nominal	
		AC			±25 digits from nominal	
DCV FILT. IN	0.1	DC			±5 digits from nominal	
		AC			±12 digits from nominal	

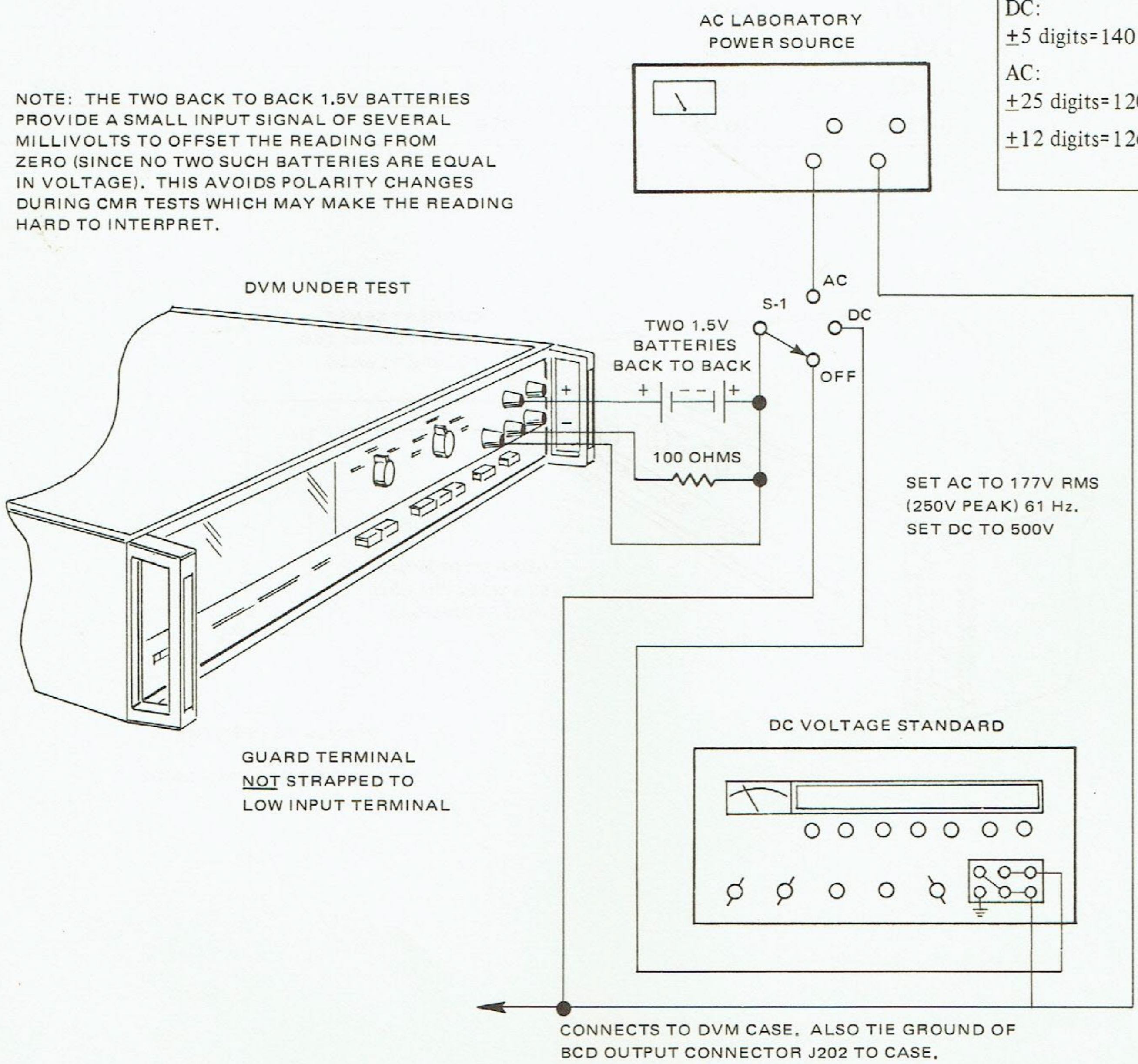


Table 3.11 - Normal Mode Noise Rejection (In DC Volts Function)

DVM		INPUT SIGNAL		NOMINAL READING	TOLERANCE	NOTE
FUNCTION	RANGE	DC	AC			
DC FILT. OUT	10	0.5V		00.500	±1 digit	
		0.5V	10V*, 60 Hz	00.500	±40 digits	
FILT. IN	10	0.5V	10V*, 59 Hz	00.500	±40 digits	
	1	0.5V	10V*, 300 Hz	0.5000	±3 digits	

*peak

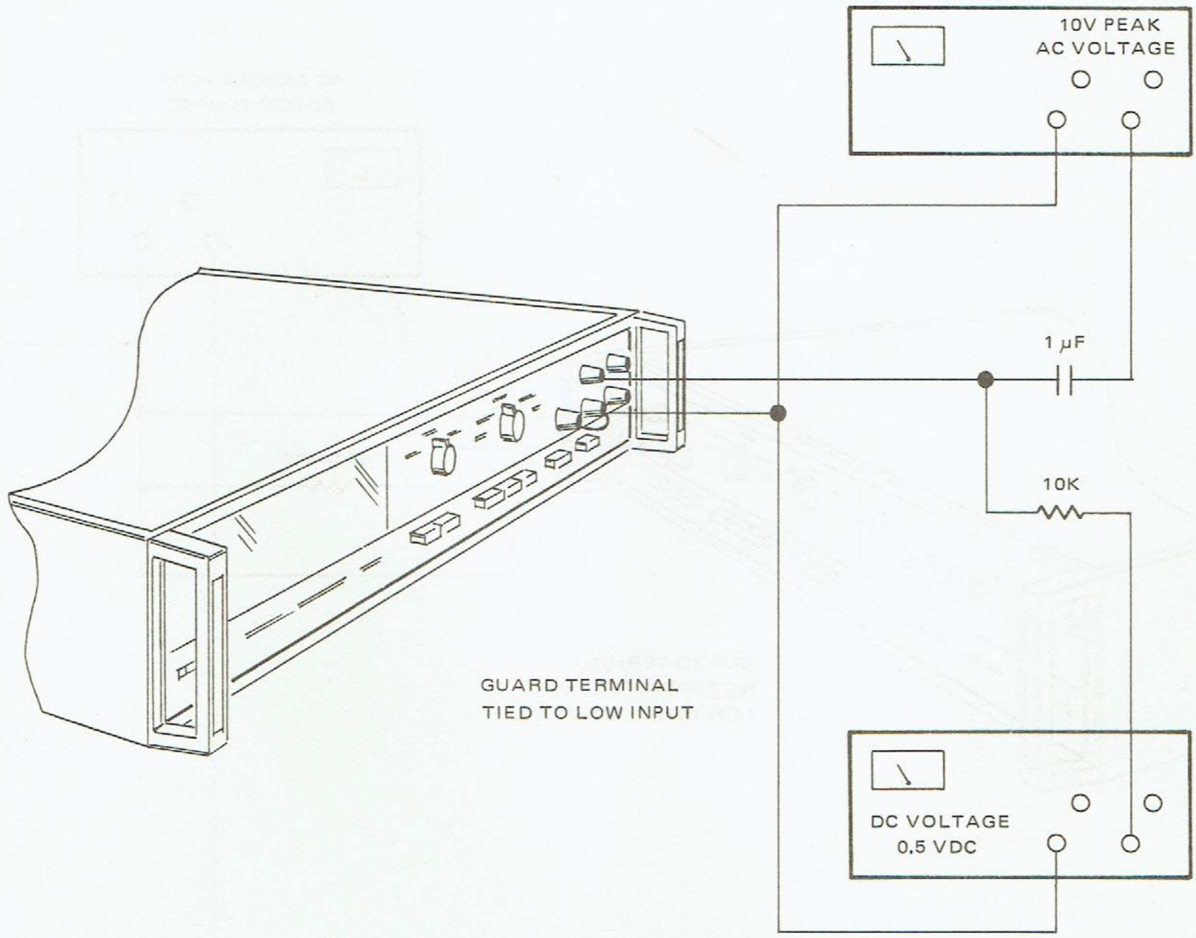
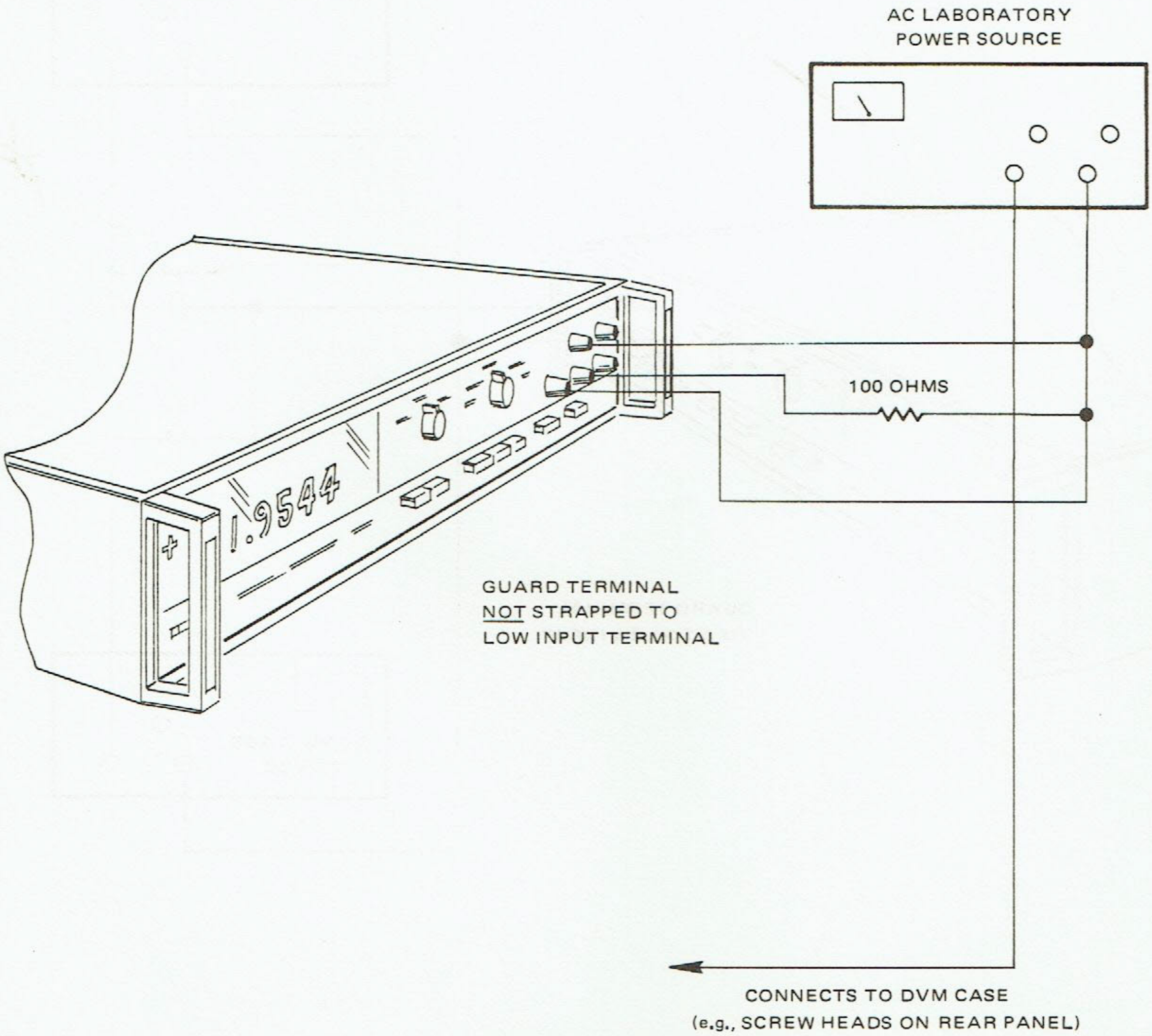


Table 3.12 - Common Mode Rejection (In AC Volts Function)

DVM		COMMON MODE INPUT SIGNAL		NOMINAL READING (see note)	TOLERANCE	NOTE
FUNCTION	RANGE	VOLTAGE	FREQ.			
AC	1	200V P.P.	60 Hz		±1 digit	Enter reading with shorted input in nominal column before beginning
	10	200V P.P.	60 Hz		±1 digit	
	100	200V P.P.	60 Hz		±1 digit	
	1000	200V P.P.	60 Hz		±1 digit	
	0.1	200V P.P.	60 Hz		±10 digits	



4.1 GENERAL.

4.2 This section covers the general theory of the Model 4800 DVM. The instrument is defined in terms of its operating principles and the sequence of a normal measurement. Each board is then described individually. All drawings in this section are simplified for the purpose of this description and serve only to supplement the complete schematics of Section 6.

4.3 The Model 4800 DVM is a dual-slope integration instrument consisting of three major functional parts: signal conditioning, integrating, and display. The signal conditioning section consists of the switching card, a-c converter, ohms converter, millivolt converter (preamplifier), attenuator, isolator, and filter. The function of these components is to convert the incoming signal to a stable d-c signal, scaled to 10 volts full-scale. The integrating section consists of the integrator, amplifier, null detector, and the plus and minus reference supplies. The purpose of these components is to convert the conditioned input signal into an equivalent time-period and transmit this time period to the display portion of the DVM. The signal conditioning and integrating portions are floating and isolated from the grounded display to achieve high common mode rejection. All digital inputs and outputs are interfaced through the display section.

4.4 The display section consists of the program logic, range logic, clock, counter, storage, readout, remote program, and BCD output. The purpose of the display portion is to control the signal conditioning and integrating portions and to convert the time-period generated by integrator into a numeric value for display by the readout.

4.5 PROGRAM STATES.

4.6 The Model 4800 is shown in a simplified block diagram form in figure 4.1 and a program sequence timing diagram in figure 4.2. Referring to these figures, the instrument follows four well-defined program states, generated by two flip-flops (designated A and B) in the program logic.

4.7 PGM-0.

4.8 PGM-0 is the reset state, with the value of the previous DVM reading displayed on the readout and the instrument prepared to accept a command for a new reading. This step is defined by the program logic flip-flops being in the state $\overline{A} \cdot \overline{B}$. Read commands are generated in three ways: internally, every 250 milliseconds + reading time with PERIODIC selected; externally, by depressing the SINGLE switch on the front panel with HOLD selected; or remotely, by externally generating a command pulse with REMOTE selected. The command pulse, regardless of how produced, initiates a five-millisecond delay during which the integrator is reset to zero.

4.9 PGM-1.

4.10 At the completion of the 5 ms delay; the program logic advances to $A \cdot \overline{B}$ and the signal integrate sequence (PGM-1) begins. The signal integrate period converts the conditioned input signal into an equivalent charge which is a function of the input value and the integration period. At the beginning of the signal integration period, the count line is enabled, permitting clock pulses to advance the counter at the clock rate (600 kHz). Simultaneously, the integrator reset is disabled and the isolator gate is enabled permitting the integrator to charge at a rate determined by the input signal. After 16-2/3 milliseconds, the counter overflows (10,000 clock cycles) and the signal integration period is complete.

4.11 PGM-2.

4.12 PGM-2 is the reference integration state. The counter overflow advances the program logic to $A \cdot B$ and a 16.7* microsecond delay pulse is generated. The isolator gate is disabled, the polarity of the input signal is determined, and the reference gate is enabled (the gate is selected which connects the integrator input to the reference having the opposite polarity as the input signal). During the delay pulse, the counter is held at zero by the counter reset (for ten clock counts) to permit settling of the integrator. At the end of the delay, the reset is disabled and the counter again advances at the clock rate. The integrator begins discharging at a rate determined by the reference voltage. The time required for the integrator to discharge is measured by the clock-counter and is determined by the initial charge developed during the signal integration period. The state PGM-2 is completed when the integrator charge returns to zero and is indicated by the zero axis-crossing signal. The time required for the period to elapse is the sum of the 16.7 microsecond delay and the time interval of the reference integration (zero to 33.3 milliseconds with 100% overrange).

4.13 PGM-3.

4.14 When the zero axis signal is produced, the program logic is advanced to $\overline{A} \cdot B$, the strobe step. A strobe pulse (one clock pulse) is generated, commanding the transfer of

*For 50 Hz instruments; see figure 4.2

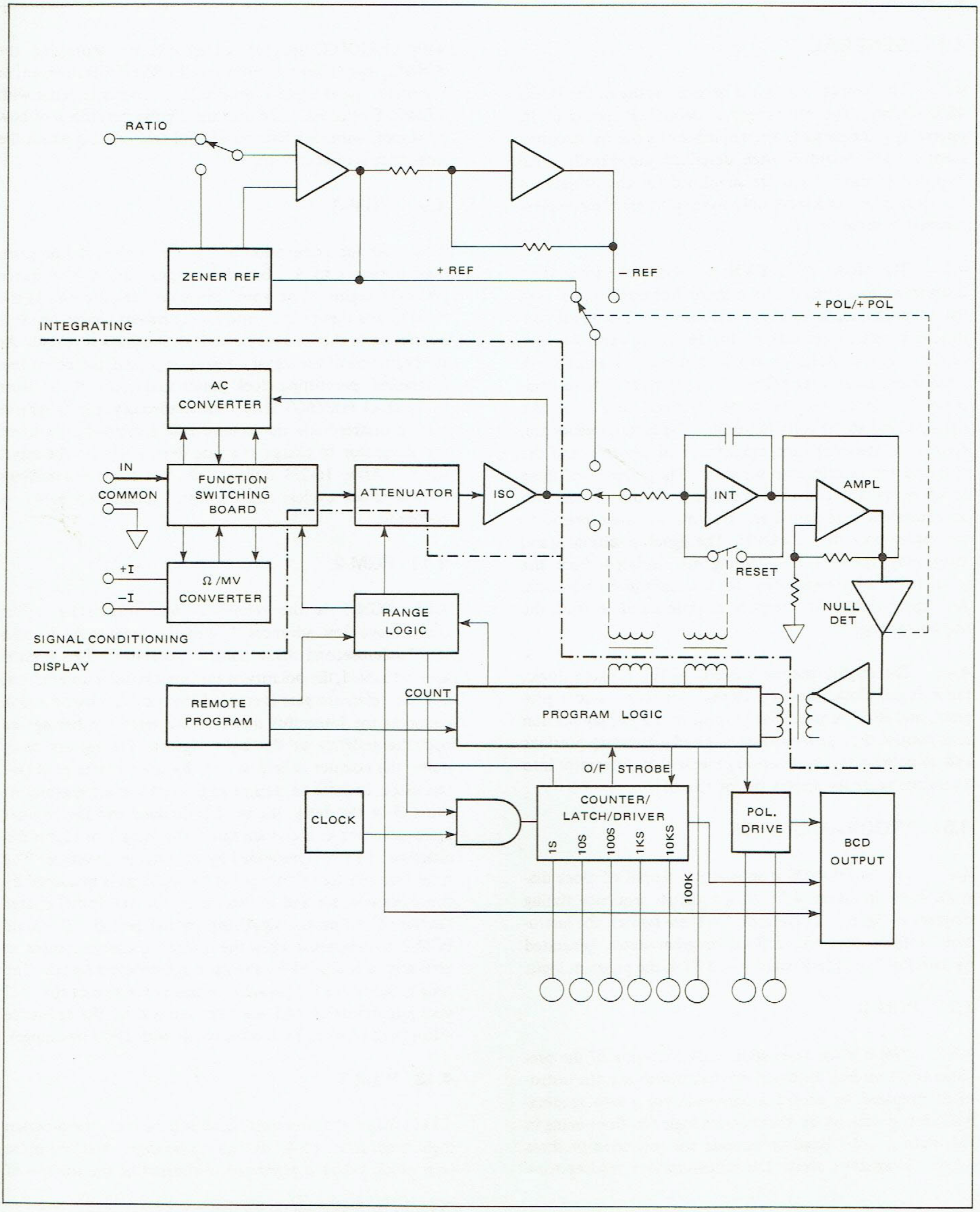


Figure 4.1 - Block Diagram 4800 DVM

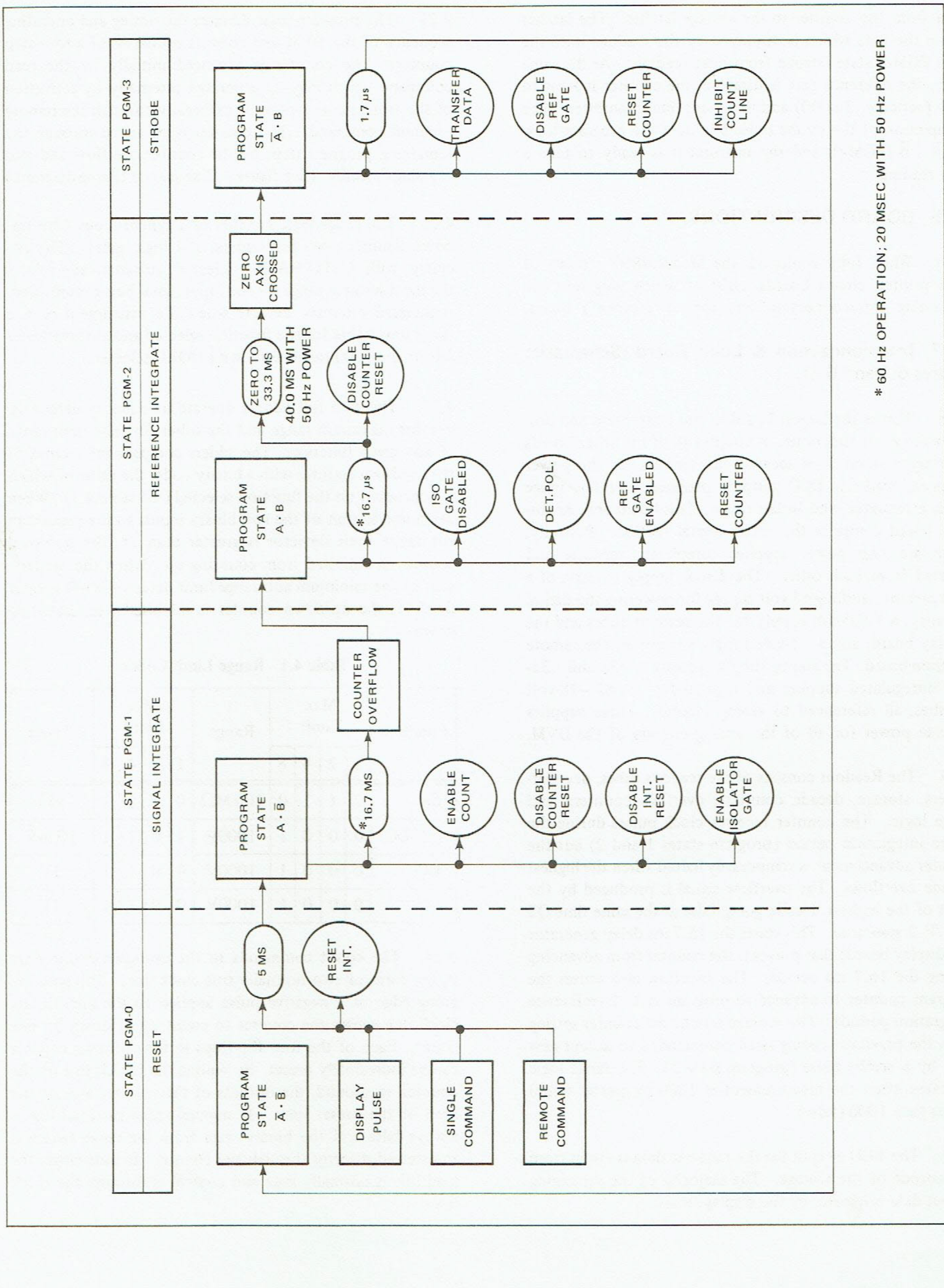


Figure 4.2 - Sequence Timing Diagram

data from the counter to the storage latches. The latches retain the data which is displayed by the readout until the next PGM-3 state (strobe from next reading). At the same time, the reference gate is disabled, the counter is reset to zero (actually, 30,000) and the count line is inhibited. The completion of the strobe pulse advances the program logic to $\overline{A} \cdot \overline{B}$ (PGM-0) and the instrument is ready to take a new reading.

4.15 BOARD DESCRIPTIONS.

4.16 When fully equipped, the Model 4800 consists of nine printed circuit boards, eight of which plug into the remaining interconnection and logic ("mother") board.

4.17 Interconnection & Logic Board (Schematic: figures 6.1 and 6.3).

4.18 This is the largest board in the instrument and provides the most functions. It couples all of the other boards together and on it is located the circuits for the power supplies, readout, BCD output, program counter, range logic, attenuator, and isolator gain. This board and the display board comprise the entire digital section. Basically, there are two power supplies completely separate and isolated from each other. The digital supply consists of a high current handling +5-volt supply for powering the digital circuitry, a +220-volt supply for the readout tubes and the display board, and a −1-volt supply for use on the remote program board. The analog supply consists of +31 and −31-volt unregulated supplies and regulated +18 and −18-volt supplies, all referenced to analog ground. These supplies provide power for all of the analog circuits of the DVM.

4.19 The Readout consists of the readout tubes, decoder-drivers, storage, decade counters, overflow counters, and range logic. The counter receives clock pulses during the entire integration period (program states 1 and 2) but the counter advancement is temporarily halted when the highest decade overflows. The overflow signal is produced by the 8 bit of the highest decade going false at the same time Q2 of F/F 2 goes true. This starts the 16.7 ms delay generator (on display board) that prevents the counter from advancing during the 16.7 ms period. The overflow also causes the program counter to advance to program state 2 (reference integration period). The storage retains the counter setting from the previous reading until commanded to accept new data by a strobe pulse (program state 3). The range logic indicates when the measurement is 1000 or greater (true) or less than 1000 (false).

4.20 The BCD output for the numeric data is taken from the output of the storage. The majority of the remaining output data originates on the display board.

4.21 The program logic dictates the timing and operating sequence of the DVM and consists primarily of a four-step counter. The counter is advanced initially by the read command which may be generated internally by activation of the front panel switch or externally through the remote program command. The counter is advanced through the remaining program steps by the counter overflow and axis crossing detector. (See figure 4.2, sequence timing diagram.)

4.22 The range logic consists of a synchronous 4-bit up/down counter, two full adders, and logic gates. The circuitry, with AUTO RANGE selected, automatically selects the most suitable range for the input signal being monitored. Associated circuitry detects when the instrument is in a range unsuitable for the function selected and automatically selects the 1000 range, even with HOLD selected.

4.23 The two full adders operate as equality detectors, one for maximum range and the other for minimum range of any given function. The adders compare the output of the up/down counter with a binary code, the value of which is dependent on the function selected (see table 4.1). When the numeric sum of the two binary inputs to the maximum autorange limit detector is greater than 15, the up/down counter is inhibited from counting up. When the numeric sum of the minimum autorange limit detector is not greater than 15, the up/down counter is inhibited from counting down.

Table 4.1 - Range Limit Codes

Function	Max Limit				Range	Min Limit				Range
	1	2	4	8		1	2	4	8	
Ω	0	1	1	0	100 MΩ	0	1	1	1	1Ω
mV-DC	0	0	0	1	1000V	1	0	1	1	10 mV
DC	0	0	0	1	1000V	0	0	1	1	.1V
AC	0	0	0	1	1000V	0	0	1	1	.1V

4.24 The count commands to the up/down counter are in the form of two normally true clock lines. The positive-going edge of a negative pulse applied to the appropriate clock line causes the counter to count up or down by one count. Each of the four flip-flops in the up/down counter can be individually preset. By pulling the LOAD line on the counter to ground, the outputs of the counter assume the level of the preset lines. In manual range the load line is always false and the binary data from the range switch is transferred directly through the counter. In autorange, the load line is normally true and control is through the clock lines.

4.25 Range changes are generated if required during program step 3 (the one-clock-pulse strobe during which the data from the decade counters is transferred to the storage). At this time a pulse, designated $\overline{X}$ and generated solely for the range circuitry, is enabled ($\overline{X}$ is generated with clock but lags it by 90^{o}). The enabled $\overline{X}$ generates an uprange command, a downrange command or neither if the proper range has been reached. An uprange command is generated if $\overline{\text{MAX LIMIT}}$ is true (instrument is not in the highest possible range for the function selected) and $\overline{Q_2O/F}$ is true (instrument has reached the 100% overrange limit). A downrange command is generated if the MIN LIMIT detector is true (instrument is not in the lowest possible range for the function selected) and downrange is true (readout is less than 10% of full-scale).

4.26 In addition to the normal autorange functions, the same basic circuits take the instrument out of forbidden ranges that may develop when a function is changed and the instrument is in PGM-0.

4.27 In program step 0, the one bit that is normally added to the value of the up/down counter through the carry in of the MAX LIMIT full adder is removed, effectively subtracting one. Also, a one bit is added to the MIN LIMIT full adder. This action effectively expands the minimum and maximum limits by one digit in each direction; it permits the instrument range to be at the minimum or maximum setting for a given function without producing a limit signal ($\overline{\text{CARRY OUT}}$ for max, CARRY OUT for min) for either full adder. If the instrument is in autorange and the range position is beyond the range limits for the selected function, a limit signal is generated during program step 0, allowing an $\overline{X}$ pulse to generate a load command to the up/down counter. When in autorange, the range lines are automatically set to the 1000 range, forcing the up/down counter to the 1000 range (this range is legal for any function selected).

4.28 Attenuator & Gain Networks (Schematic: figure 6.1).

4.29 The attenuator is a precision voltage divider used in d-c voltage measurement. The attenuator basically consists of a double-pole, double-throw relay and three precision resistors. There are two states available: X1, in which no attenuation occurs and the dc volts input from the switching card is applied through a 100 Kohm resistor to the isolator positive input; and X.01, in which the dc volts input is applied through a 100 to 1 divider having an input resistance of 10 megohms and an output resistance of 100 kohms. The output of the divider is applied to the isolator positive input. The isolator gain network permits the isolator to operate at gain levels of X1, X10, and X100. This divider consists of two voltage tap positions on a single voltage divider string and two relays. Relay settings determine the fraction of the isolator output applied to the isolator input, thereby setting the gain.

4.30 Display Board (Schematic: figure 6.21).

4.31 On this board are mounted: the annunciators and drivers for the functions, ratio, plus and minus polarity and NO; decimal point drive, the isolator gain relay decode and drive, ratio relay drive, filter relay drive, overflow (counter, storage, and drive) range switch, function switch, and counter reset logic. The decimal point drive circuit and the isolator gain relay decoding circuit each consist of a BCD to 10 line decoder. Ratio and filter drive circuits are initiated from front panel switches. The overflow counter consist of two JK flip-flops preset to 0-0. The flip-flops are advanced during a measurement cycle by the overflow of the decade counters. The output of the f/f's steer two D type f/f's (storage) and a one-shot generator (counter reset). On the first counter overflow, the counters advance to 1-1, and the counter reset is energized. If a strobe is generated, the storage is commanded to transfer and the 0 of the overflow display tube is energized. If one more overflow is generated prior to the strobe, the counter advances to 0-1 and the 1 of the overflow display tube is energized. If two overflows are generated prior to the strobe, the counter advances to 1-0 and the overflow display tube indicates 2. The range selector provides nine range positions and auto. These positions are encoded into a standard 1, 2, 4, 8 BCD code by a diode matrix. The function switch has four positions used directly as negative true logic inputs.

4.32 Switching Bypass Card.

4.33 This board is used in basic instruments only (AC, Millivolts or Ohms/Millivolts options not included). The PC board has two interconnecting printed circuit straps that tie pin E to pin L and pin P to pin 15 of connector J6.

4.34 Switching Card (Schematic: figure 6.5).

4.35 This board is used whenever the AC, Millivolt or Ohms/Millivolt options are included in the DVM. The board consists of three relays, their drivers, and an accessory range matrix. As shown in figure 4.3, relay K2 is energized when the AC function is selected, K3 is energized when the ohms function is selected and K1 is energized as indicated by the Boolean equations given. The seven range lines that comprise the output of the accessory range matrix are negative true (minus 31-volts true and zero volts false). The logic for each of the accessory range lines is given in the figure. The purpose of the relays is to route the input

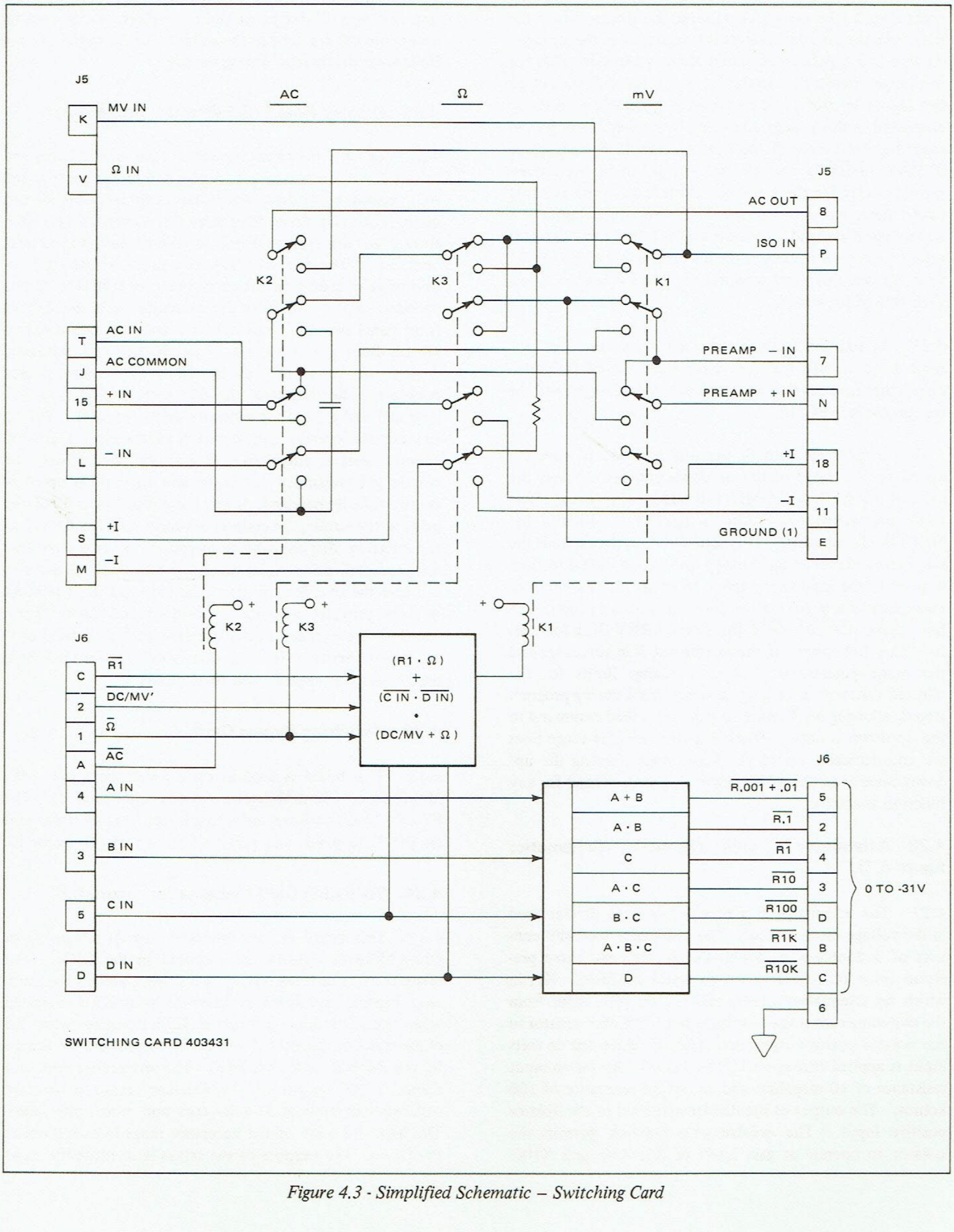


Figure 4.3 - Simplified Schematic – Switching Card

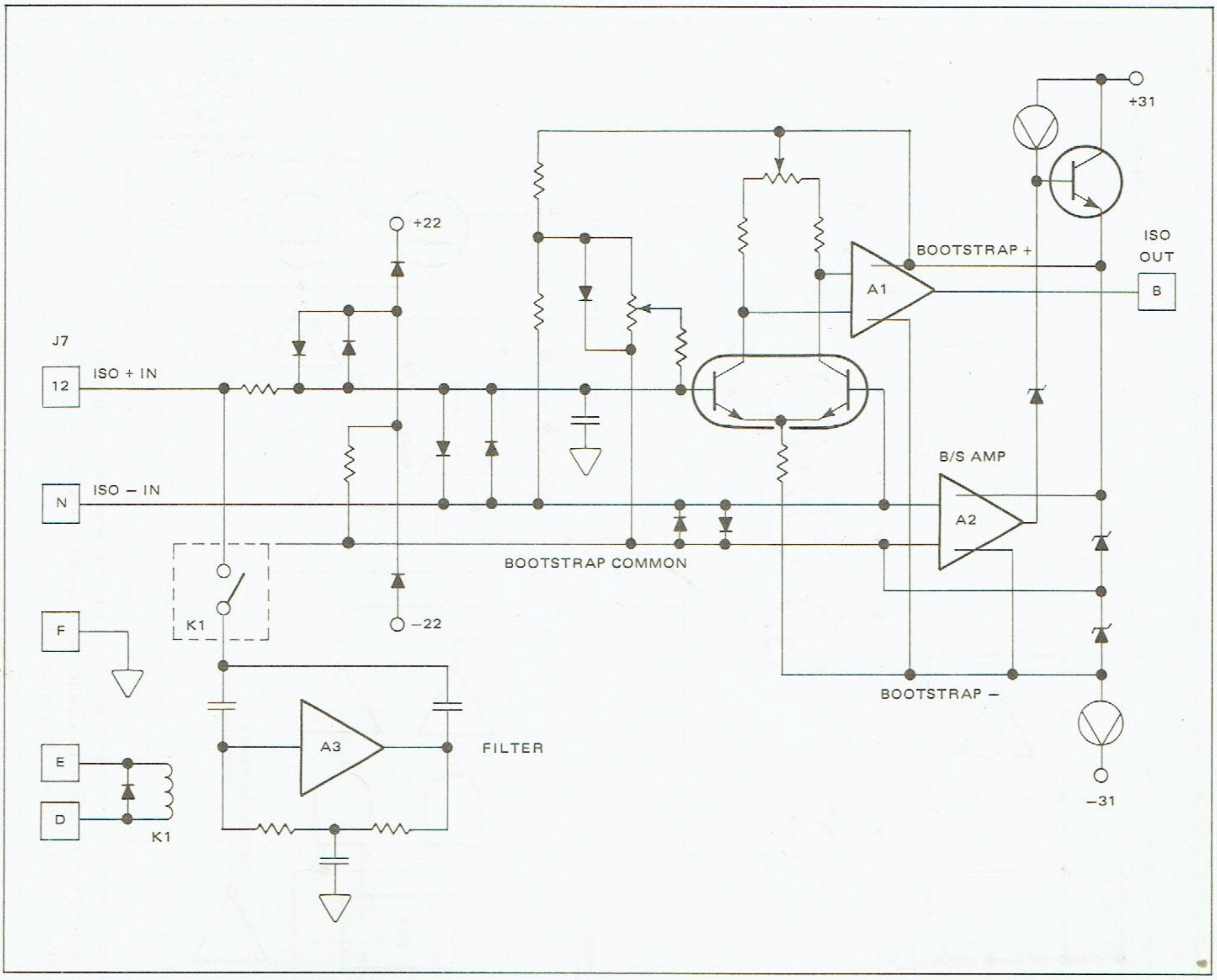


Figure 4.4 - Simplified Schematic – Isolator

signal to the attenuator when the DC function is selected or the appropriate accessory module when AC, Ohms or Millivolts is selected.

4.36 Isolator Assembly (Schematic: figure 6.17).

4.37 The isolator receives the conditioned input signal from the attenuator on the mother board. With filter selected or when the AC function is selected (in which case filter is automatically selected) normal mode noise on the input signal is attenuated. Filtering is achieved by an active 3-pole filter operating in conjunction with the 100 Kohm impedance of the attenuator. The input signal is then buffered and, if required, amplified by the isolator. The isolator (shown simplified in figure 4.4) consists of an input-current-compensated differential stage (with emitter follower omitted for simplicity) driving a 748 operational amplifier. These stages receive positive and negative supply voltages from a bootstrap supply. The bootstrap arrangement allows the isolator stages to follow the input signal, thereby greatly enhancing the effective input impedance. The output of the amplifier drives a discrete output stage powered by the ± 31-volt supplies and permitting an output swing of greater than ± 20 volts.

4.38 Digitizer Assembly (Schematic: figure 6.19).

4.39 The digitizer accepts the conditioned input signal from the isolator and converts it to a set of timing signals for transmission to the logic circuitry. The digitizer, shown

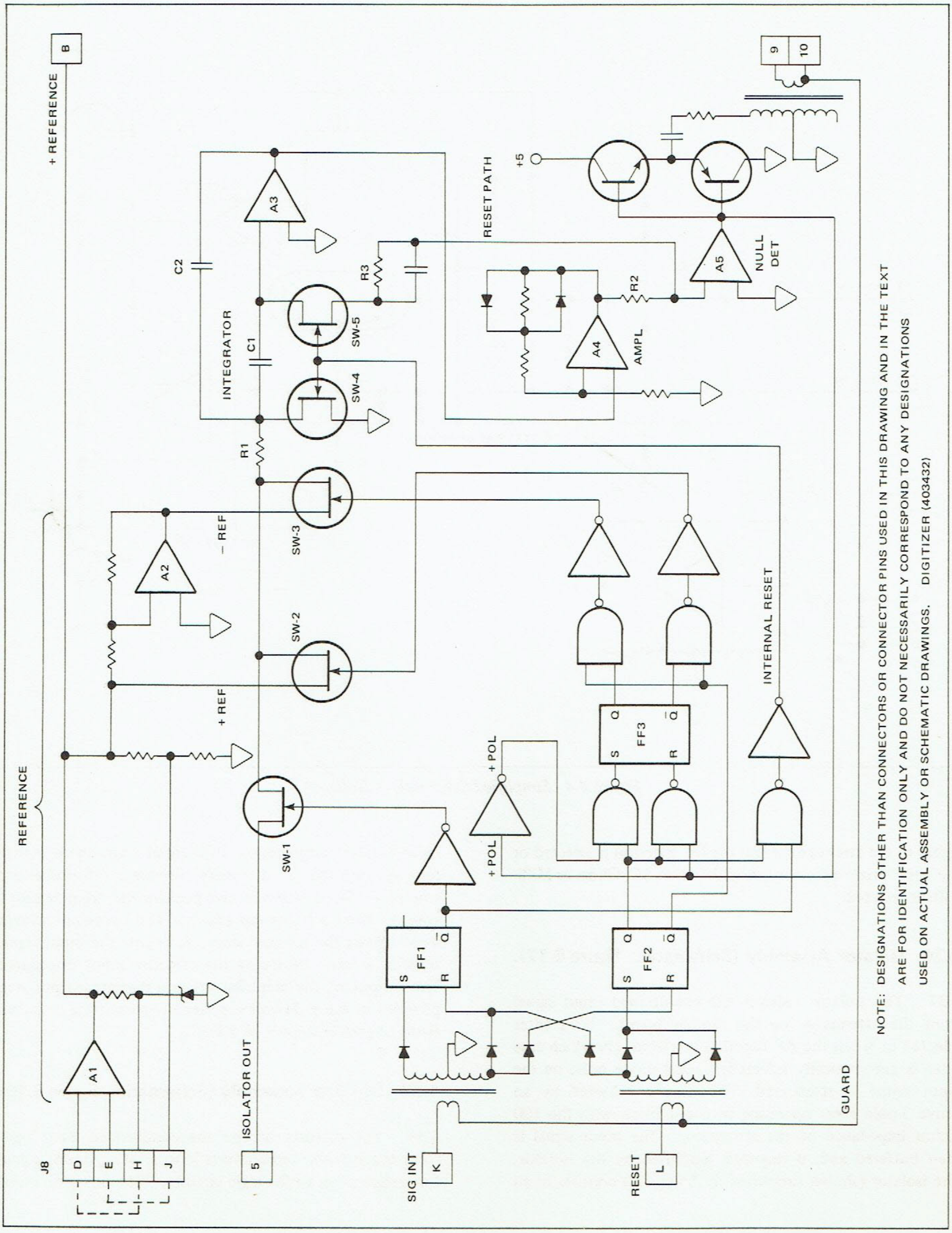


Figure 4.5 - Simplified Schematic – Digitizer

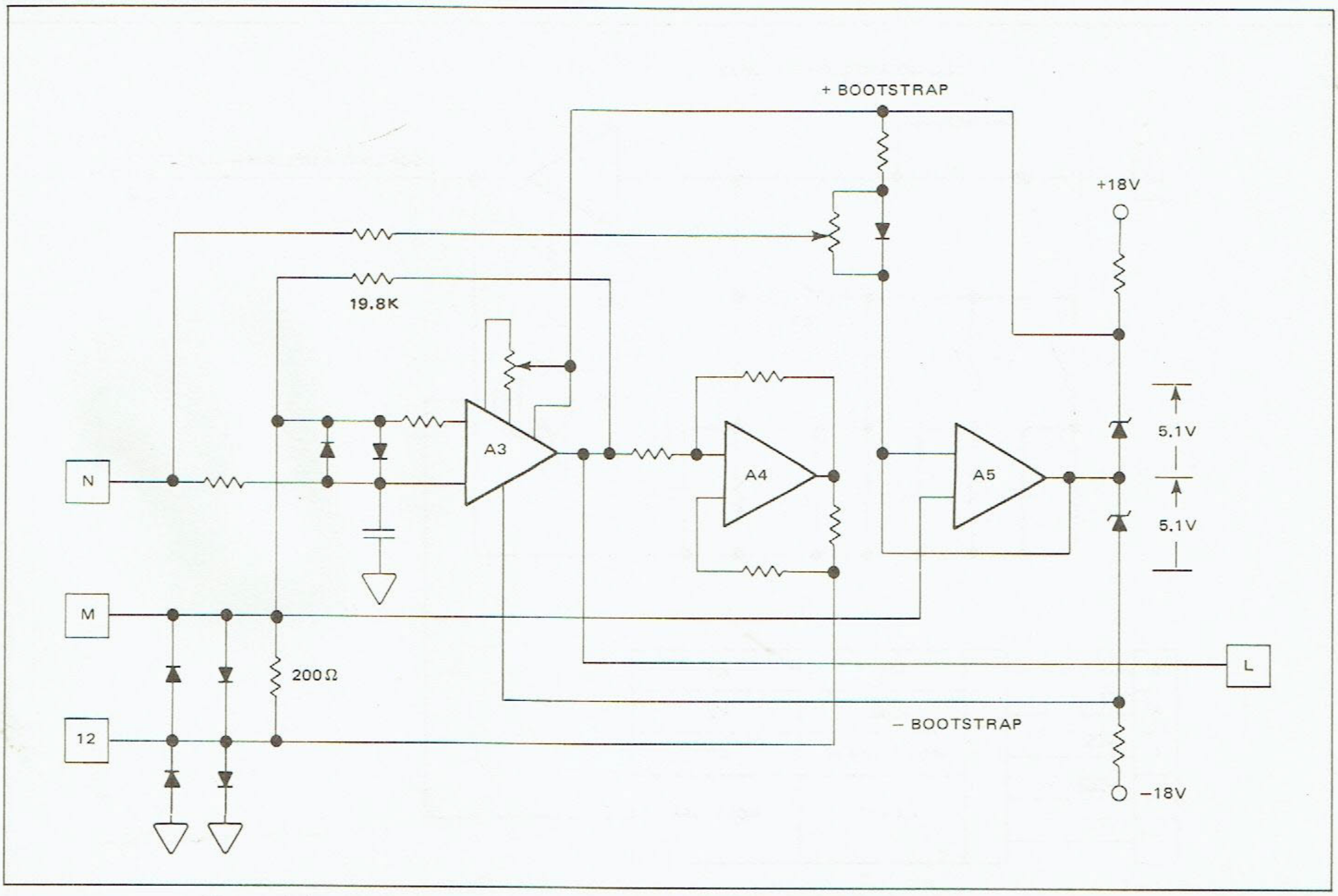


Figure 4.6 - Simplified Schematic – Millivolts Preamp of Millivolts/Ohms Converter Board

simplified in figure 4.5, consists of three switches, integrator, amplifier, null detector, output transformer, two demodulators, and decode logic. The operating sequence is determined by the program logic (see figure 4.2). The output of the isolator is applied to a FET (switch 1) connected to the input of the integrator. Two other FET switches (2 and 3) tie the integrator input to either the positive or negative reference supplies. All switches are off during the PGM-0 program step. The voltage level of the positive and negative reference supplies, (P1, P2) is 10 volts when ratio is not selected (internal reference). With ratio selected the reference supplies are equal to the value of the external reference input. Switching between ratio and internal reference takes place on the interconnection and logic board. The reference element and feedback resistors for the internal reference are located on the digitizer board.

4.40 When program step PGM-0 is initiated, a positive pulse appears on the signal integrate line causing f/f 1 $\overline{Q}$ to go false, turning on switch 1 and turning off the integrator reset switches (described later). From the previous reading, a negative pulse on the reset line causes f/f 2 Q to go true causing f/f 3 Q to follow the polarity of the integrator. With switch 1 closed, the isolator output voltage (+10V in this discussion) is sensed through R1-C1 by the input of the integrator amplifier A3, causing the output of the amplifier to go negative. The output draws current through C2 pulling the R1-C1 junction back towards zero. Equilibrium is reached when the current through R1 equals the current through C2 causing the junction of R1, C1, C2 to be at approximately zero volts and the output of the amplifier (voltage across C2) increasing linearly in the negative direction. The integrator charges for 16-2/3 milliseconds (counter overflow). The charge across the integrator is now –5 volts (with +10 volts in). When the counter overflows (program step PGM-2), a negative pulse appears across the signal integrate transformer causing both f/f's 1 and 2 to reset. This turns switch 1 off and turns switches 2 or 3 on depending on the position of f/f 3 (polarity of the integrator output. With +10 volts in, switch 3 is selected and applies –10 volts to the integrator input. Because, in this example, the input is equal but opposite, the time required to discharge the integrator is equal to the time required to charge the integrator or 16-2/3 milliseconds. The output of the integrator is amplified by a gain of approximately 100 and applied to the input of the null detector through resistor

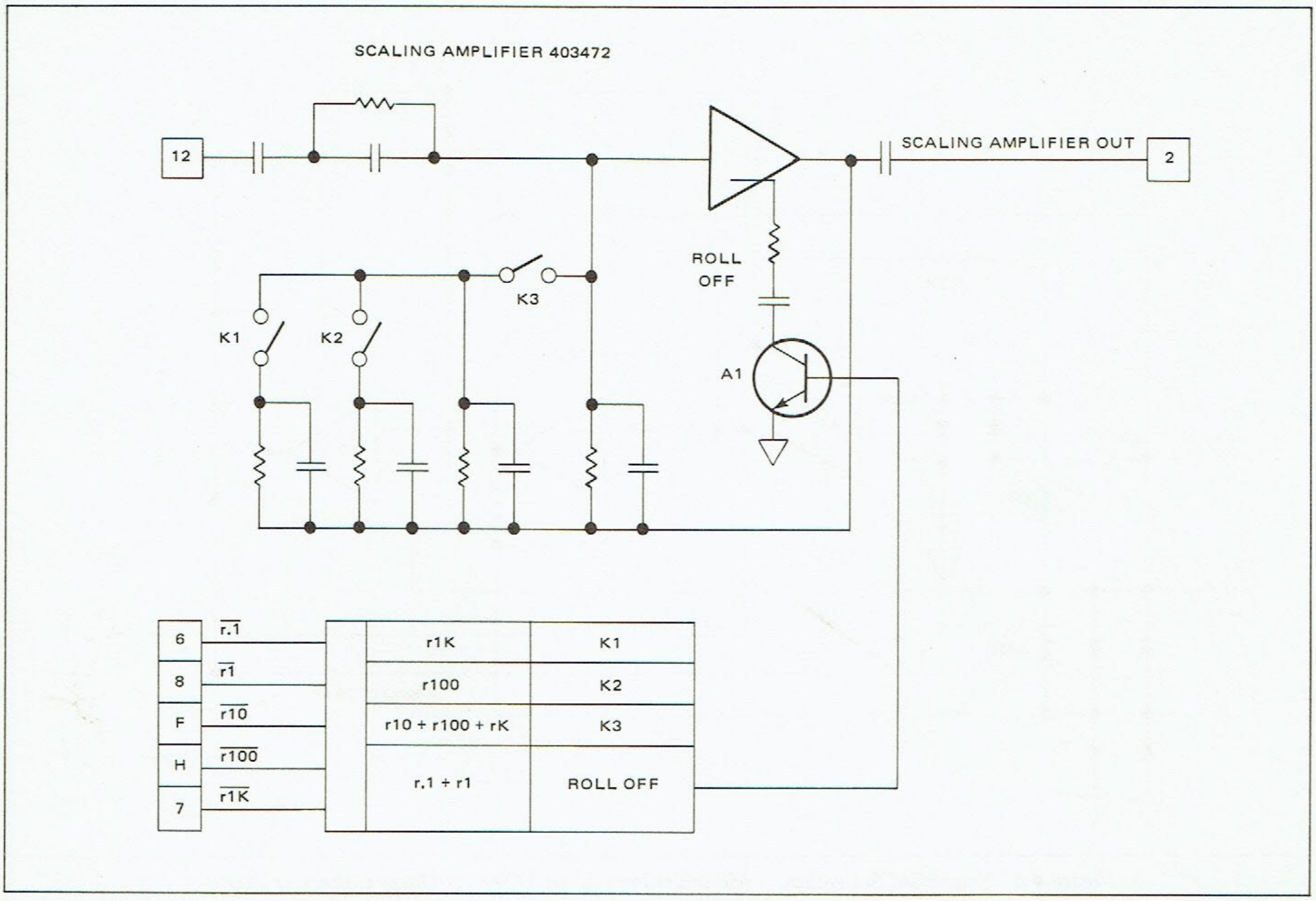


Figure 4.7 - Simplified Schematic – DIAC Scaling Amplifier

R2. The null detector inverts the integrator causing the transformer driver to set at +5 volts during the entire integrate period. When the charge across the integrator reaches zero, the transformer driver goes to zero causing the program logic to advance to program step PGM-3. At this time, a negative pulse on the reset line resets f/f 2 opening the reference switch and energizing the internal reset line. This line shorts the junction of R1, C1, and C2 to ground and connects the junction of C1 and input A3 to the junction of R2 and input A5. This allows input voltage errors of A3 and A4 and any input current error of A5 to be lumped together and reduced by a factor equal to the product of both amplifiers A3 and A4 (C1 charges to required offset during reset, effectively eliminating all zero shifts in the digitizer).

4.41 Millivolt Preamplifier (Schematic: figure 6.7).

4.42 This option is available as a separate option (403464) or combined with the Ohms converter (403435) and consists of a precision, fixed gain amplifier. As shown in figure 4.6, the millivolt amplifier consists of three parts: a potentiometric amplifier (A3) set at a fixed gain of 100, a "current sink" amplifier (A4), and a bootstrap amplifier (A5). The potentiometric amplifier is a stable low-drift operational amplifier (op amp) with voltage and current offset compensation. The power to the potentiometric op amp is supplied by the bootstrap supply, providing extremely high input impedance. The op amp output drives a discrete component amplifier for greater voltage swing. The bootstrap amplifier is non-inverting with a voltage gain of one. The input of the bootstrap is tied to the reference input of the potentiometric amplifier allowing the bootstrap supplies to follow the input voltage.

4.43 The current sink eliminates measurement errors due to I-R drops developed in the common line by the feedback resistance of the potentiometric amplifier. The amplifier A4 monitors and inverts the output of the potentiometric amplifier to provide, at the junction of the feedback path and the ground strap, a current that is equal to but subtracting from the current supplied by the feedback path.

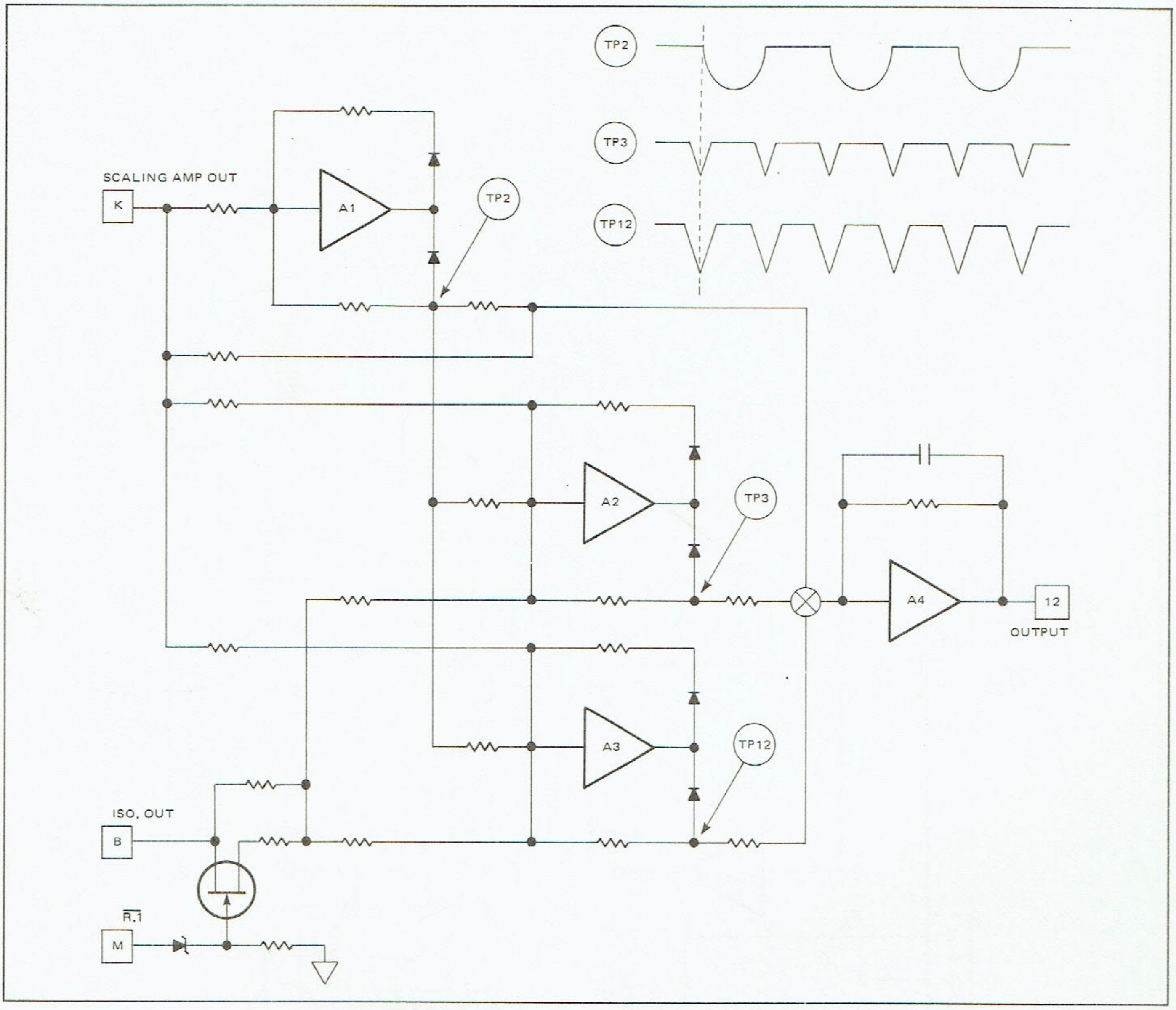


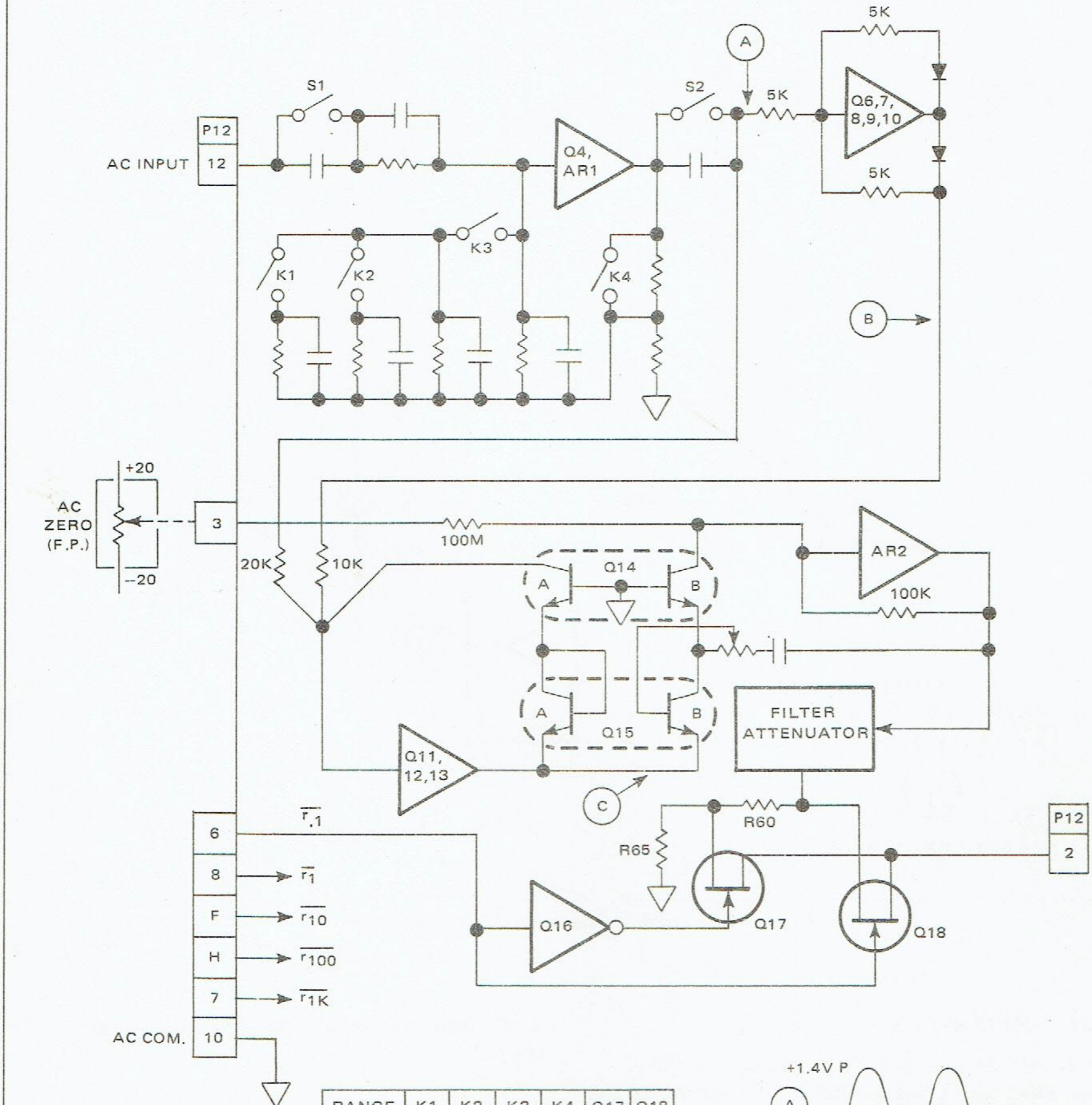
Figure 4.8 - Simplified Schematic – DIAC Converter

4.44 AC CONVERTERS.

4.45 Two AC converter options are available for use in the Model 4800, the Option 21 Distortion Insensitive AC Converter and the Option 31 True RMS AC Converter. The DIAC generates a three-segment straight-line approximation of a square law curve by which the input signal is squared, the squared result is then averaged and the root is derived by means of feedback through the system. The RMS converter takes the log of the input signal, averages it and derives the antilog of the signal to determine the RMS value. Circuit descriptions are provided in the following paragraphs.

4.46 DIAC Scaling Amplifier (Schematic: figure 6.11).

4.47 The scaling amplifier (shown simplified in figure 4.7) is one of the two DIAC converter boards used in the instrument. The scaling amplifier occupies connector J12 and consists of an ac compensated operational amplifier with four possible gain settings (X1, X.1, X.01, and X.001). The range lines are driven by decoded data from the accessory range lines. On the R.1 and R1 ranges, increased bandwidth is provided the scaling amplifier by transistor Q1 for the X1 amplifier setting.



RANGE	K1	K2	K3	K4	Q17	Q18
r.1					ON	
r1				ON		ON
r10			ON	ON		ON
r100		ON	ON	ON		ON
r1000	ON		ON	ON		ON

(shaded) ON

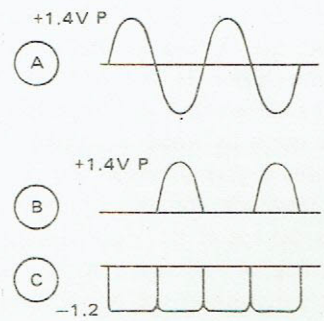


Figure 4.9 - Simplified Schematic – RMS AC Converter

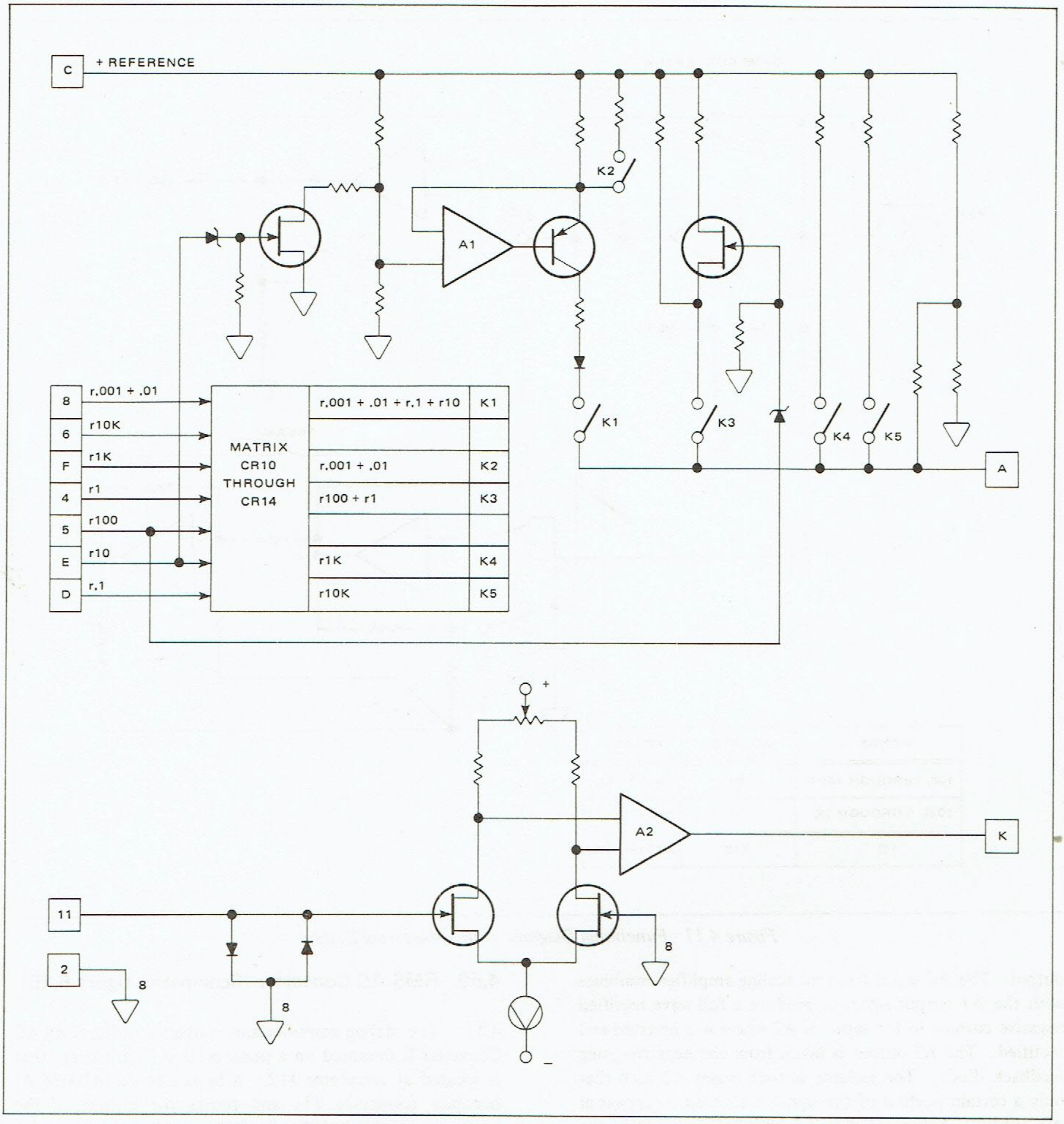
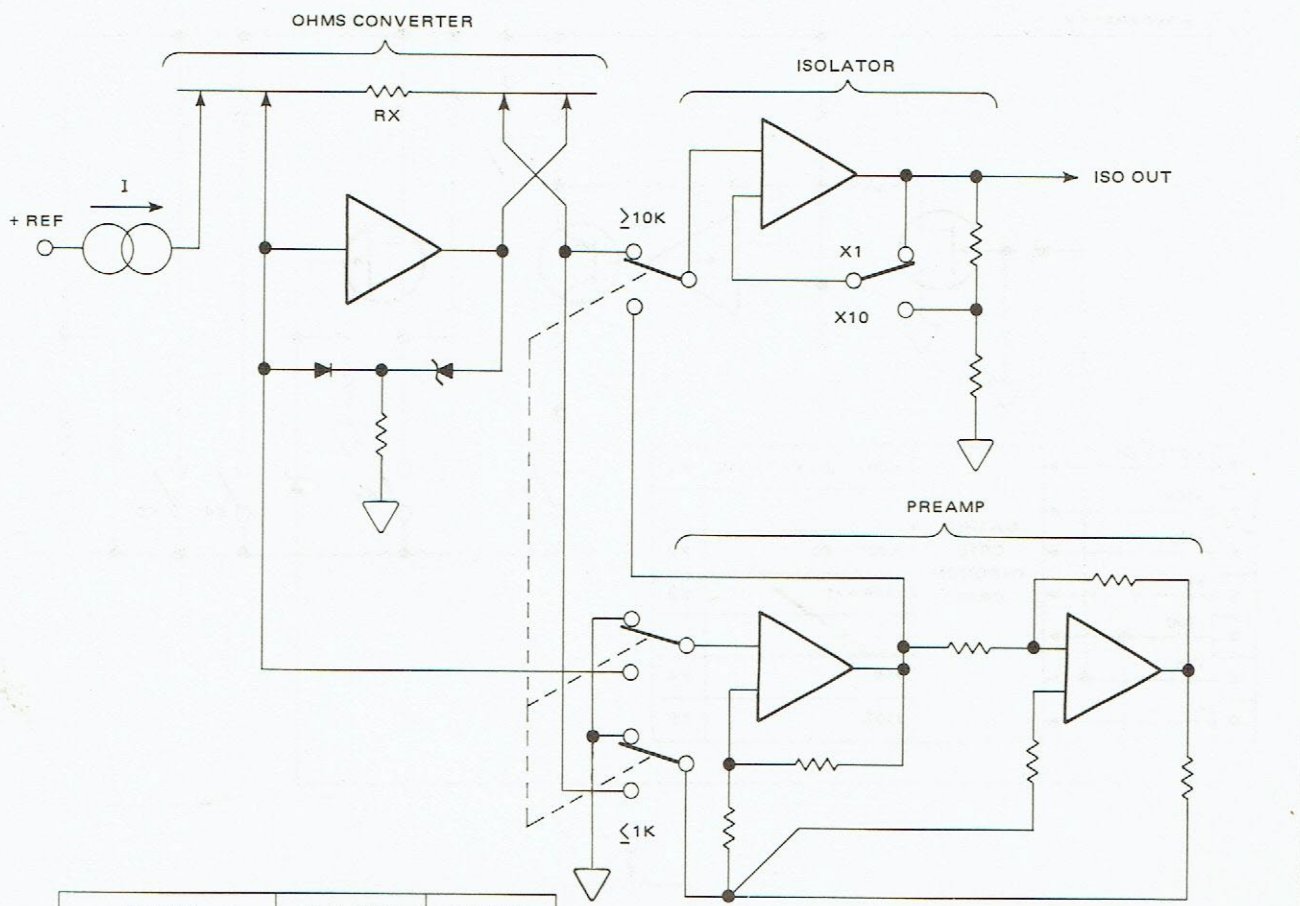


Figure 4.10 - Simplified Schematic – Ohms Converter of Millivolts/Ohms Converter Board

4.48 DIAC Converter (Schematic: figure 6.13).

4.49 The DIAC converter (figure 4.8) uses the scaled output of the scaling amplifier along with the DVM isolator output (whose value is a function of the ac input) to produce a distortion insensitive dc equivalent of the ac input. The converter, located at connector J11, consists of three active rectifiers and one summing amplifier. Active rectifier A1 inverts and rectifies the scaled input. The output of A1 is taken from the negative-going feedback diode producing a negative half-wave signal. Active rectifier A2 sees inputs from the scaling amplifier, the output of A1 and the isolator



RANGE	ISOLATOR	PREAMP
10K THROUGH 100 M	X1	NOT USED
10 Ω THROUGH 1K	X1	X99 (FIXED)
1 Ω	X10	X99 (FIXED)

Figure 4.11 - Functional Diagram, Ohms Measuring System

output. The AC signal from the scaling amplifier combines with the A1 output signal to produce a full-wave rectified negative current to the input of A2 where it is inverted and rectified. The A2 output is taken from the negative-going feedback diode. The isolator output biases A2 such that only a certain portion of the signal is allowed to appear at A2 output. Active rectifier A3 operates in precisely the same manner as A2 but with a different amount of bias from the isolator. The summing amplifier sums and filters the outputs of the scaling amplifier and the three active rectifiers to produce the dc equivalent voltage. Full-scale output for the summing amplifier is +1 volt (.1 volt on the .1 volt range). The output is fed through the switching card to the isolator where, on the AC 1, 10, 100, and 1000 volt ranges the isolator gain is at X10 and on the AC .1 volt range, the gain is X100.

4.50 RMS AC Converter (Schematic: figure 6.15).

4.51 The scaling amplifier and converter of the RMS AC Converter is mounted on a single printed circuit board that is located at connector J12. A bypass board (410686-A) occupies connector J11 and routes the output of the converter to the isolator input by way of the switching board. The converter circuitry is shown in simplified form in figure 4.9.

4.52 The Scaling Amplifier consists of an operational amplifier capable of providing five gains (X10, X1, X.1, X.01, and X.001) selectable by data from the accessory range lines. On the .1 volt range the signal is amplified by a gain of 10 to provide adequate signal strength for the converter portion of the circuitry. The signal is subsequently

Table 4.2 - Ohm Converter Current Generator

Range	Accessory Range Line	Converter Output Voltage, Full Scale	Current through Unknown	Current Generated By:	
100M	r100K	10V	.1 μA	Non-switched .1 μA (added to all other ranges)	
10M	r10K	10V	1 μA	+	K5 (.9 μA)
1M	r1K	10V	10 μA	+	K4 (9.9 μA)
100K	r100	10V	.1 mA	+	K3 (99.9 μA)
10K	r10	10V	1 mA	+	K1 (999.9 μA)
1K	r1	100 mV/.99	.10101 mA	+	K1 (1 mA) + FET2 (X1.0101)
100Ω	r.1	100 mV/.99	1.0101 mA	+	K3 (99.9 μA + FET1 (1.01 μA)
10Ω	r.01	100 mV/.99	10.101 mA	+	K1 (1 mA) + K2 (9 mA) + FET2 (X1.0101)
1Ω	r.001	10 mV/.99			

reduced by a factor of 10 prior to leaving the circuit board. In each case, the scaling amplifier supplies a full scale 1 volt output. The scaling amplifier can be operated in either the dc or ac operating mode. The dc mode permits measuring the combined RMS value of an ac signal riding on a dc level; the ac mode permits measurement of the ac portion of a signal only. Both switches must be moved to the desired operating mode to operate. Switch position is indicated in the Calibration section.

4.53 The active rectifier is an operational amplifier with two polarity selective feedback paths (one conducting only with a positive amplifier output and the other conducting only with a negative amplifier output). The voltage developed across the positive conducting leg is applied through a 10K resistor to the summing node of the log amplifier along with the full wave signal through a 20K resistor from the output of the scaling amplifier. These two inputs are combined and, due to the non-linear feedback loop of the log amplifier (consisting of Q14A and Q15A) produce the log of the combined signal at ⓒ. This signal is fed through an identical path (consisting of transistors Q15B and Q14B) to the input of the summing amplifier.

4.54 The summing amplifier converts the signal to a dc level. The ripple content of the dc level is attenuated and the output reduced to provide a dc equivalent of the RMS value of the ac input signal. The dc output is 1 volt full scale on the 1, 10, 100, and 1000 volt ranges and 0.1 volt full scale on the .1 volt range. The isolator amplifies the output by a factor of 100 on the .1 volt range and by a factor of 10 on all other ac ranges.

4.55 Ohms/Millivolt Converter Preamp (Schematic: figure 6.9).

4.56 The ohms converter permits DVM ohms measurement on nine ranges with full-scale readings from one ohm to 100 megohms. On each range, a precise reference current is supplied to the resistance under test. The voltage developed across the resistance under test is amplified if required and measured by the DVM.

4.57 Referring to figure 4.10, the converter consists of a current generator driving the summing node of an operational amplifier. Considering the summing node as a virtual ground the current developed by the current generator is equal to the equivalent resistance of the generator divided into the reference voltage (+10 volts). The current developed by the generator for each range is given in table 4.2. As shown in figure 4.11, the converter output is routed either through the preamplifier, or directly to the isolator. For ranges 10K through 100 Megohms, the current supplied by the generator produces 10 volts across the resistor under test when the resistance is equal to the full-scale value of the range selected (i.e., 100 kilohms on the 100K range, 10 kilohms on the 10K range, etc.). The voltage developed for full-scale resistances under test on the 10 ohm through the 1K ohm ranges is approximately 100 millivolts and on the one ohm range approximately 10 millivolts. For these ranges, the + input of the preamp is connected to the summing node (effective ground) and the – input of the preamp is connected to the output of the op amp (through the – CURRENT lead). Connected in this configuration, the preamplifier operates as an operational amplifier with the input impedance made effectively very high by the action of the current sink circuitry (see discussion of Preamplifier in paragraph 4.41). The gain of the preamp in this configuration is 99 (in contrast to the normal potentiometric gain of the preamp of 100). The current supplied by the current generator for the lower ranges are adjusted to compensate for the gain of the preamp not being a factor of ten. The values of the currents are given in table 4.2. On the one-ohm range, the voltage, available for measurement with the Preamplifier included, is only one volt with full-scale resistance being measured (one ohm). The isolator therefore is set to the X10 position for this ohms range only to provide 10 volts full-scale to the DVM measuring circuitry.

4.58 Program Board (Schematic: figure 6.23).

4.59 The program board is mounted on standoffs above the digital portion of the logic and interconnection board and electrically connected to it through two cables. An edge connector consisting of printed circuit contacts on the board extends through the back panel of the instrument to form the remote input connector J202.

4.60 The program board permits the operation of the instrument remotely through connector J202 by contact closure. With remote selected, either by the front panel REMOTE switch or through the remote input connector, control of the function and range is determined by the selection of the control lines as described in Section 2. The selection of remote enables the remote control lines and, by removing logic common from the wiper contact of the function and range switches, disables the front panel control of range and function. The function data from the remote input is parallel fed to the function switch lines and the range data is applied in parallel to the BCD coded output lines of the range diode matrix. Logic is also provided for timeout and external measurement command of the instrument. Two external commands are provided, direct (fast) command and timeout command. Both are used in conjunction with Hold, which prevents the instrument from taking periodic readings from the internal rate oscillator.

4.61 The direct command is applied directly to the program control logic circuitry. The timeout command generates a delay by initiating the timeout circuit (the period of the timeout is dependent on the function selected). During the timeout, the print command is inhibited. At the completion of the timeout, a new measurement cycle is initiated. When the measurement cycle is completed, the print command is generated as usual. The timeout circuit is also initiated when remote auto range is selected and ranging takes place.

5.1 GENERAL.

5.2 This section contains the calibration and trouble-shooting procedures and instructions for disassembling the instrument.

5.3 CALIBRATION.

5.4 The calibration procedure is designed to keep the Model 4800 operating within its specifications for indefinite periods of time. Make any necessary instrument repairs as covered under the troubleshooting procedure prior to calibration. Allow 30 minutes warmup time for temperature stabilization.

5.5 Required Equipment.

5.6 The equipment necessary for calibration is listed in table 5.1.

5.7 Disassembly for Calibration.

5.8 Remove Power cable. Loosen the four captive screws at each corner of the top cover and remove the top cover. Remove the four countersunk Phillips head screws from the metal shield covering the analog and digitizer portion of the instrument.

Table 5.1 - Required Calibration Equipment

Name	Use	Recommended Type
precision DC voltage standard	DC, DC/mV Range calibration	FLUKE 332A (or equivalent)
microvoltmeter	isolator, preamplifier, ohms converter, & AC converter zero	FLUKE 845A (or equivalent)
AC laboratory power source	AC scaling amplifier	HP 745 & 746 (or equivalent)
standard resistors: 100 Megohms 19 Megohms 1.9 Megohms 190 Kilohms 19 Kilohms 1.9 Kilohms 190 Ohms 19 Ohms 1.9 Ohms	ohms converter	ESI Series SR1 (or equivalent)
insulated adjustment tool	All adjustments	JFD 5284
clipleads	approximately 12" long made with copper mini-gator clips & slip on insulators	
1 Megohm, 1/4 Watt, 5%, Carbon	isolator current zero	
100 Kilohm, 1/4 Watt, 5%, Carbon	preamp current zero	
10 Kilohm, 1/4 Watt, 5%, Carbon	AC converter bias current zero	

Table 5.2 - DC Gain

Signal Input	Ref. Input	Mode	Adjust:	For Display of:
−1.90000V	+1.00000V	DC/DC	(1V Ratio − Pol.) R55	−19.000V
+1.90000V	+1.00000V	DC/DC	(1V Ratio + Pol.) R68	+19.000V
−19.0000V	+10.0000V	DC/DC	Verify a readout of −19.000V ± 1 digit	
−19.0000V	———	DC*	Ref. − Pol., R43	−19.0000V ± 1 digit
+19.0000V	———	DC	Ref. + Pol., R59	+19.0000V ± 1 digit
*Set instrument out of Ratio mode.				

5.9 DC Calibration.

5.10 ISOLATOR VOLTAGE ZERO.

a. Select 0.1 Range, DC FUNCTION, and FILTER OUT.

b. Remove Shield. Referring to figure 5.1, connect a jumper from point ① (pin 4 of relay K1) to the *front panel* − input terminal. Connect one end of another jumper wire to point ② (bottom of resistor R35) and dress both wires towards the front of the instrument. Replace shield (do not replace screws) and allow five minutes for the circuitry to stabilize.

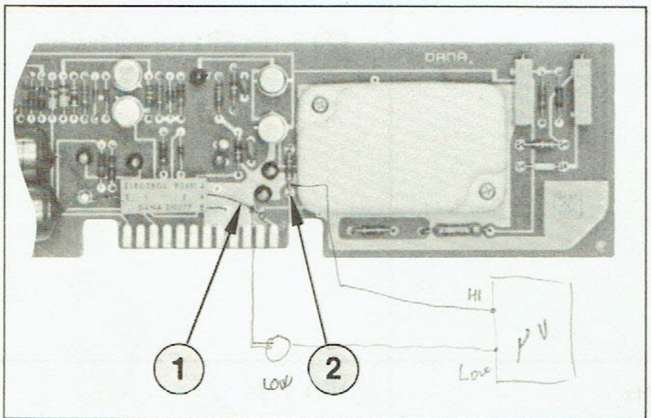


Figure 5.1 - Test Points – Isolator Voltage Zero

c. Connect the microvoltmeter High input lead to the jumper from R35 and the Low input lead − input terminal.

d. Adjust potentiometer R36 (DC ZERO, figure 5.2) for a microvoltmeter reading of less than ± 10 microvolts. Remove microvoltmeter leads.

e. Remove shield and remove jumpers from Isolator board. Replace shield and allow five minutes for instrument to temperature stabilize.

5.11 ISOLATOR CURRENT ZERO.

a. Short DVM input. Connect the high input lead of the microvoltmeter to ANALOG OUTPUT and the low input side to common on the instrument *rear panel.*

b. Adjust the *front panel* OFFSET DC potentiometer for a microvoltmeter reading of ± 100 microvolts.

c. Remove short and insert a 1 Megohm resistor across the + and − input terminals.

d. Adjust potentiometer R12 (input offset current) on isolator for a microvoltmeter reading of less than ± 1 millivolt. Remove 1 Megohm resistor and microvoltmeter leads.

5.12 DC VOLTAGE ZERO.

a. Select DC FUNCTION and 10 Range.

b. Apply +0.9 millivolts to DVM input.

c. Adjust R34 on Digitizer board for a DVM readout of zero with the last digit alternately reading zero and one.

5.13 DC GAIN ADJUSTMENT.

a. Select AUTO RANGE, DC FUNCTION and RATIO.

b. Apply inputs to DVM and make indicated adjustments as shown in table 5.2.

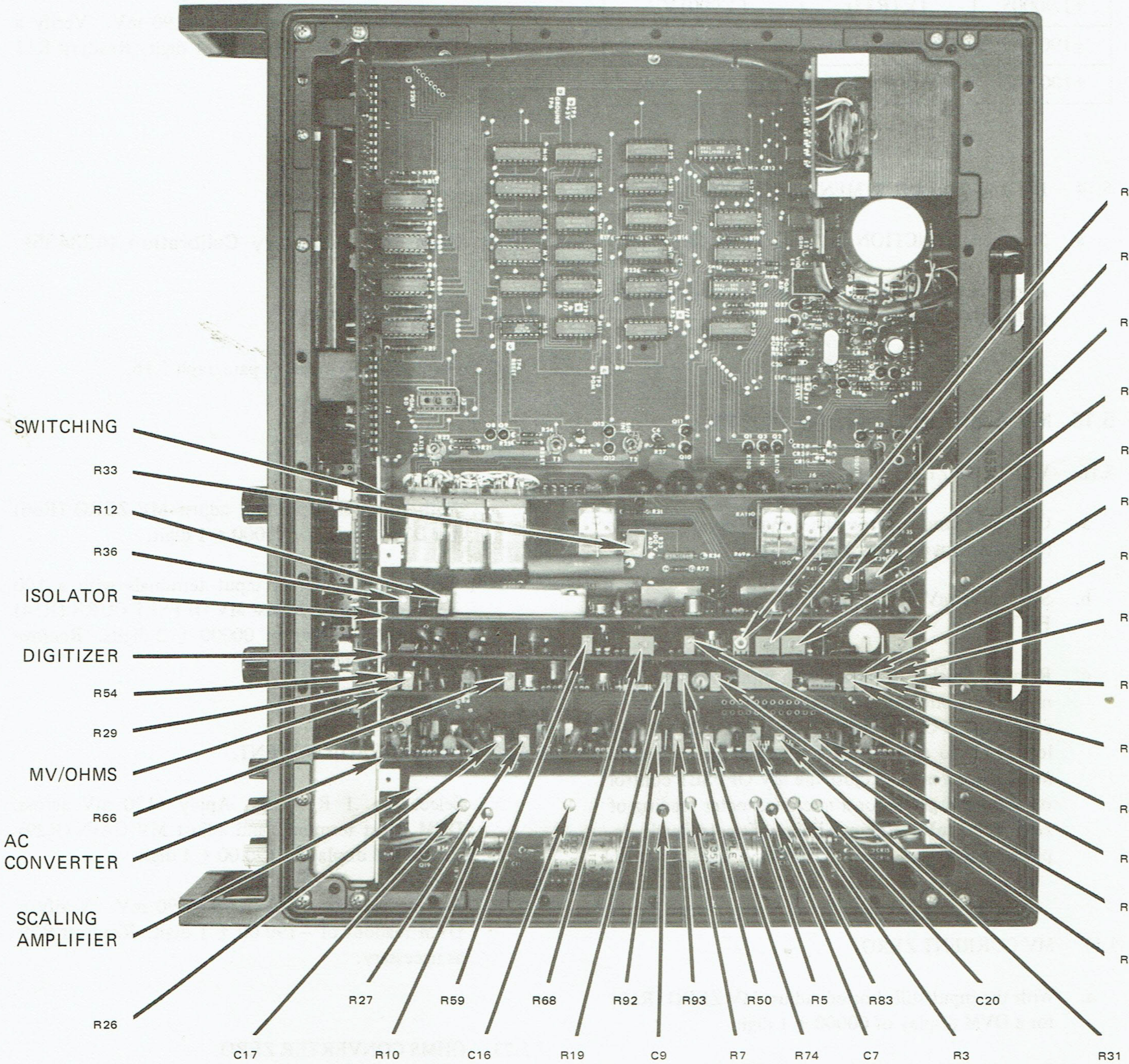


Figure 5.2 - Adjustment Locations

Table 5.3 - DC Range

Input	Adjust	For Readout of:
±.190005	.1V (R68)	±.19001V
±1.90005	1V (R37)	±1.9001V
±190.005	100/1000 (R33)	±190.01V
±1000.00	Verify Readout	±1000.0V ± .5 digit

5.14 DC RANGE ADJUSTMENT.

a. Select DC FUNCTION and AUTO RANGE.

b. Apply inputs to DVM and make the indicated adjustments as shown in table 5.3.

5.15 MV Accessory Calibration (403464).

5.16 VOLTAGE ZERO.

a. Connect a jumper across the + and – input terminals (use jumper with copper clipleads).

b. Select DC/mV FUNCTION, 10 MV RANGE, and FILTER IN.

c. Remove Shield. Connect high input of microvoltmeter to front end of resistor R46 on main interconnection PCB (point (1) in figure 5.3) and the low input to the – INPUT terminal on the instrument *front panel*. Adjust the MV OFFSET control on the *front panel* for a microvoltmeter reading of zero ± 50 mV. Remove microvoltmeter leads, replace shield and allow 5 minutes warmup time.

5.17 MV CURRENT ZERO.

a. With the input still shorted, adjust MV ZERO (R10) for a DVM display of 00000 ± 1 digit.

b. Remove short across input terminals and replace with a 100 kilohm resistor. Adjust MV OFFSET CURR (R20) for a DVM display of 00000 ± 2 digits. Remove 100 kilohm resistor.

5.18 MV GAIN ADJUSTMENT.

a. Select the .1 RANGE. Apply +190 mV across DVM input terminals and adjust MV GAIN (R13) for a DVM display of 190.00 ± 1 digit.

b. Reverse polarity of input to –190 mV. Verify a DVM readout of –190.00 ± 1 digit. Readjust R13 as necessary.

5.19 Ohms-mV Accessory Calibration (403435).

5.20 MV VOLTAGE ZERO.

Perform procedure provided in paragraph 5.16.

5.21 MV CURRENT ZERO.

a. With input still shorted, adjust MV ZERO (R66) for DVM display of 00000 ± 1 digit.

b. Replace short across input terminals with a 100 Kilohm resistor. Adjust MV OFFSET CURR (R54) for a DVM display of 00000 ± 2 digits. Remove 100 Kilohm resistor.

5.22 MV GAIN ADJUSTMENT.

a. Select the .1 RANGE. Apply +190 mV across DVM input terminals and adjust MV GAIN (R29) for a DVM display of 190.00 ± 1 digit.

b. Reverse polarity of input to –190 mV. Verify a DVM readout of –190.00 ± 1 digit. Readjust R29 as necessary.

5.23 OHMS CONVERTER ZERO.

a. Select the Ω-MΩ FUNCTION and 100 MΩ RANGE. Short the + INPUT, – INPUT, + OHMS CURRENT, and – OHMS CURRENT terminals together.

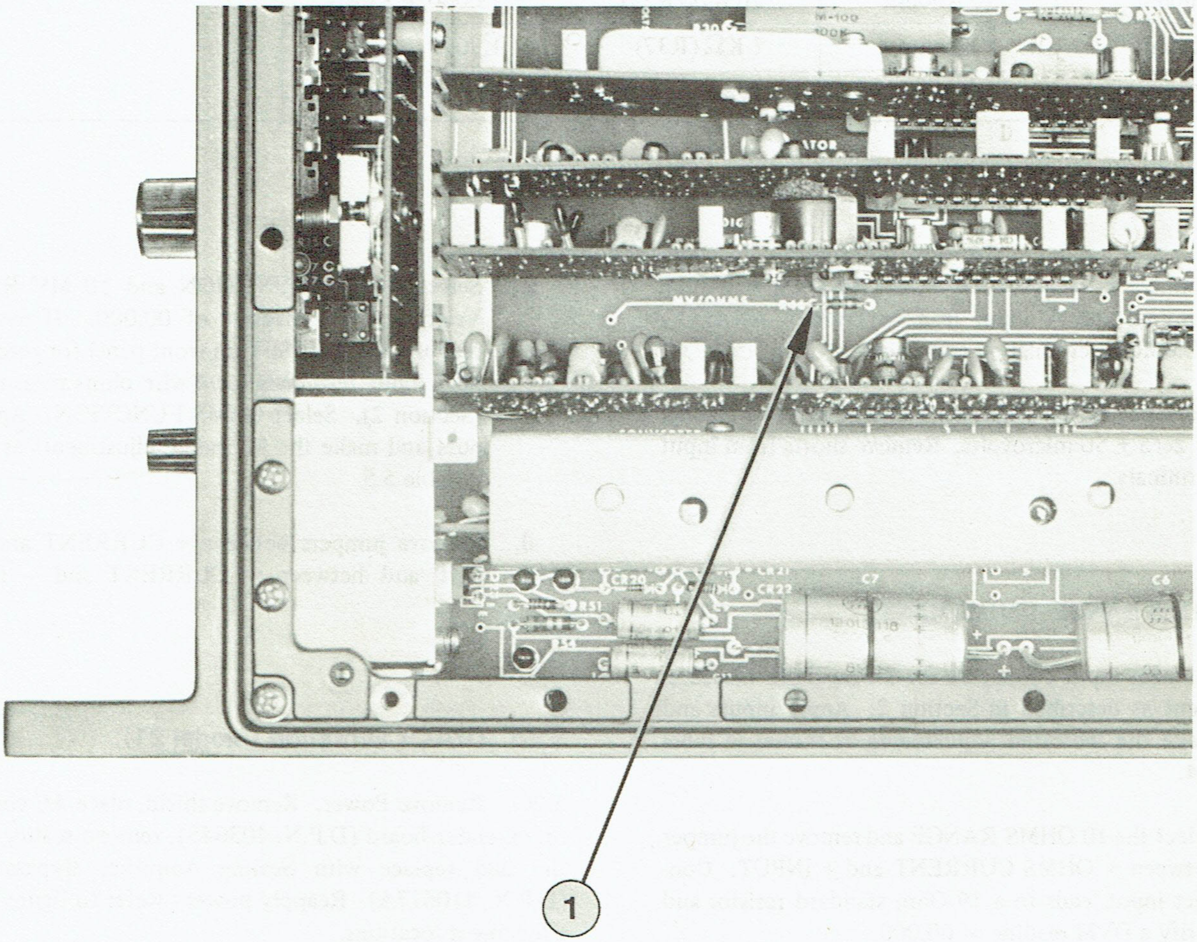


Figure 5.3 - Test Point – mV Offset

Table 5.4 - Ohms Range

Resistance Standard	Range	Adjustment	DVM Readout	Note
100 Megohm	100 MΩ	100 MΩ (R50)	100.00 ± 1 digit	Standard resistors given indicate nominal values. Calibrate for DVM readout equal to actual standard value ± 1 digit
19 Megohm	10 MΩ	10 MΩ (R44)	19.000 ± 1 digit	
1.9 Megohm	1000 Kilohm	1 MΩ (R42)	1900.0 ± 1 digit	
190 Kilohm	100 Kilohm	100 KΩ (R35)	190.00 ± 1 digit	
19 Kilohm	10 Kilohm	10 KΩ (R23)	19.000 ± 1 digit	
1.9 Kilohm	1 Kilohm	1 KΩ (R37)	1.9000 ± 1 digit	
190 Ohm	100 Ohms	Verify a reading of 190.00 ± 1 digit		

b. Connect microvoltmeter + lead to DVM + INPUT terminal and – input lead to DVM – ANALOG COMMON terminal on *rear panel.*

c. Adjust Ω ZERO (R19) for a microvoltmeter reading of zero ± 50 microvolts. Remove shorts from input terminals.

5.24 OHMS RANGE ADJUSTMENT.

a. Connect input connector for 2-wire ohms measurement as described in Section 2. Apply inputs and make the indicated adjustments as shown in table 5.4.

b. Select the 10 OHMS RANGE and remove the jumper between + OHMS CURRENT and + INPUT. Connect input leads to a 19 Ohm standard resistor and verify a DVM reading of 00.000.

c. Select DC/MV FUNCTION and 10 MV RANGE. Verify a DVM readout of 00.000. If necessary, readjust MV OFFSET on front panel for zero. Connect input terminals for 4-wire ohms measurement (Section 2). Select OHMS FUNCTION. Apply inputs and make the indicated adjustments as shown in table 5.5.

d. Remove jumpers between + CURRENT and + INPUT and between – CURRENT and – INPUT.

5.25 DIAC Calibration (Model 21).

5.26 Remove Power. Remove shield, place AC converter on extender board (D.P.N. 403645), remove scaling amplifier and replace with Scaling Amplifier Bypass Board (D.P.N. 410617A). Reapply power. Refer to figure 5.4 for adjustment locations.

Table 5.5 - Ohms Low Range

Resistance Standard	Range	Adjustment	DVM Readout	Note
19 Ohm	10 Ohms	10Ω (R25)	19.000 ± 1 digit	Use low-thermal standard resistors
1.9 Ohm	1 Ohm	Verify a reading of 1.9000 ± 1 digit*		
*If not, repeat step 5.24b				

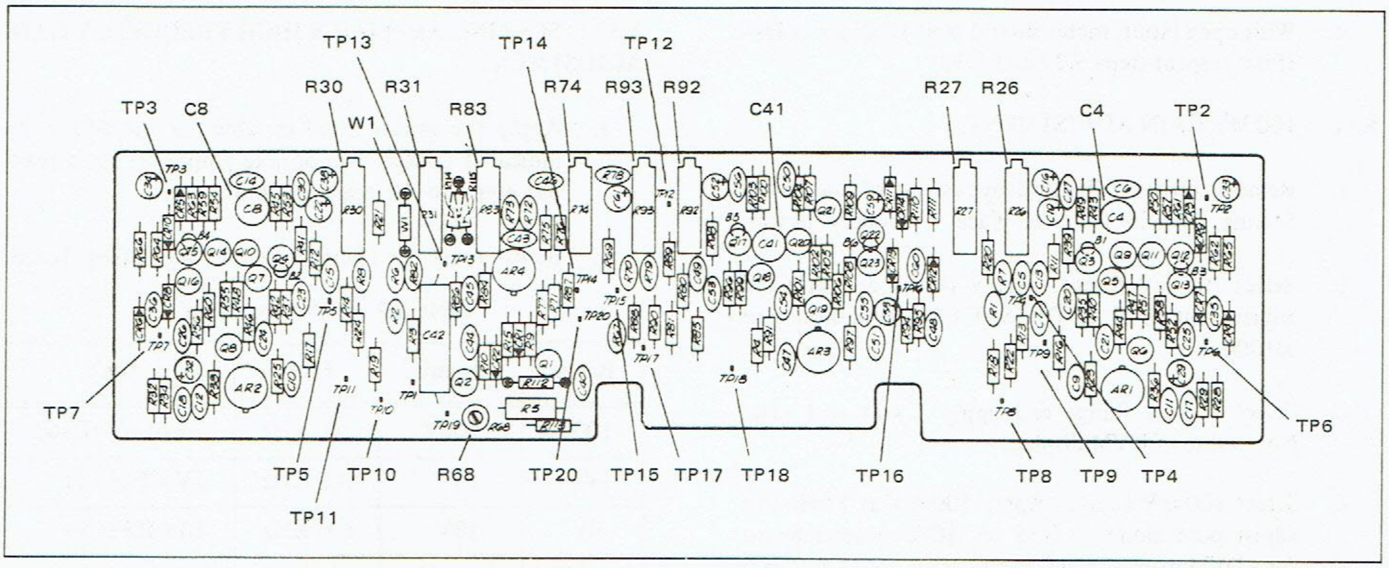


Figure 5.4 - Test Points – DIAC Converter

5.27 DIAC ZERO ADJUSTMENT.

a. Select AC Function, 1V Range, and leave input terminals open.

b. Connect the microvoltmeter Low lead to Common (TP9, TP11 or TP18) and the High lead through a 10 Kilohm resistor to the test points listed in table 5.6.

Table 5.6 - AC Zero

Test Point (fig. 5.)	Adjust:	Reading
TP8	R26	0 ± 10 µV
TP10	R30	
TP17	R92	
TP14	R74	
TP4	R27	
TP5	R31	
TP15	R93	
TP13	R83	

Table 5.7 - AC Symmetry

Test Point	Adjust:	Voltage at Balance
TP2, TP6	R27	Less than ± 10 µvolts
TP3, TP7	R31	Less than ± 30 µvolts
TP12, TP16	R93	Less than ± 30 µvolts

c. Adjust for symmetry of the following pairs of test points (e.g., if TP6 reads +6 µvolts, TP2 will read –6 µvolts when adjusted. (Table 5.7.)

5.28 AVT FREQUENCY RESPONSE ADJUSTMENT.

a. Open jumper W-1 on AC converter (figure 5.4).

b. Apply 1.0000 volts RMS at 1 kHz to DVM input and record the readout (about 1.8410).

c. Apply 1.0000 volts RMS at 100 kHz to DVM input. Adjust C4 for reading recorded at 1 kHz.

5.29 BREAK AMPLIFIER FREQUENCY RESPONSE ADJUSTMENT.

a. Replace jumper W-1. Set input to 1.0000V RMS, 1 kHz and record readout (should be very close to 1.0000).

b. Set input to 1.0000V RMS, 100 kHz. Adjust C8 and C41 for the same readout as recorded in step a, with each capacitor contributing about the same amount (caps in approximately the same position).

5.30 100 mV ZERO ADJUSTMENT.

a. Select 100 mV Range. Apply 10.000 millivolts, 1 KHz to input terminals.

b. Adjust AC OFFSET on the front panel for a readout of .01000.

c. With open input, meter should read 12 digits or less. If not, repeat steps 5.27 and 5.30.

5.31 100 MV GAIN ADJUSTMENT.

a. Remove power. Remove bypass board and install Scaling Amplifier in its place. Reapply power.

b. Select 100 mV Range. Apply 10 mV at 1 kHz and adjust front panel AC OFFSET for a DVM display of .01000.

c. Select 1 Volt Range and apply 1 volt at 1 kHz. Note value of DVM display.

d. Select 100 mV Range. Apply 100 mV at 1 kHz and adjust potentiometer R68 on AC Converter board for a DVM display equal to the value noted in step b (neglect decimal position).

5.32 Scaling Amplifier Low Frequency Gain Adjustment.

a. Remove power. Remove extender board and plug AC Converter board directly into connector J11. Replace shield and top cover on DVM. Reapply power and allow thirty minutes for the instrument to stabilize.

b. Select AUTO RANGE. Apply 10 mV at 1 kHz and adjust front panel AC OFFSET for a DVM display of .01000. Remove input.

c. Connect jumper across DVM input terminals and verify a DVM display of less than 15 digits. If not, repeat paragraphs 5.27, 5.30, and 5.32, steps a, b, and c.

d. Apply the inputs listed in table 5.8 and adjust the indicated control (on the Scaling Amplifier) for a readout equal to the input voltage.

Table 5.8 - Low Freq. Gain

Range	Input	Freq.	Adj.
1	1.0000V	1 KHz	1V LF (R10)
10	10.000V	1 KHz	10V LF (R7)
100	100.00V	1 KHz	100V LF (R5)
1000	1000.0V	1 KHz	1 KV LF (R3)

5.33 SCALING AMPLIFIER HIGH FREQUENCY GAIN ADJUSTMENT.

a. Apply the inputs listed in table 5.9 and adjust the indicated control (on Scaling amplifier) for a read-out equal to the applied input.

b. Steps must be performed in the order listed.

Table 5.9 - High Freq. Gain

Range	Input	Freq.	Adj.
1000	500V	40 KHz	Input HF (C16)
1V	1V	100 KHz	1V HF (C17)
10V	10V	100 KHz	10V HF (C9)
100V	100V	100 KHz	100V HF (C7)

c. Apply 100 mV at 1 kHz and select 100 mV Range. Verify DVM readout of 100 mV ± 1 digit. If not, repeat paragraph 5.31, steps c and d.

5.34 RMS AC Calibration (Model 31).

NOTE

Use 10 KΩ resistor in series with + lead of micro-voltmeter.

a. Set DVM power switch to off. Extract converter and remove environmental shield. Set S1 and S2 to DC (away from center of board), replace converter and set power switch to on. Select AC and 1 volt range on DVM front panel. Allow 10 minutes for temperature to stabilize. Refer to figure 5.5.

b. Connect jumper across DVM input terminals. Connect the microvoltmeter to TP1 (+) and TP5 (–). Adjust R17 for a microvoltmeter reading of 0 ± 30 μV. Remove + microvoltmeter lead from TP1. Turn R41 fully clockwise.

c. Connect microvoltmeter + lead to TP4. Adjust R42 for a microvoltmeter reading of +20 μV ± 10 μV.

d. Connect + microvoltmeter lead to TP2. Adjust R33 for a microvoltmeter reading of 0 ± 30 μV. Remove microvoltmeter + lead from TP2.

e. Connect + microvoltmeter lead to TP3. Adjust R31 for 0 ± 30 mV. Remove + microvoltmeter lead from TP3.

f. Connect + microvoltmeter lead to TP4. Adjust R41 counterclockwise until the voltage at TP4 reads 0 ± 5 μV. Remove microvoltmeter leads and remove jumper across DVM input.

g. Apply −1.0000V DC and note DVM display.

h. Reverse polarity of input to +1.0000V DC and adjust R28 to obtain approximately the same DVM display as obtained in step g. Repeat steps g and h until the two readings are within .01% of each other. Remove DC supply from DVM input.

i. Apply +0.1000 to DVM input and note DVM display.

j. Reverse polarity of input to −0.1000 and verify DVM display is within ±.5 digits of the reading obtained in step i. If not, use R31 to balance the readings.

NOTE

R54 is an FSV adjustment and is reset only if major repairs have been performed on the converter. In this event, perform the following adjustment:

Apply a calibrated 1.0000V RMS pulse train with a crest factor of 7 and a period of 1 millisecond (1 kHz repetition rate). Adjust R54 for a readout of 1.0000. Remove the pulse generator from the DVM input and continue with the calibration procedure starting at step k.

k. Set power switch on DVM to off, extract converter, set S1 and S2 to AC (toward center of board). Replace environmental shield on converter and replace converter in DVM. Reapply power and allow 10 minutes for temperature to stabilize.

l. Connect the AC source to the DVM input terminals. Apply the inputs listed in the following table and adjust the indicated control for the proper readout.

Range	INPUT		Adjust	Readout
	AC Voltage	Freq		
1V	1.0000	500 Hz	R58	1.0000
1V	.1000	500 Hz	ac offset	0.1000
Repeat steps for R58 and ac offset until no adjustment is required.				
1000V	1000.0	500 Hz	R3	1000.0
1000V	500.00	40 kHz	C11*	500.00
1V	1.0000	50 kHz	C9*	1.0000
10V	10.000	500 Hz	R7	10.000
10V	10.000	50 kHz	C7*	10.000
100V	100.00	500 Hz	R5	100.00
100V	100.00	50 kHz	C4*	100.00
.1V	.1000	500 Hz	R20	.10000
.1V	.1000	20 kHz	C28	.10000
*Use an insulated screwdriver when adjusting the capacitors. High voltage present on C11.				

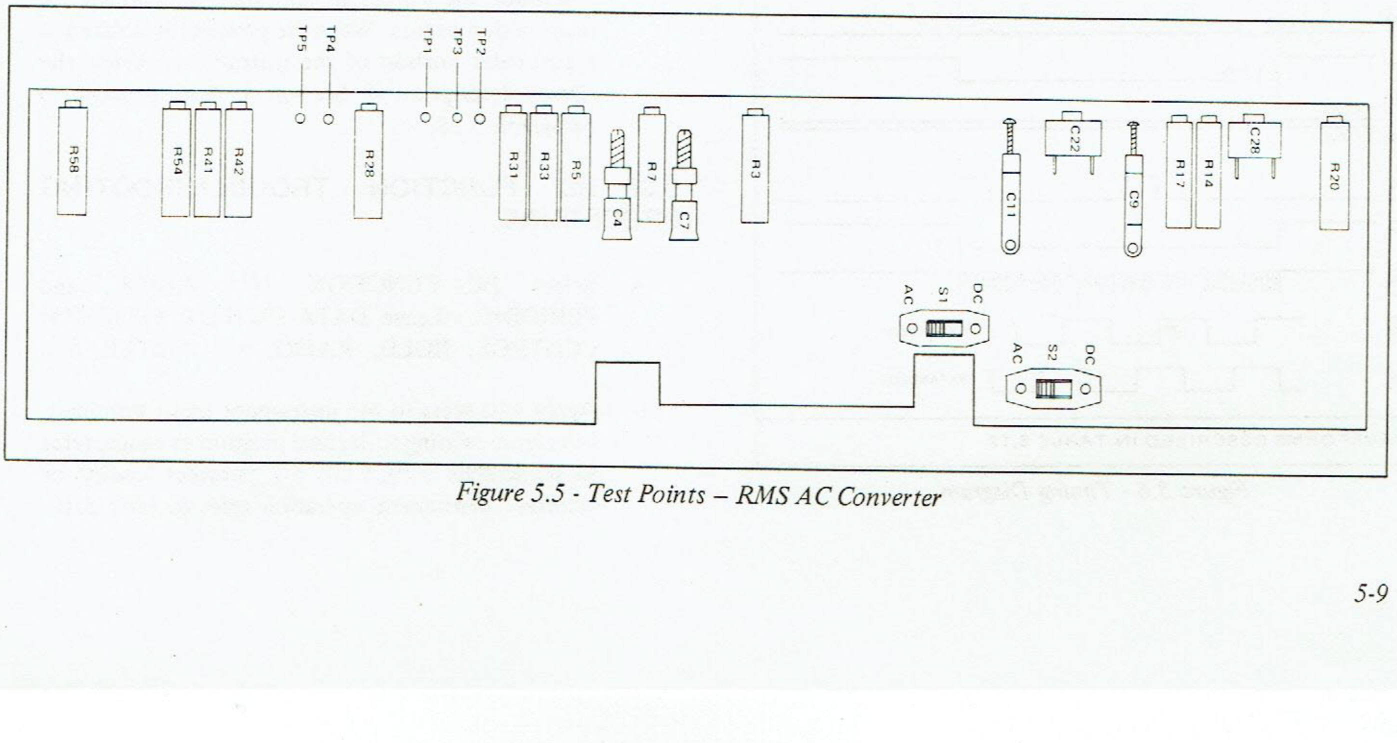
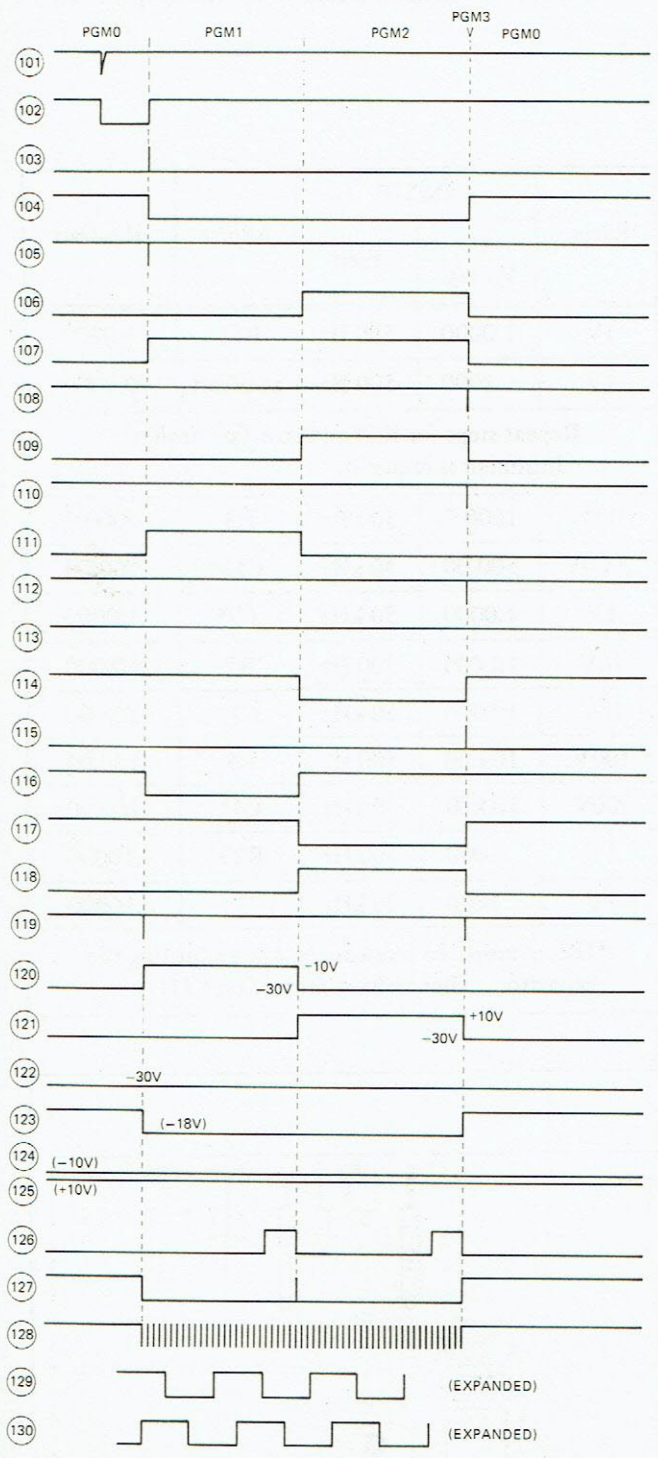


Figure 5.5 - Test Points – RMS AC Converter

5.35 TROUBLESHOOTING.

5.36 This procedure is designed to aid in the location of a malfunctioning component in the event of an instrument failure. The procedure consists of a timing diagram, signal descriptions, logic table, pertinent voltage points for the analog circuitry and troubleshooting guide. All signals described are referenced by the 100 series numbers in brackets located on the schematic drawings in Section 6 and the timing diagram (figure 5.6).



WAVEFORMS DESCRIBED IN TABLE 5.12

Figure 5.6 - Timing Diagram

CAUTION

Do not remove or replace PC Boards with power applied.

5.37 Preliminary Checks.

a. Remove the top cover and shield as described in the calibration procedure. Apply power to the instrument and check for the supply voltage as given in the table below. Nominal voltage check points are silk-screened on the Interconnect PC board.

+220V +5V −1V	Referenced to TP6 (Interconnect board)
+31V +18V −18V −31V	Referenced to – INPUT terminal on front panel

b. If all supply voltages are missing, check fuse, power cord and line voltage source. Correct any supply malfunctions.

c. If the instrument is equipped with a program board, eliminate it as a possible problem source by disconnecting J3 and J4 and rechecking for the symptoms. If the problem is isolated to the program board, refer to paragraph 5.43.

d. Perform the specification tests in Section 3 and determine the Functions and Ranges in which the malfunction occurs. When the problem is isolated to a particular portion of the instrument, review the circuit description in Section 4, then proceed to paragraph 5.38.

5.38 DC FUNCTION TROUBLESHOOTING PROCEDURE.

a. Select DC FUNCTION, 10V RANGE, and PERIODIC. Leave DATA OUTPUT, PROGRAM CONTROL, HOLD, RATIO, and FILTER out.

b. Apply +10 volts to the instrument input terminals. For errors relating to decimal position or range, refer to paragraphs 5.39, 5.40; for incorrect reading or incorrect instrument operation refer to table 5.10.

Table 5.10 - Troubleshooting the DC Function

SYMPTOM	Test Point	Location	Signal	Procedure (if Signal incorrect)
1. Erroneous Reading	1. M29-9	Interconnection Board	(129)	Check Clock and Oscillator Circuitry
	2. ANALOG OUTPUT	Rear Panel	+10 Volts	Refer to SYMPTOM 7, paragraph 5.43
	3. TP1, TP2	Interconnection Board	(107), (109)	Determine state of Program Counter and refer to SYMPTOMS 2, 3, 4, 5, and 6
2. TP1 = FALSE TP2 = FALSE (PGM-0)	1. M19-10		(101)	Check Display Rate Oscillator
	2. TP7		(102) Refer to: (103), (104), and (105)	If TRUE, check M19, M18; if FALSE, refer to figure 6.22 and check PROGRAM CONTROL LOGIC components M24, Q7, M18, M17, M11, and M5 for correct output logic levels for the input signals observed. Replace any malfunctioning component.
	3. M12-1		(128)	If Clock present, M12 is bad or M12-12 is shorted
	4. M24-2		(104)	If False, Check M24, M23
3. TP1 = TRUE TP2 = FALSE (PGM-1)	1. TP3		(111)	Replace M18
	2. M17-5		(106)	Check M3 on Display board. If (126) missing from M3-5, check M13, M14, M15, and M16 on Interconnection board
4. COUNTER LOCKED UP	M13-2		(127)	Check M3, Q12, Q13, M10, and M5 on Display Board
5. TP1 = TRUE TP2 = TRUE (PGM-2)	M6-6		(110)	Check M5, M6
6. TP1 = FALSE TP2 = TRUE (PGM-3)	M21-3		(108)	Replace M21
7. Erroneous Reading	1. M5-4		(112)	If pulse normal replace M5, if not perform test point check 7.2. If pulse normal, check Q26 and Q27 on Digitizer board and Q9 on Interconnection board
	2. TP3	Digitizer	(119)	Monitor TP2 on digitizer for –5.0V dual-slope ramp. If normal, check AR3, Q25, and AR5. If not, continue procedure

Table 5.10 - Troubleshooting the DC Function (continued)

SYMPTOM	Test Point	Location	Signal	Procedure (if Signal incorrect)
Erroneous Reading	3. TP4	Digitizer	(125)	Check RATIO relay K2 and relay drive transistor Q2 on Interconnection board. Check Q24 and AR2 on Digitizer
	4. TP5		(124)	Check AR4
	5. TP6		(116)	Check Q1, Q2. Check Q10, Q11 on Interconnection board
	6. M2-1		(117)	Check Q3, Q4. Check Q12, Q13, and M6 on Interconnection board
	7. Q14 Collector		(120)	Check Q6, Q14, M1, M2
	8. Q18 Collector		(121)	Check Q10, Q18, Q19, M1, M2
	9. Q16 Collector		(122)	Check Q8, Q16, M1, M2
	10. Collector Q12		(123)	Check Q12, Q11, M2
	11. J8-5		+10 Volts	Check Q9, Q17, Q7, Q15, Q5, Q13

NOTE

If instrument is locked up in a program state, the signal should be at the logic level required for the state indicated (e.g., during PGM-0, (104) should be true).

5.39 Range.

5.40 The routing of range logic throughout the instrument is shown in figure 5.8. The tables indicated in the blocks provide the output at important stages of the flow. (1's indicate logic true states, X's indicate the energizing of the component).

5.41 Auto Range.

5.42 The Autorange circuitry consists of an up/down counter M30, two full adders M29 and M31 and Logic circuitry consisting of portions of M18, M21, M25, M27, and M28. All of the components are located on the main board. The normal up and down range sequence for the ohms function are shown in figure 5.7. The upper and lower range limits are determined by the function selected, generating codes to the full adders. The codes for each function are shown in table 5.6.

5.43 Program.

5.44 The program circuit, when selected, disables the Function and Range switches and enables the external programming lines through the M1, M2, and M3 'AND' gates. The program board also generates delayed commands when HOLD and EXT DVM COMMAND (TIMEOUT) are used. The timeout periods are dependent on the function selected and shown in table 5.11. For troubleshooting, refer to table 5.22 and schematic, figure 6.22.

Table 5.11 - Timeouts

Function	Timeout
DC	30 ms
1 ohm to 10 Megohm	30 ms (with W-1 out) 300 ms (with W-1 in)
100 Megohm	300 ms
Filter	250 ms (plus Function Timeout)
AC	500 ms

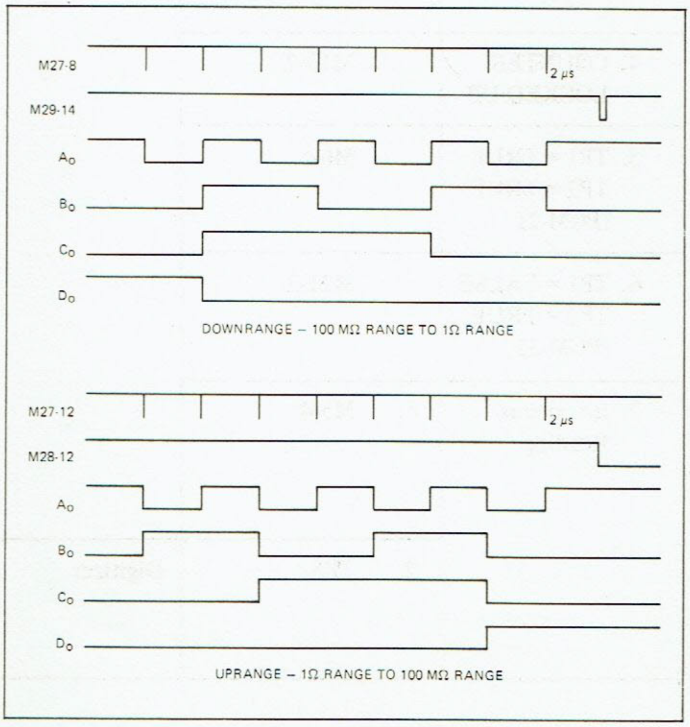


Figure 5.7 - Auto Range Sequence

Table 5.12 - Timing Diagram Signal Description

Fig. Designator	Circuit Name	Circuit Components	Output Signal Description	Circuit Input Signals	Purpose	Output	Routed to:
(101)	Display Rate Oscillator	Q26, Q27	Negative going ≈.5 ms pulse, 5V	Instrument in Periodic mode, PGM-0	Initiates a new reading at completion of a measurement cycle	Q27 Collector	M19-10
(102)	5 ms Delay Driver	M19, M18	Negative going 5 ms pulse, 3.8V	Periodic: display pulse (101); HOLD: PGM Com'd, DVM Com'd, or SINGLE	Negative going edge initiates 5 ms delay Generator	M18-4 (TP7)	M18-3, M6-1 5 ms delay Ckt.
(103)	Delayed Pulse Circuitry	M18, M24, Q7	Positive going 1 to 2 μs pulse, 4V	(102)	Advances Program Counter to PGM-1	M18-1	M17-9
(104)	PGM-0 Decoder	M23, M24	Negative going 33-1/3 ms pulse, 4V	M12-9, M12-12	Premeasurement state of program logic	M24-2	Display Rate Osc, M17-10, M23-2, M21-5 M29-13
(105)	Nand Gate	M17	Negative going 1 to 2 μs pulse, 4V	(103) & (104)	Allows command pulse during PGM-0 only	M17-8	M5-13
(106)	Q1 Overflow	M3 (display board)	Positive going 16-2/3 ms pulse, 4V	Counter overflow (126)	Advance Program Counter to PGM-2	M3-9	M17-5, M6-12
(107)	Program F/F A	M12	Positive going 33-1/3 ms pulse, 4V	M11-1	Determines state of measurement cycle	M12-12 (TP1)	M17-1, M23-6, M12-7
(108)	PGM-3 Decoder	M21	Negative going 2 μs pulse, 4V	M12-9, M12-13	Generates latch strobe pulse	M21-3	M17-13, M18-11, M22-2, 13
(109)	Program F/F B	M12	Positive going 16-2/3 ms pulse, 4V	M11-1	Determines state of measurement cycle	M12-9 (TP2)	M12-3, M21-1, M18-9, M23-5, M6-4
(110)	Axis crossing memory	M6, M5	Negative going 3.4 μs pulse, 4V	M6-11, Q8, Q9 (113) (114)	Advances program counter to PGM-3	M6-6	M5-1

Table 5.12 - Timing Diagram Signal Description (continued)

Fig. Designator	Circuit Name	Circuit Components	Output Signal Description	Circuit Input Signals	Purpose	Output	Routed to:
(111)	PGM-1 Decoder	M18	Positive going 16-2/3 ms pulse, 4V	M12-9, M12-13	Signal integrate period	M18-10 (TP3)	Base Q10, Q11, M17-4
(112)	Axis & Polarity Amplifier (1/2) (used in positive polarity inputs)	Q9	Negative going 100 ns pulse, 4V	Axis crossing detector output (digitizer board)	Clear polarity f/f (M26), reset axis crossing memory (M5, M6)	Q9 Collector	M26-1, M5-4
(113)	Axis & Polarity Amplifier (1/2)	Q8	Same as (112) (with negative polarity inputs)	Same as (112)	Set polarity f/f, reset axis crossing memory	Q8 Collector	M26-4, M5-5
(114)	Q2 Overflow	M3 (on display board)	Negative going 16-2/3 ms pulse, 4V	(106)	Indicates an overload when 50 ms in duration	M3-13 (display board)	M2-12 (display board) M6-13, M27-2, M11-5
(115)	Strobe B	M22	Positive going 2 μs pulse, 4V	M21-3 (108)	Strobes latch for 1 K's digit & polarity F/F (M26)	M22-6	M10-4-13, M26-11 M23-11 (display board)
(116)	Signal Integrate De-Code Circuit	Q1, Q2 (digitizer board)	Negative going 16-2/3 ms pulse, 4V	M18-10 (111)	Controls signal switch drive circuit on digitizer	Q1 Collector (TP6)	Q6 emitter through R14, M2-5 (digitizer board)
(117)	Reset De-code Circuit (Q)	Q3, Q4 (digitizer board)	Negative going 16-2/3 ms pulse, 4V	M6-3	Enables polarity change	Q4 Collector	M2-1-4-13 (digitizer board)
(118)	Reset De-code Circuit (Q)	Same as (117)	Positive going 16-2/3 ms pulse, 4V	Same as (117)	Enables reference drive circuit	Q3 Collector	M1-2-5 (digitizer board)
(119)	Axis Crossing Detector	AR5 (digitizer board)	2-Negative going pulses: #1 14 μs, 4V #2 70 μs, 4V	AR3, Q25 on digitizer board	Indicates polarity and axis crossing	AR5-9 (TP3)	Base of Q26, Q27, M2-10-12 (digitizer board)

Table 5.12 - Timing Diagram Signal Description (continued)

Fig. Designator	Circuit Name	Circuit Components	Output Signal Description	Circuit Input Signals	Purpose	Output	Routed to:
(120)	Signal Switch Drive Circuit	Q6, Q14 (digitizer board)	Positive going 16-2/3 ms pulse, 40V (–30V to +10V)	(116)	Controls gate of signal switch (Q13 on digitizer board)	Q14 Collector	Gate of Q13 (digitizer board)
(121)	– Reference Switch Drive Circuit	Q10, Q18 (digitizer board)	Positive going 16-2/3 ms pulse, 20V (–30 to –10)	M1-3	Controls – Reference switch FET (Q17 on digitizer board)	Q18 Collector	Gate of Q17 (digitizer board)
(122)	+ Reference Switch Drive Circuit	Q8, Q16 (digitizer board	–30 volt level (positive signal input)	M1-6	Controls + Reference switch FET (Q15 on digitizer board)	Q16 Collector	Gate of Q15 on digitizer board
(123)	Internal Reset Circuit	M2, Q11, Q12 (digitizer board)	Negative going 33-1/3 ms pulse, –18V	(117), (118)	Activates FET switches Q20 and Q28 during non-measurement period to reset integrator	Q12	Gates of Q20, Q28 (on digitizer board)
(124)	Negative Reference	AR4 (digitizer board)	–10 volt level	(125) through R61	Used for measurement of positive input signals	AR4-6 (TP5)	Source of Q17
(125)	Positive Reference	AR2 (digitizer board)	+10 volt level	CR10 reference zener	Used for measurement of negative input signals	Q24 emitter (TP4)	Source of Q15, J9-C (ohms conv.)
(126)	Counter Overflow	M16	2-positive going 3.3 ms pulses, 4V	M15-11	Drives overflow F/Fs (M3 on Readout board)	M16-11 (8-bit)	M3-5 (on display board)
(127)	Counter Reset	M5 (on display board)	2-negative going 16-2/3 ms pulse, 4V, 16-2/3 μs a part	M10-10 (display board) M23-13	Resets counter to zero during PGM-0 and during integrator crossover	M5-3	M13-2, M14-2, M15-2, M16-2
(128)	Count Circuit	M17	Negative going 600 KHz square wave, 33-1/3 ms, 4V	Clock (129), (107)	Advance counter	M17-3	M13-14
(129)	Clock	M20	600 KHz square wave, 4V	M24-6, 2.4 MHz oscillator	Master timing	M20-9	M17-2

Table 5.12 - Timing Diagram Signal Description (continued)

Fig. Designator	Circuit Name	Circuit Components	Output Signal Description	Circuit Input Signals	Purpose	Output	Routed to:
(130)	Clock (X)	M20	600 KHz square wave, 4V, leads clock by 90°	Same as (129)	Ranging circuitry	M20-13	M18-12, M25-9

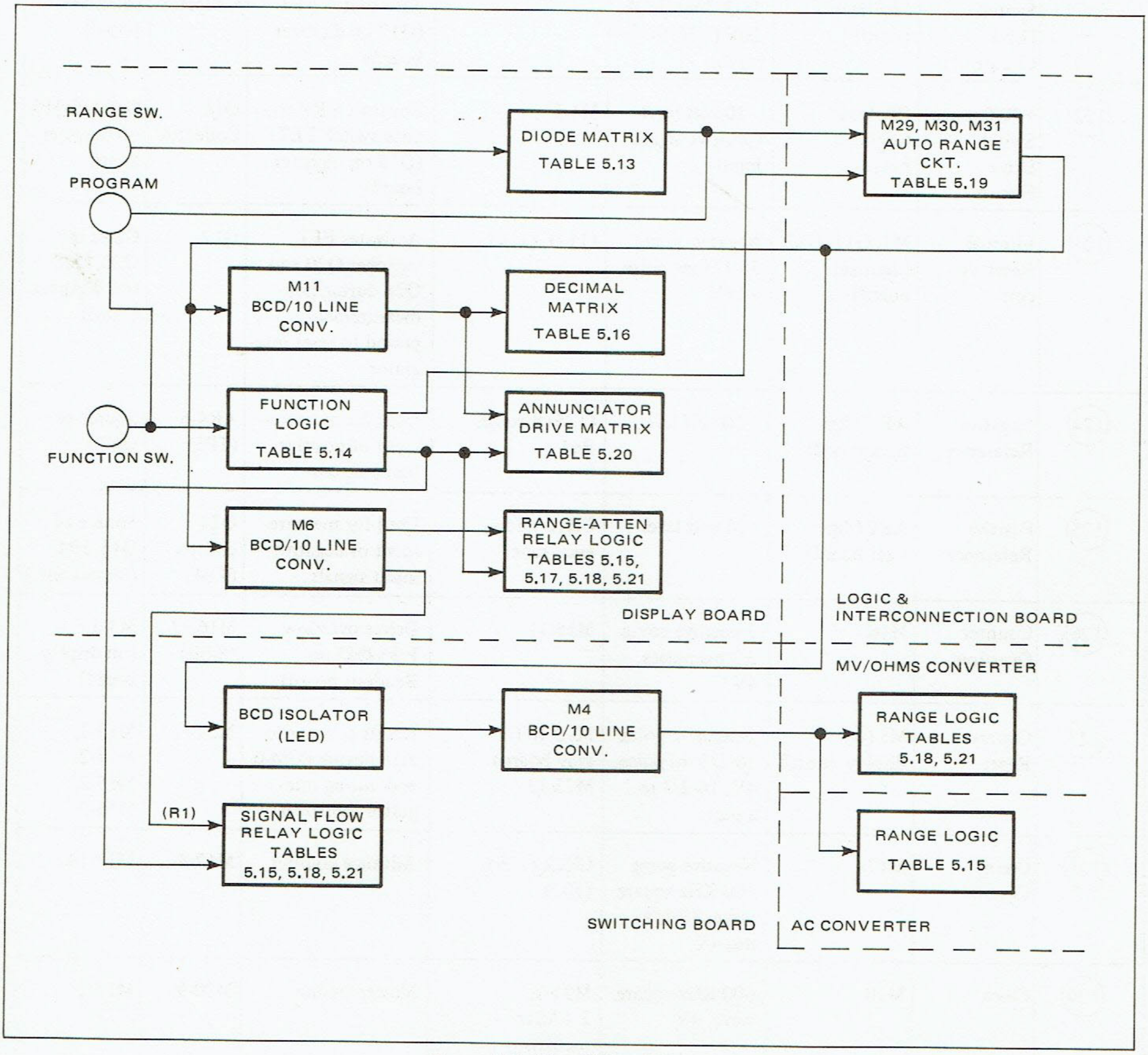


Figure 5.8 - Signal Flow Diagram

Table 5.13 - BCD Coding

Range Switch (Input)	Diode Matrix Output Code			
	A	B	C	D
1	1	0	0	0
10	0	1	0	0
100	1	1	0	0
1	0	0	1	0
10	1	0	1	0
100	0	1	1	0
1000	1	1	1	0
10M	0	0	0	1
100M	1	0	0	1
Auto	1	1	1	0

Table 5.14 - mV Function Coding

Jumper (W2)	INPUT		OUTPUT	
	$\overline{DCMV}$	$\overline{DC}$	$\overline{DC'}$	$\overline{DCMV'}$
Short	1	1	1	1
Short	0	1	0	1
Short	1	0	0	1
Open	1	1	1	1
Open	0	1	1	0
Open	1	0	0	1

Table 5.15 - AC Mode

Range	ISO*			SW. BD.			DIAC** CONVERTER			
	K1	K3	K4	K1	K2	K3	K1	K2	K3	Q5
100 mV		X			X					X
1	X				X					X
10	X				X				X	
100	X				X			X	X	
1000	X				X		X		X	

*Gain & Attenuation relays on the Interconnection Board used in conjunction with the Isolator Board
**RMS Code given in figure 4.9

Table 5.16 - Decimal Point Code

BCD Input				Decimal	Range	Mode
A	B	C	D			
1	0	0	0	0.0000	1	Ohms
0	1	0	0	00.000	10	mV Ohms
1	1	0	0	.00000	100	
0	0	1	0	0.0000	1	Volts Kohms
1	0	1	0	00.000	10	
0	1	1	0	000.00	100	
1	1	1	0	0000.0	1000	
0	0	0	1	00.000	10M	Mohms
1	0	0	1	000.00	100M	

Table 5.17 - DC Mode

Range	ISO*		
	K1	K3	K4
100 mV		X	
1	X		
10			
100	X		X
1000			X

*Gain & Attenuation relays on the Interconnection Board used in conjunction with the Isolator Board

Table 5.18 - mV-DC Mode

Range	ISO*			SW. BD.		
	K1	K3	K4	K1	K2	K3
10 mV	X			X		
100 mV				X		
1	X					
10						
100	X		X			
1000			X			

*Gain & Attenuation relays on the Interconnection Board used in conjunction with the Isolator Board

Table 5.19 - Function Limit Codes

Range BCD Code (Input)				FUNCTION															
				Ohms				DC/mV				DC				AC			
1	2	4	8	1	2	4	8	1	2	4	8	1	2	4	8	1	2	4	8
1	0	0	0	0	1	1	1												
0	1	0	0					1	0	1	1								
1	1	0	0									0	0	1	1	0	0	1	1
0	0	1	0			(Legal Range Area)													
1	0	1	0																
0	1	1	0																
1	1	1	0					0	0	0	1	0	0	0	1	0	0	0	1
0	0	0	1																
1	0	0	1	0	1	1	0												

Impossible Range Area

Table 5.20 - Annunciator Coding

Inputs		MΩ		KΩ				Ω		1 mV		Ratio		AC		+ Pol		– Pol		NO			
		DS1		DS2				DS3		DS4		DS5, 6		DS7		DS8		DS9		DS10			
M1 Output Code	1						X		X														
	2					X		X		X													
	8		X		X																		
	9	X		X																			
	$\overline{\lambda}$			X	X	X	X	X	X														
	$\overline{\Omega}$									X											X		
	$\overline{\text{Ratio}}$											X											
	$\overline{\text{AC}}$													X						X			
	+ Polarity															X							
	– Polarity																	X					
	W-1 Short																			X			
	W-3 Short																				X		
	Overload																					X	
	Q2 $\overline{\text{Overflow}}$																						X

Table 5.21 - Ohms Mode

Range	ISO*			SW. BD			OHMS CONVERTER						
	K1	K3	K4	K1	K2	K3	K1	K2	K3	K4	K5	Q1	Q12
1	X			X		X	X	X					
10				X		X	X	X					
100				X		X	X						
1				X		X			X				
10						X	X					X	
100						X			X				X
1000						X				X			
10000						X					X		
*Gain & Attenuation relays on the Interconnection Board used in conjunction with the Isolator Board													

Table 5.22 - Program Troubleshooting

Symptom (Inoperative)	Input (J202)	Name	Output	Components Used
Program	Pin 21	Ext. Program Control	P3-8	M5, M3, & Q1
Function	Pin 14	Ext. DC	P3-7	M5, M2
	Pin 19	Ext. DC/mV	P3-9	M5, M3
	Pin 26	Ext. AC	P3-1	M4, M1
	Pin 24	Ext. Ω	P3-2	M4, M1
Range	Pin 16	Ext. Auto	P4-8	M4, M2
	Pin 12	Ext. A_{in}	P3-13	M5, M2
	Pin 18	Ext. B_{in}	P3-6	M4, M2
	Pin 15	Ext. C_{in}	P3-12	M5, M3
	Pin 17	Ext. D_{in}	P3-10	M5, M3
Ratio	Pin 22	Ext. Ratio	P3-3	M4, M1
Filter	Pin 20	Ext. Filter	P3-4	M4, M1
Hold	Pin 28	Ext. Hold	P4-11	M7, M6
Command (FAST)	Pin 29	Ext. DVM Command (FAST)	P4-6	M7, M6
Command (TIMEOUT)	Pin 27	Ext. DVM Command (TIMEOUT)		M7, M6, Q6, Q7, Q8, Q5, Q4, Q3, Q2, M10

5.45 ANALOG TROUBLESHOOTING.

5.46 The analog portions of the instrument are located on the ISOLATOR, MILLIVOLT, OHMS Converter/ MILLIVOLT, AC Converter and AC PRESCALER boards. The following paragraphs and tables provide pertinent operating information and voltage levels at various points in the circuitry. The voltage levels are keyed to designators on the schematics in Section 6. All voltage levels in the analog circuitry unless otherwise noted are referenced to the – INPUT terminal on the front panel of the instrument.

5.47 Isolator.

5.48 The Isolator amplifier (figure 6.17) accepts inputs of approximately ± 24 volts, limited by the input clamp network (Q15, Q16, Q5, Q6, CR1, and CR2). The output swing is approximately ± 26 volts.

5.49 Voltage levels of major points on the amplifier for various inputs are shown in table 5.23.

Table 5.23 - Isolator Voltage Levels

Input	TEST POINT						
	A	B	C	D	E	F	G
0 Volts	+5	0	−5	−1.0	0	+0.5	+2.7
+10 Volts	+15	+10	+5	+9.0	+10	+0.5	+12.7
−10 Volts	−5	−10	−15	−11.0	−10	+0.5	−7.3

5.50 Millivolts.

5.51 The Millivolts amplifier is provided either as a single unit (figure 6.7) or combined with the OHMS converter board (figure 6.9). The Millivolts amplifier has a fixed gain of 100 when used for the mV function on a gain of 99 when used with the Ohms converter for low ohms measurements. The difference in gain is due to the routing of the input signal to the amplifier; not to any change in the gain determining resistors of the amplifier. Output voltage swing is approximately ± 24 volts. Voltage levels at various points of the amplifier are given in table 5.24.

Table 5.24 - Millivolts Voltage Levels

Input	TEST POINT					
	A	B	C	D	E	F
0	−1.3V	0V	+2.2V	+3 mV	+5V	−5V
+10 mV	−1.3V	+1V	−3.7V	+13mV	+5V	−5V
−10 mV	−1.3V	−1V	+7.6V	−7 mV	+5V	−5V

5.52 Ohms Converter.

5.53 The Ohms converter amplifier is an operational amplifier with a dual F.E.T. input. The operation of the amplifier and ranging circuit is described in the Theory of Operation section. Voltage levels are given in table 5.25.

Table 5.25 - Ohms Converter Voltage Levels

Input	TEST POINT		
	G	H	I
Short	+1V	+4.3V	0V
1 Kohm	+1V	+4.3V	−100 mV

5.54 DIAC Scaling Amplifier.

5.55 The Scaling amplifier is an operational amplifier with feedback supplied through the ranging circuits. Voltage points are supplied on the schematic (figure 6.11).

5.56 DIAC Converter.

5.57 The AC converter consists of three active rectifiers and a summing amplifier. Voltage levels and wave forms are provided on figure 6.13.

5.58 RMS AC Converter.

5.59 The RMS Converter consists of a scaling amplifier and operates in essentially the same manner as the DIAC scaling amplifier except on the .1 volt range. On this range the scaling amplifier has a gain of 10 causing the output signal of the scaling amplifier to be at a 1 volt level for a full scale 0.1 volt input. The remainder of the circuit consists of an active full wave rectifier, a log amplifier and an antilog and summing amplifier circuitry. A divide-by-10 attenuator circuit at the output of the converter reduces the dc equivalent output by a factor of 10 on the .1 volt range. Typical waveforms for a sinusoidal input are shown in figure 4.9; the schematic, indicating the actual components found on the circuit board, is provided in figure 6.15.

SECTION 6 DRAWINGS

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6.18	Layout, Digitizer	6-22
6.19	Schematic, Digitizer	6-23
6.20	Layout, Display	6-24
6.21	Schematic, Display	6-25
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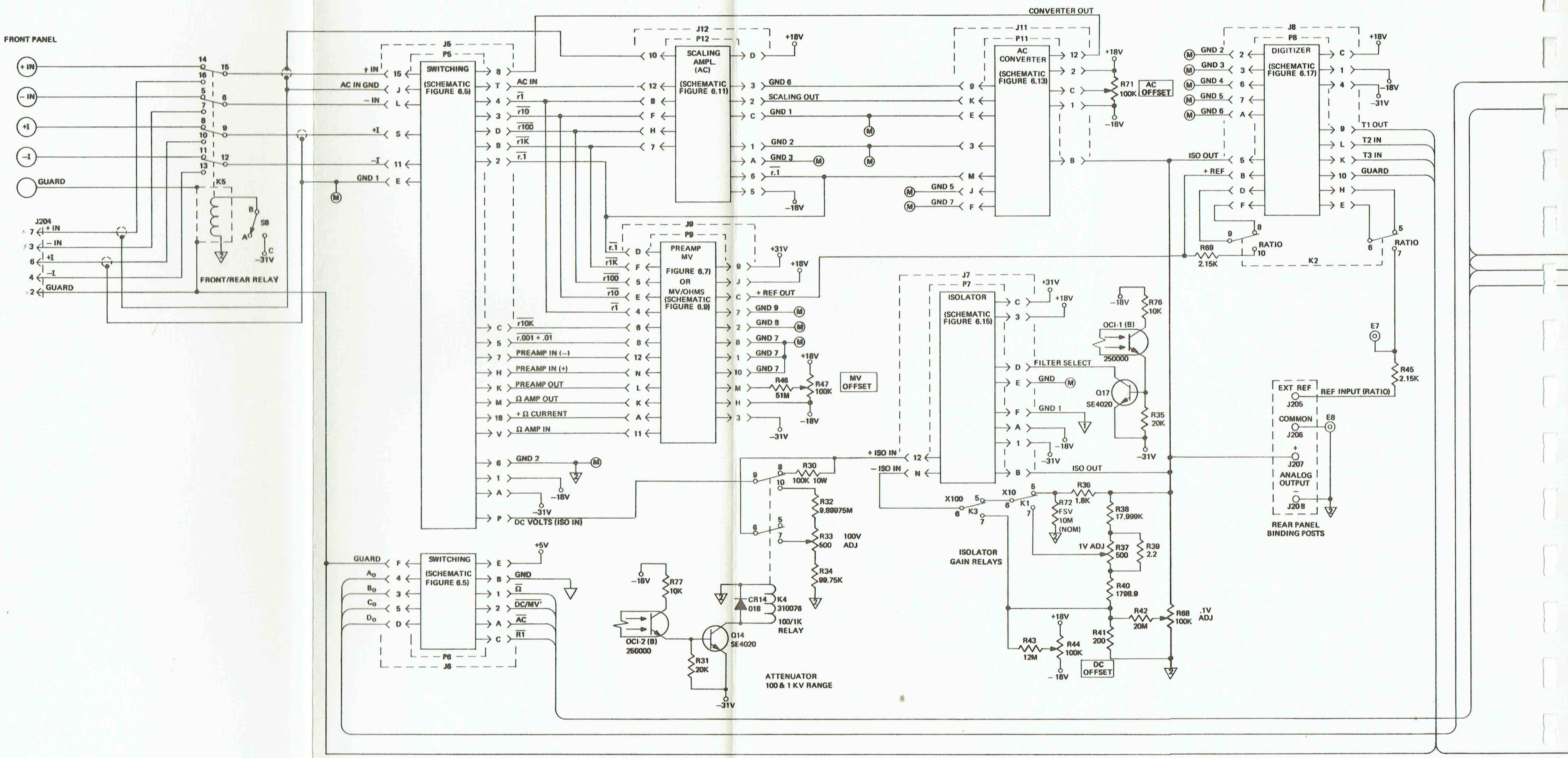
6.24	Integrated Circuits	6-28


FRONT PANEL
GUARD
J204
FRONT/REAR RELAY
K5
SWITCHING (SCHEMATIC FIGURE 6.5)
J5
P5
SCALING AMPL. (AC) (SCHEMATIC FIGURE 6.11)
J12
P12
CONVERTER OUT
AC CONVERTER (SCHEMATIC FIGURE 6.13)
J11
P11
AC OFFSET
DIGITIZER (SCHEMATIC FIGURE 6.17)
J8
P8
PREAMP MV FIGURE 6.7) OR MV/OHMS (SCHEMATIC FIGURE 6.9)
J9
P9
MV OFFSET
ISOLATOR (SCHEMATIC FIGURE 6.15)
J7
P7
FILTER SELECT
ISO OUT
RATIO
K2
EXT REF
REF INPUT (RATIO)
COMMON
ANALOG OUTPUT
REAR PANEL BINDING POSTS
ISOLATOR GAIN RELAYS
1V ADJ
.1V ADJ
DC OFFSET
100V ADJ
100/1K RELAY
ATTENUATOR 100 & 1 KV RANGE
SWITCHING (SCHEMATIC FIGURE 6.5)
P6
J6
DC VOLTS (ISO IN)

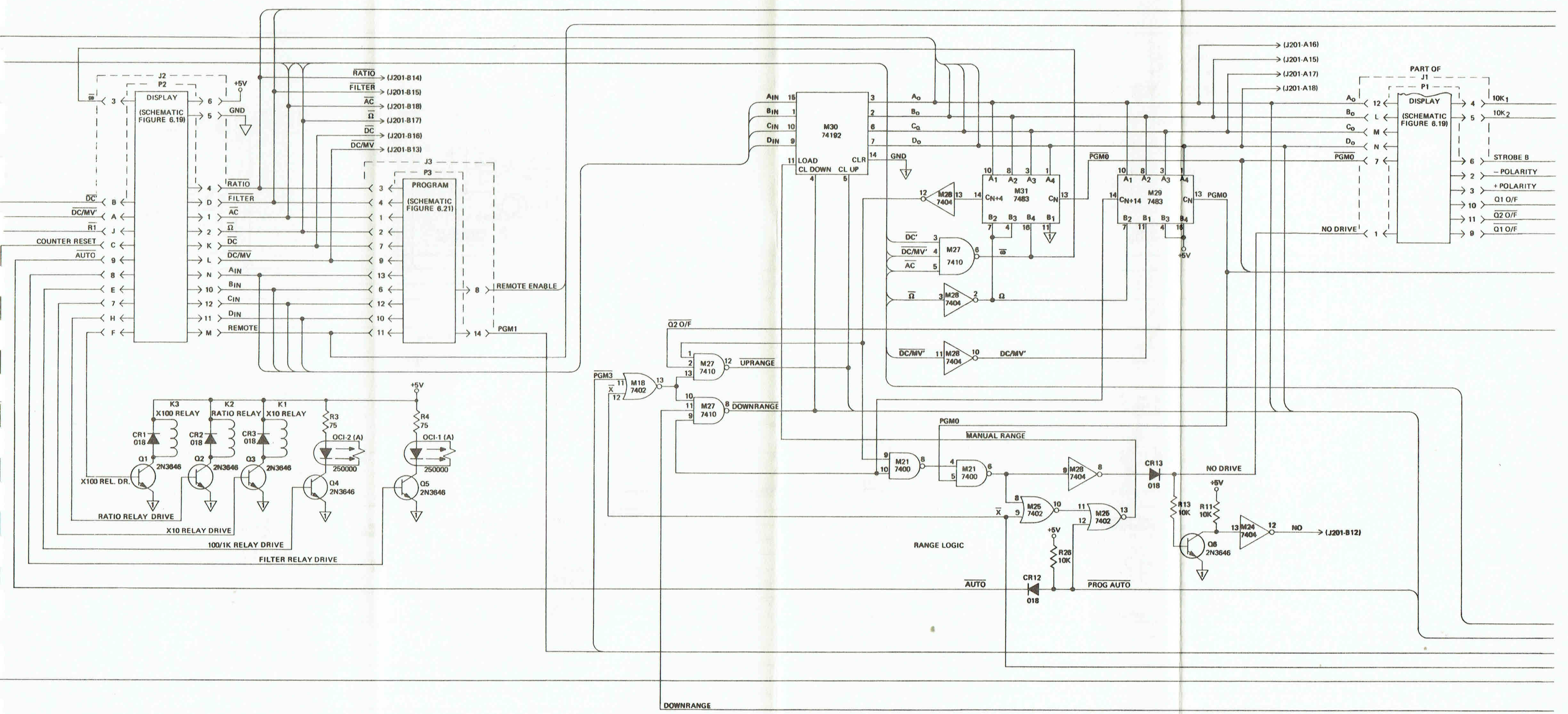
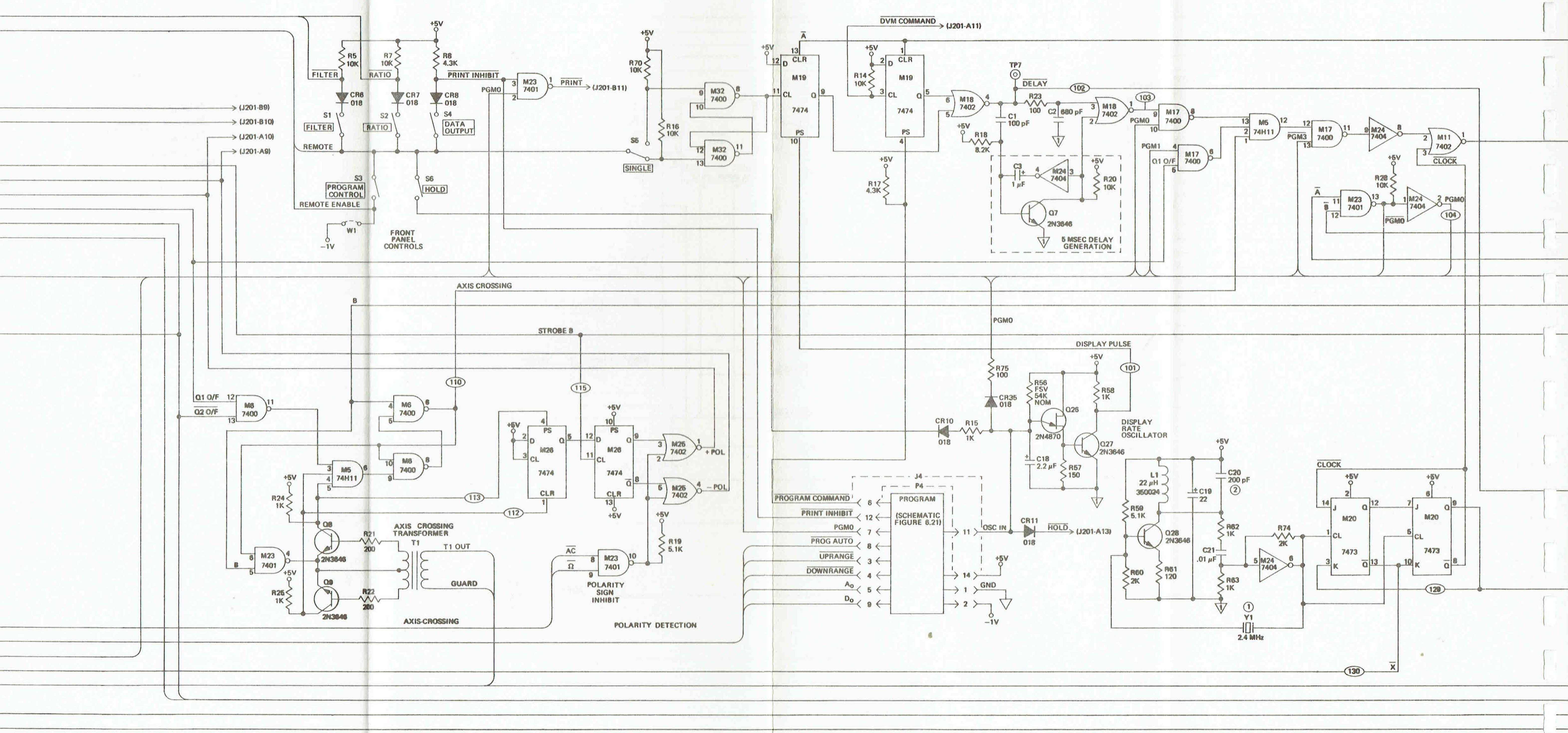
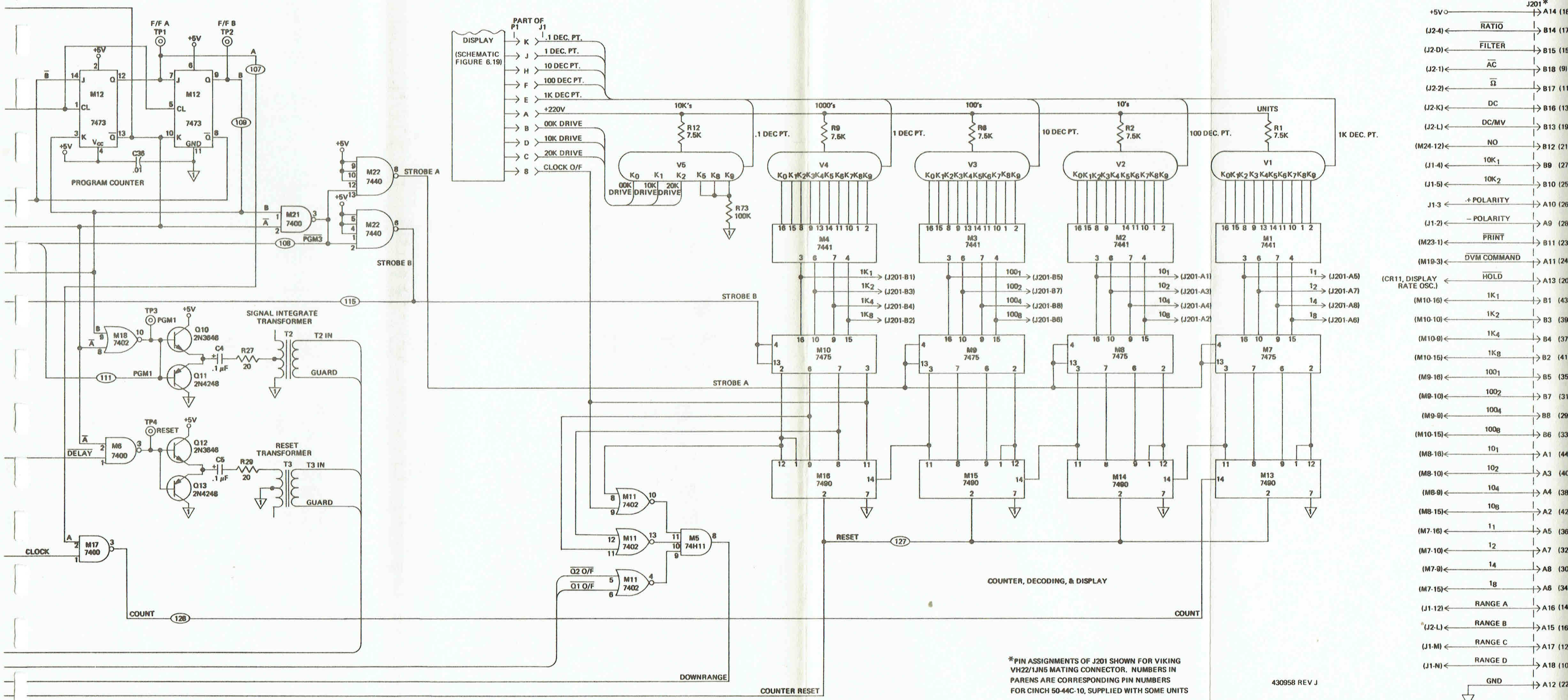


Figure 6.1 - Schematic, Interconnection & Logic


FRONT PANEL CONTROLS
AXIS CROSSING
AXIS CROSSING TRANSFORMER
POLARITY DETECTION
5 MSEC DELAY GENERATION
DISPLAY RATE OSCILLATOR
DVM COMMAND
DISPLAY PULSE
PROGRAM (SCHEMATIC FIGURE 6.21)
PRINT INHIBIT
STROBE B
POLARITY SIGN INHIBIT



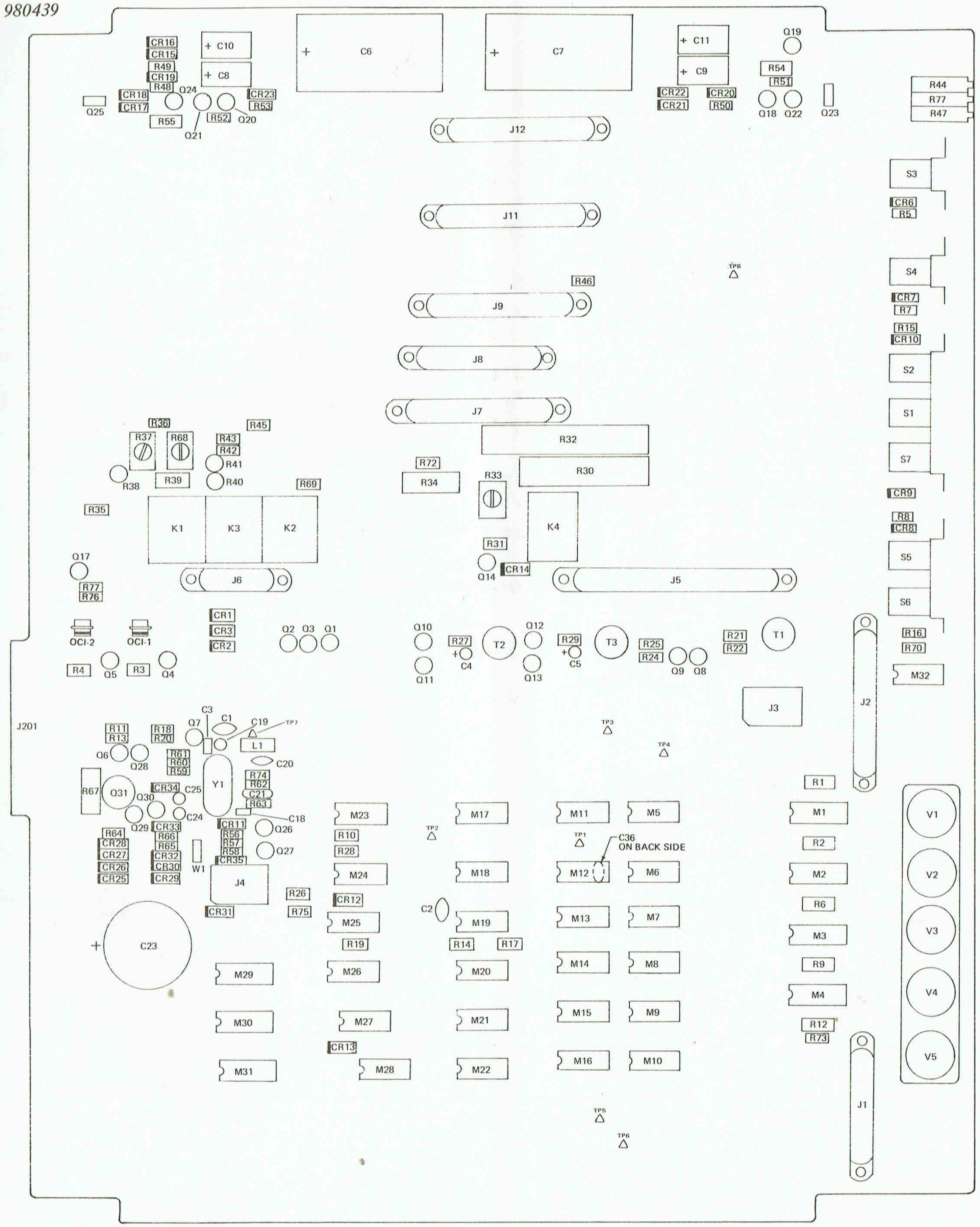
*PIN ASSIGNMENTS OF J201 SHOWN FOR VIKING VH22/1JN5 MATING CONNECTOR. NUMBERS IN PARENS ARE CORRESPONDING PIN NUMBERS FOR CINCH 50-44C-10, SUPPLIED WITH SOME UNITS

NUMBERS IN ◯ IDENTIFY SIGNALS REFERENCED IN THE TROUBLESHOOTING CHARTS AND TIMING DIAGRAM (SECTION 5).

(1) ON 50 Hz INSTRUMENTS, 2.4 MHz CRYSTAL Y1 IS REPLACED WITH 2 MHz CRYSTAL.

(2) ON 50 Hz INSTRUMENTS, C20 (200 pF) IS REPLACED WITH 270 pF CAPACITOR.

Figure 6.1 - Schematic, Interconnection & Logic continued



ASSY 403433 REV W

Figure 6.2 - Layout, Interconnection and Logic

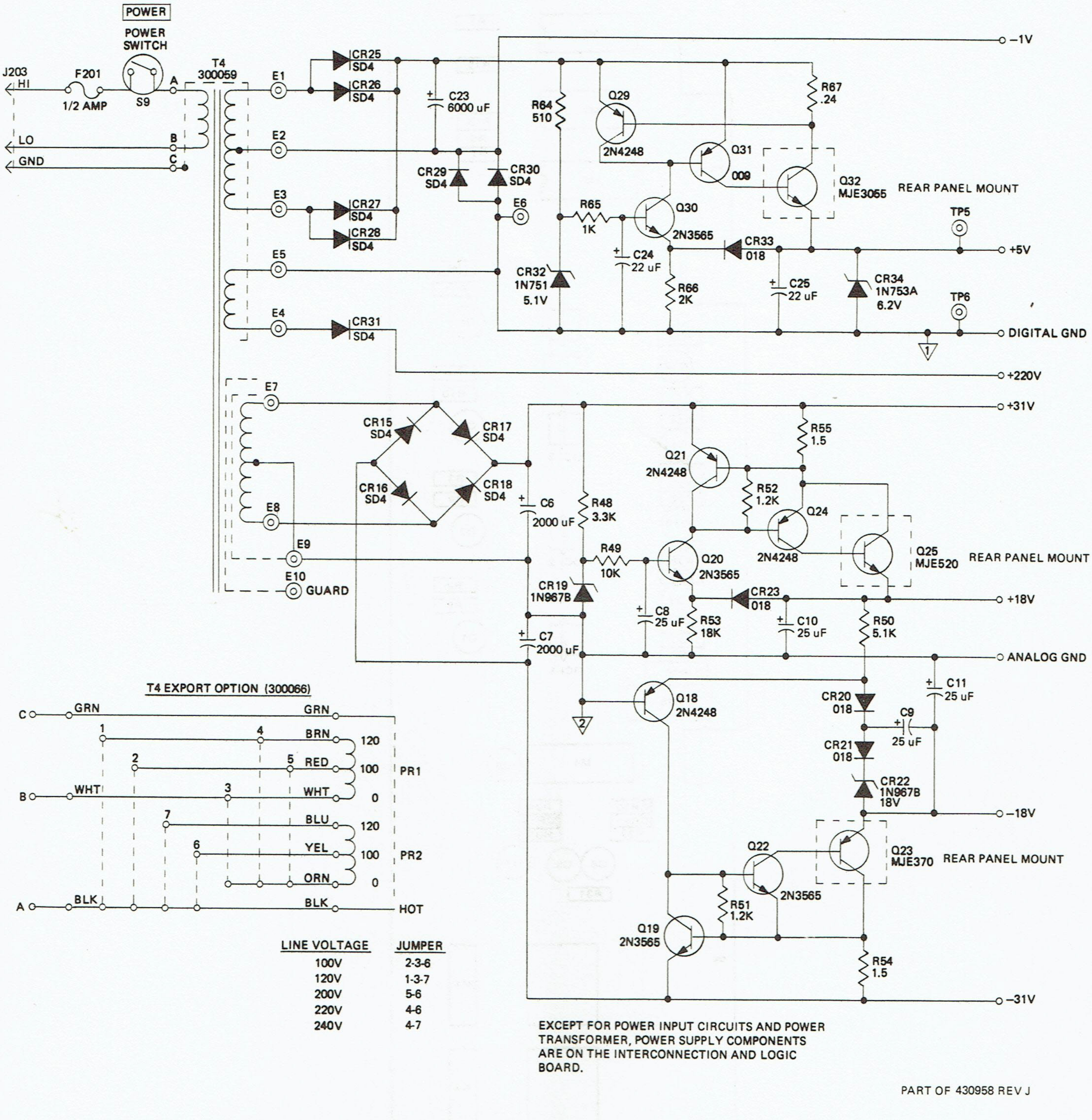


Figure 6.3 - Schematic, Power Supply

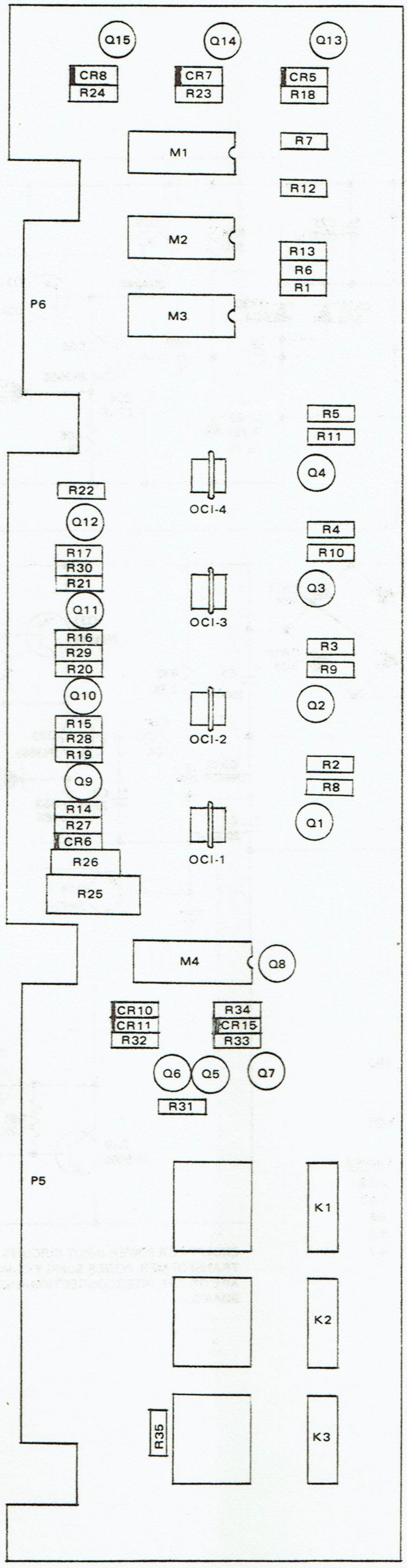


Figure 6.4 - Layout, Switching

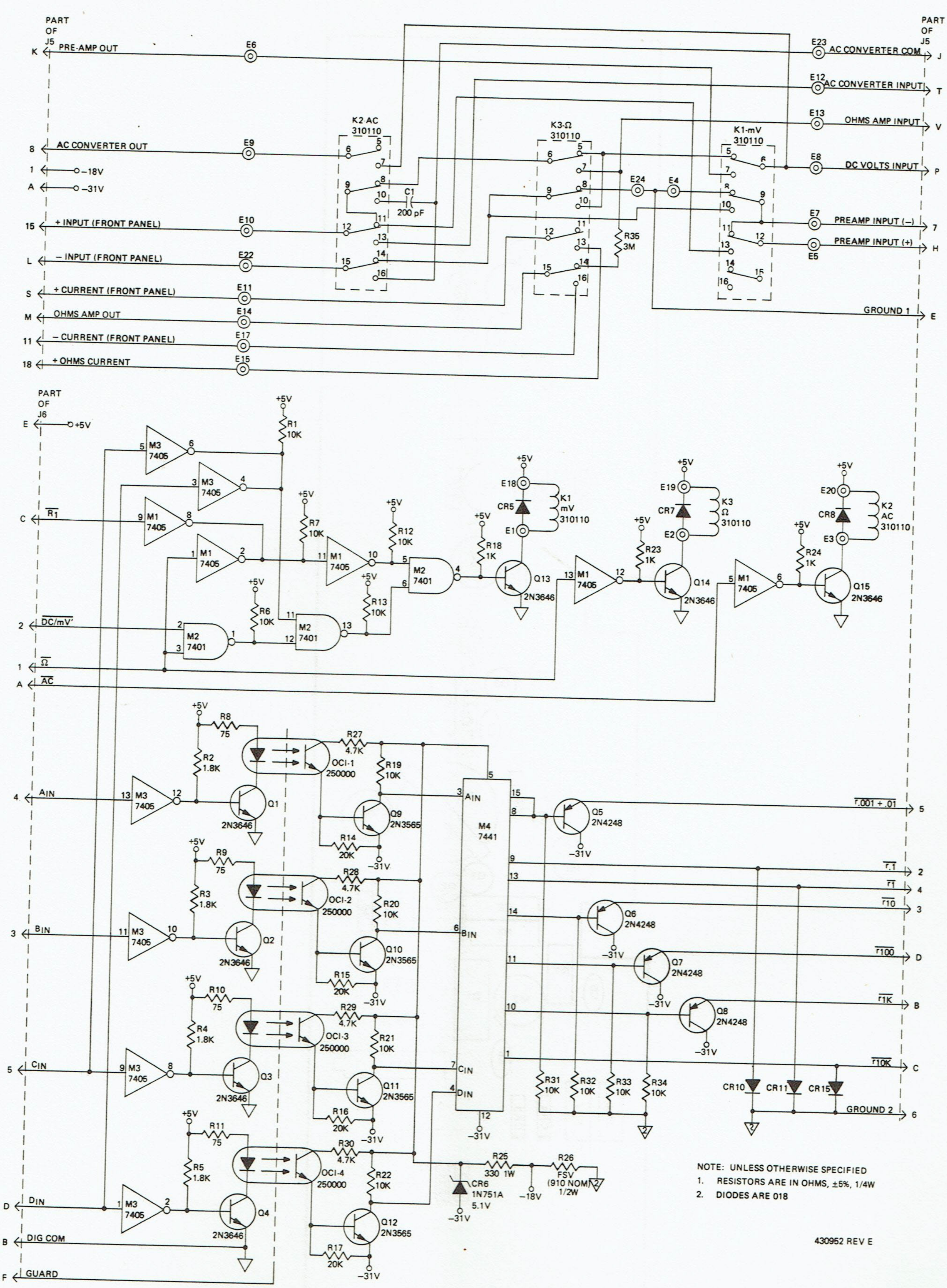


Figure 6.5 - Schematic, Switching

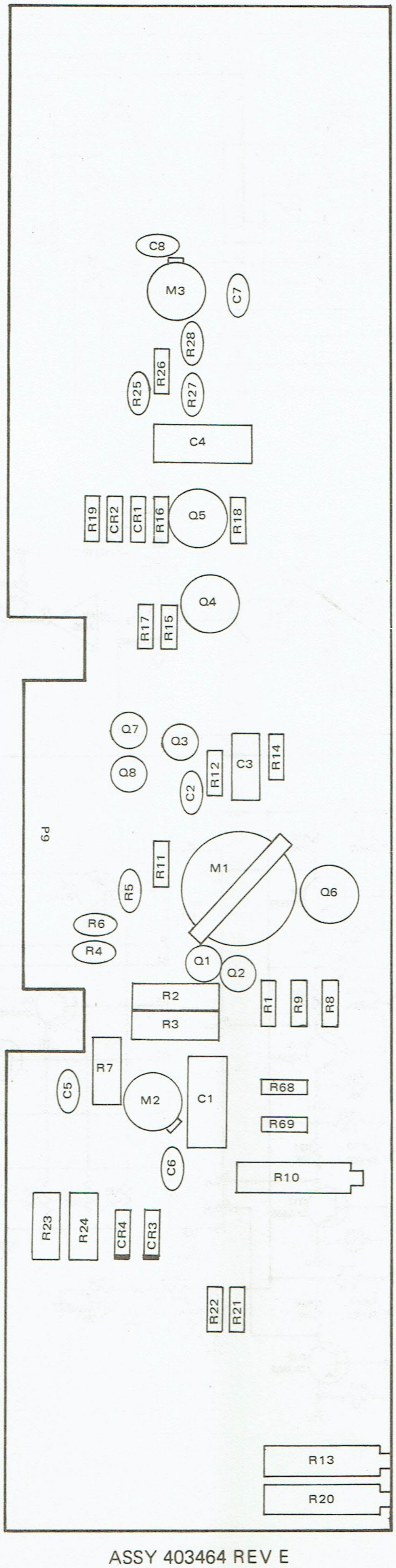


Figure 6.6 - Layout, Preamp (mV)

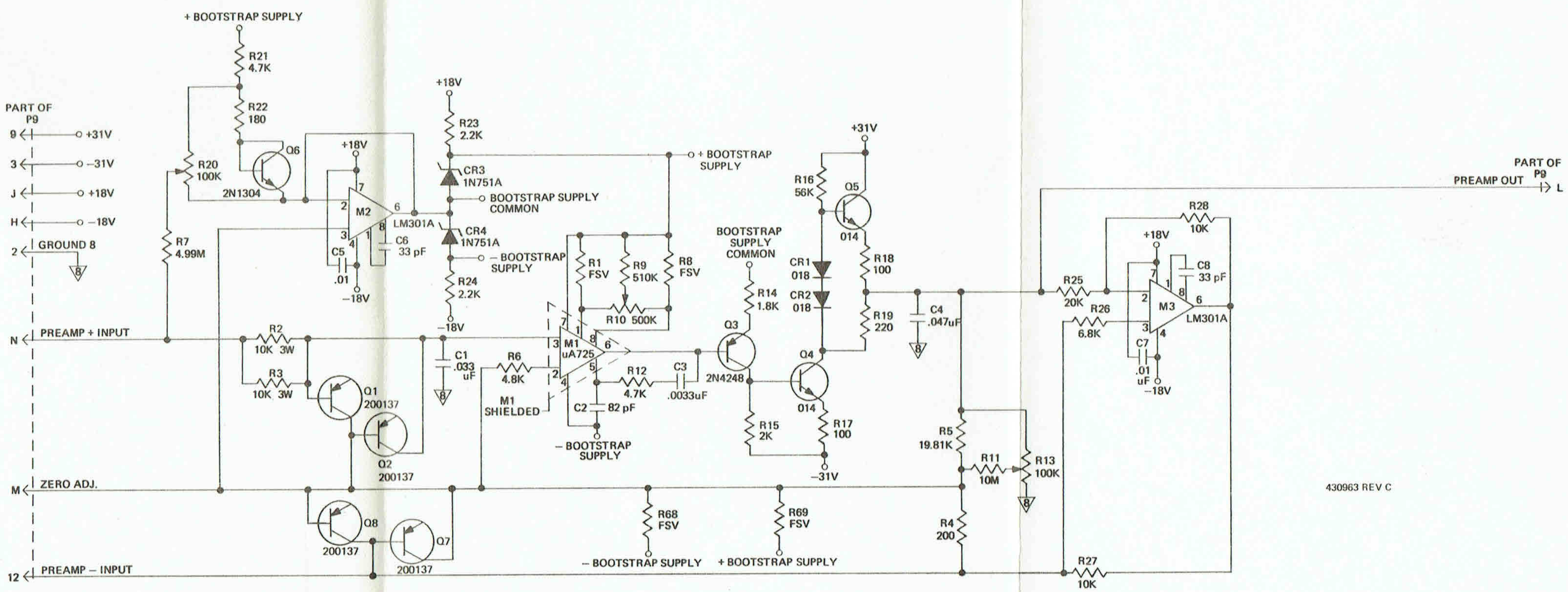


Figure 6.7 - Schematic, Preamp (mV)

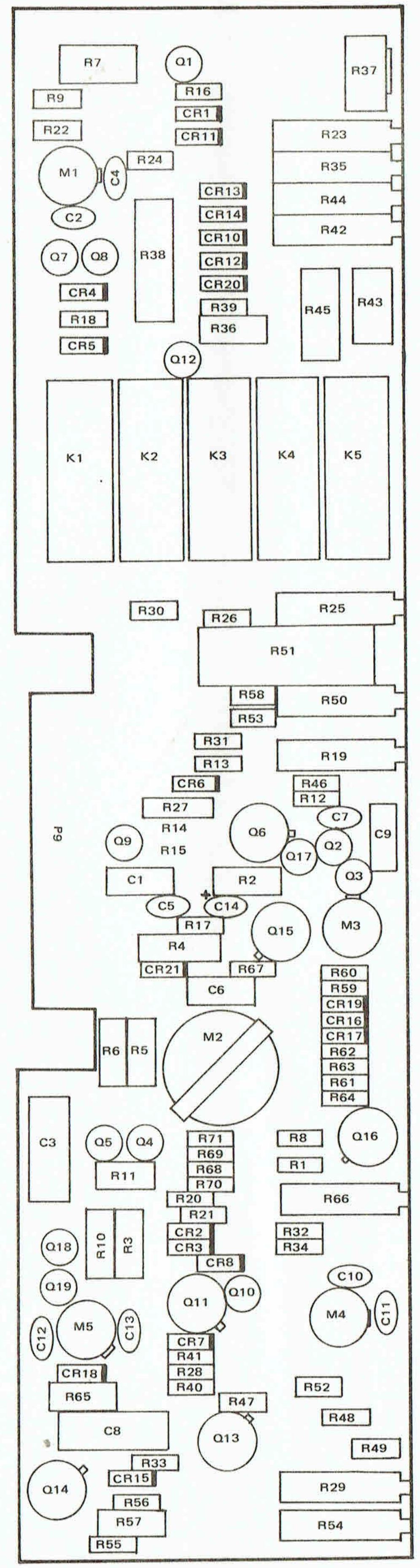


Figure 6.8 - Layout, Preamp/Ohms Converter

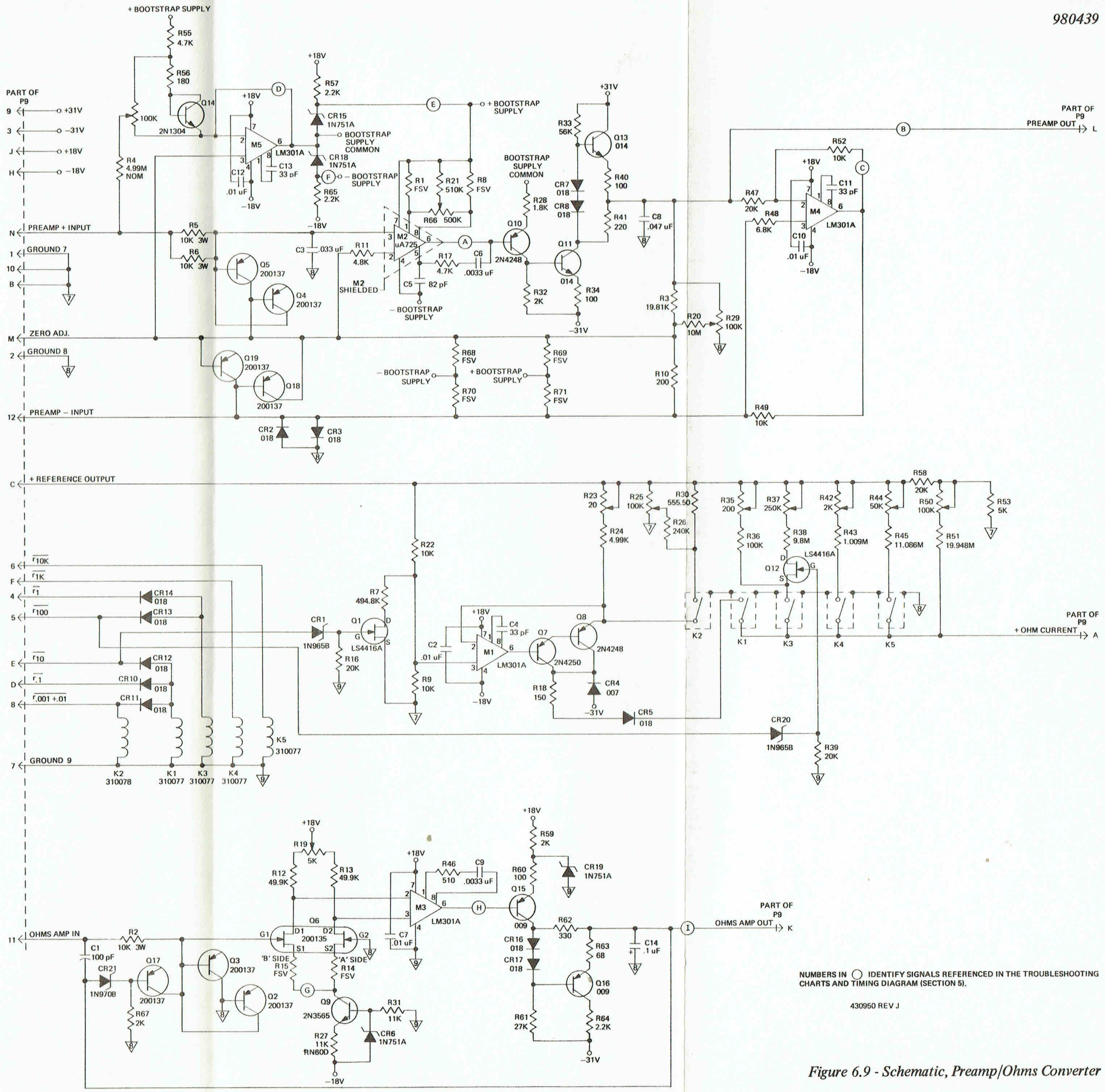


Figure 6.9 - Schematic, Preamp/Ohms Converter

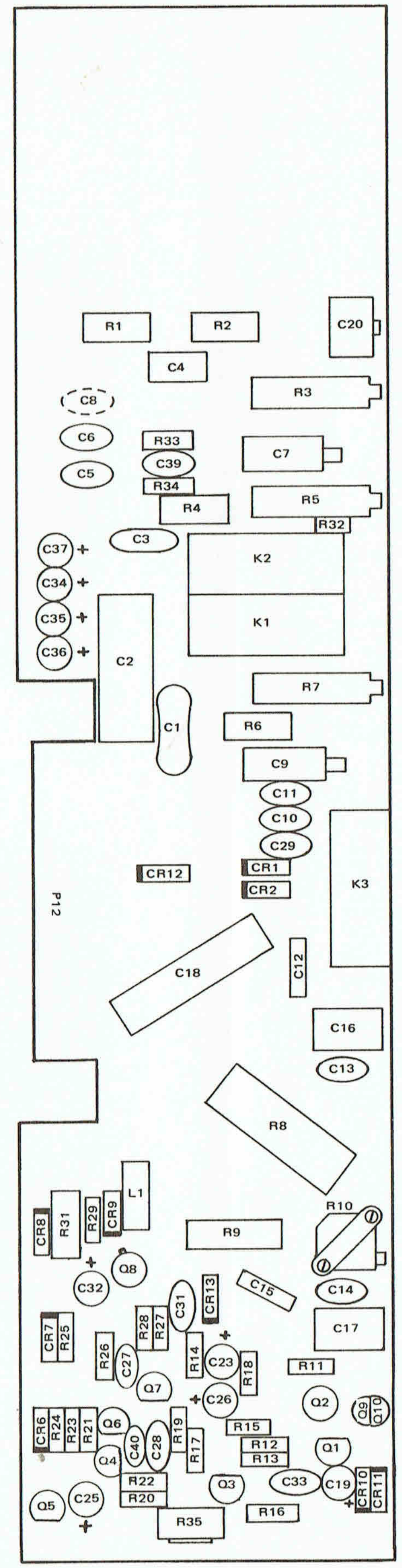


Figure 6.10 - Layout, Scaling Amplifier

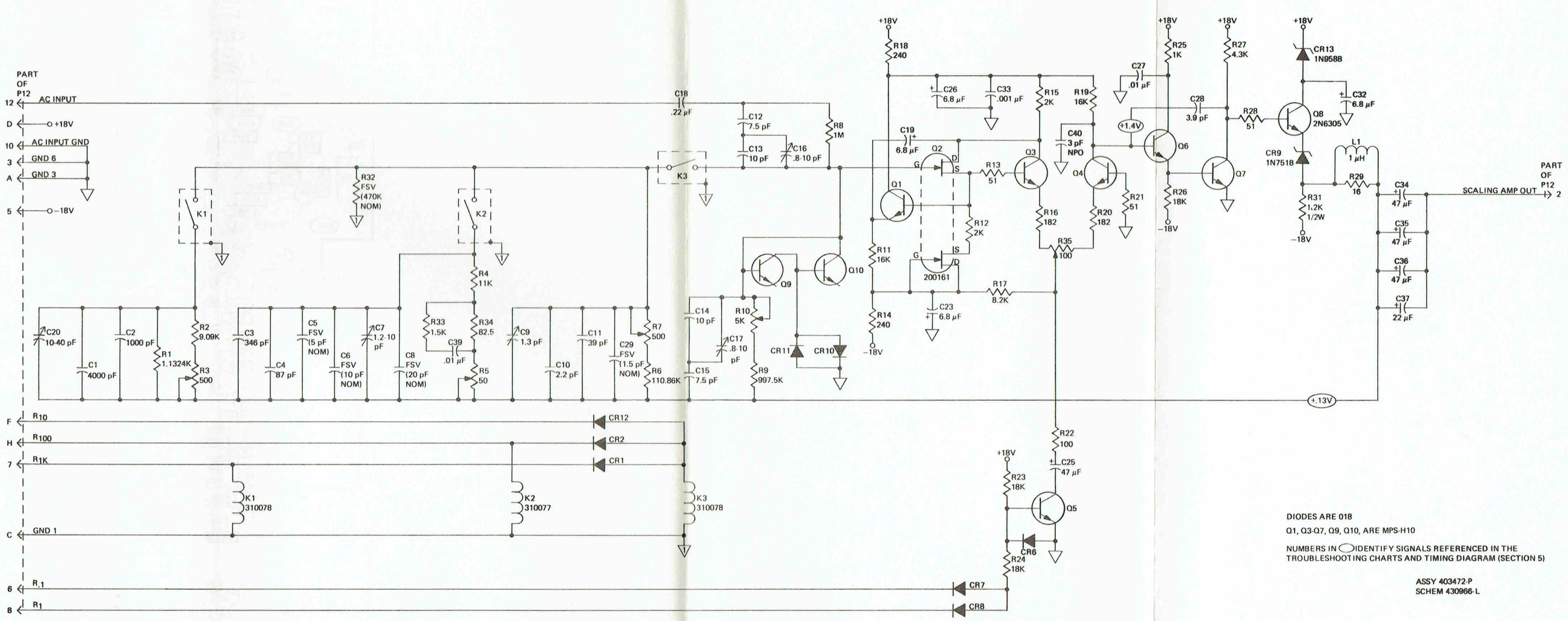
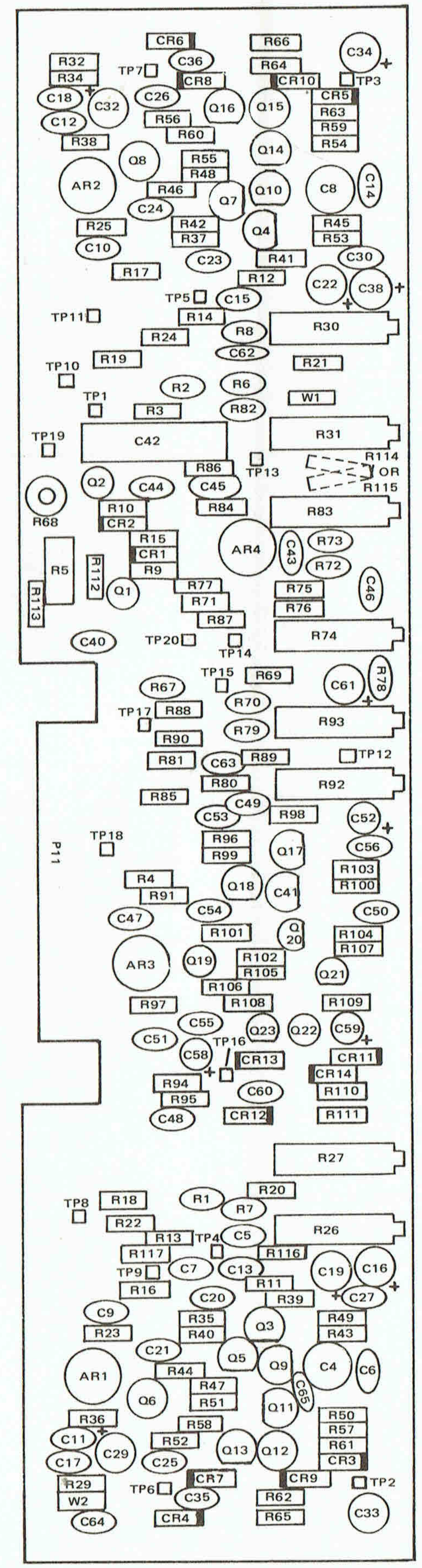
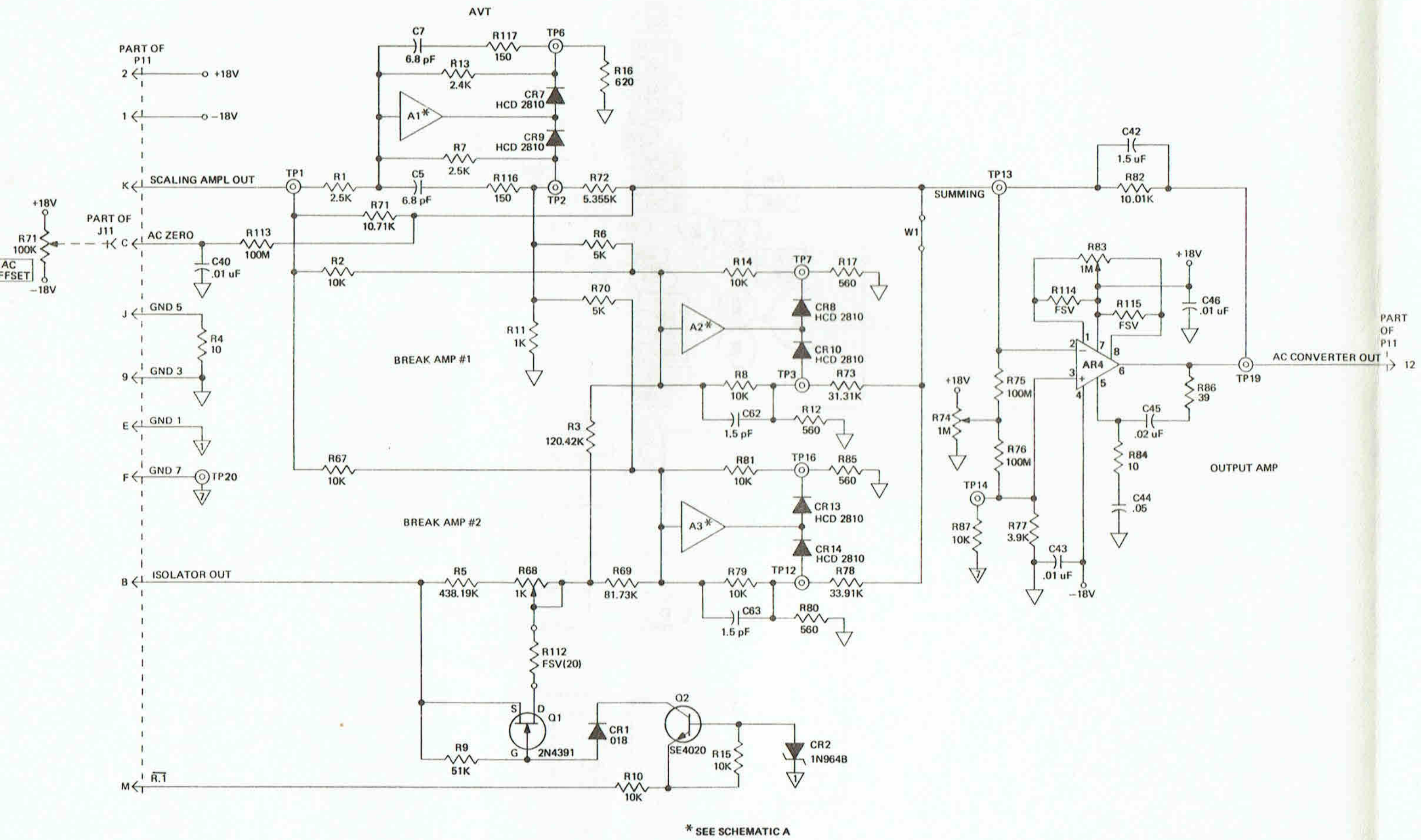


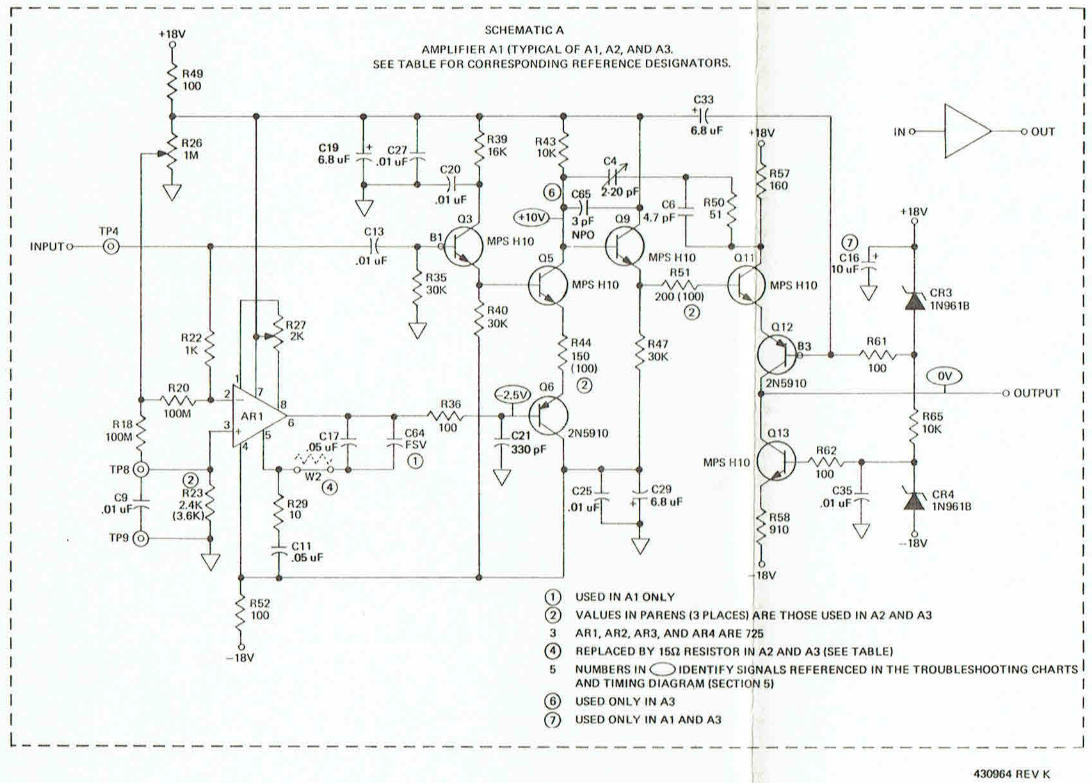
Figure 6.11 - Schematic, Scaling Amplifier



ASSY 403470 REV N

Figure 6.12 - Layout, DIAC Converter





A1	A2	A3
AR1	AR2	AR3
B1	B2	B5
B3	B4	B6
C4	C8	C41
C6	C14	C50
C9	C10	C47
C11	C12	C48
C13	C15	C49
C16	—	C61
C17	C18	C51
C19	C22	C52
C20	C23	C53
C21	C24	C54
C25	C26	C55
C27	C30	C56
C29	C32	C58
C33	C34	C59
C35	C36	C60
C64	—	—
C65	—	—
CR3	CR5	CR11
CR4	CR6	CR12
Q3	Q4	Q17
Q5	Q7	Q18
Q6	Q8	Q19
Q9	Q10	Q20
Q11	Q14	Q21
Q12	Q15	Q22
Q13	Q16	Q23
R18	R19	R88
R20	R21	R89
R22	R24	R90
R23	R25	R91
R26	R30	R92
R27	R31	R93
R29	R34	R95
R35	R37	R96
R36	R38	R97
R39	R41	R98
R40	R42	R99
R43	R45	R100
R44	R46	R101
R47	R48	R102
R49	R53	R103
R50	R54	R104
R51	R55	R105
R52	R56	R106
R57	R59	R107
R58	R60	R108
R61	R63	R109
R62	R64	R110
R65	R66	R111
TP4	TP5	TP15
TP8	TP10	TP17
TP9	TP11	TP18
W2	R32	R94

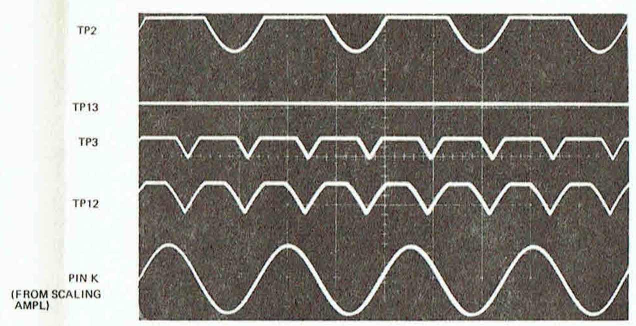
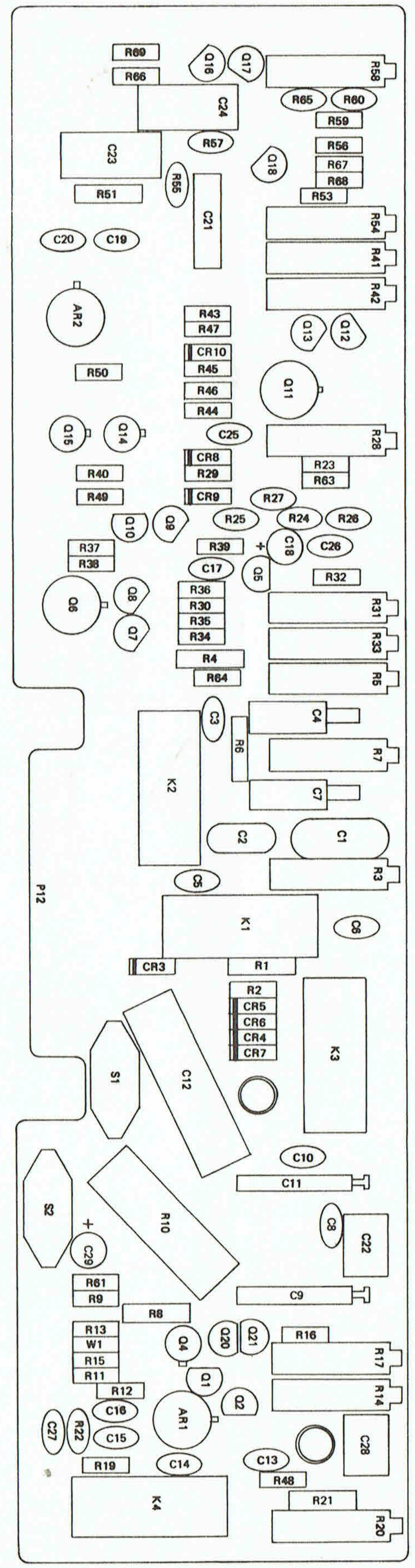
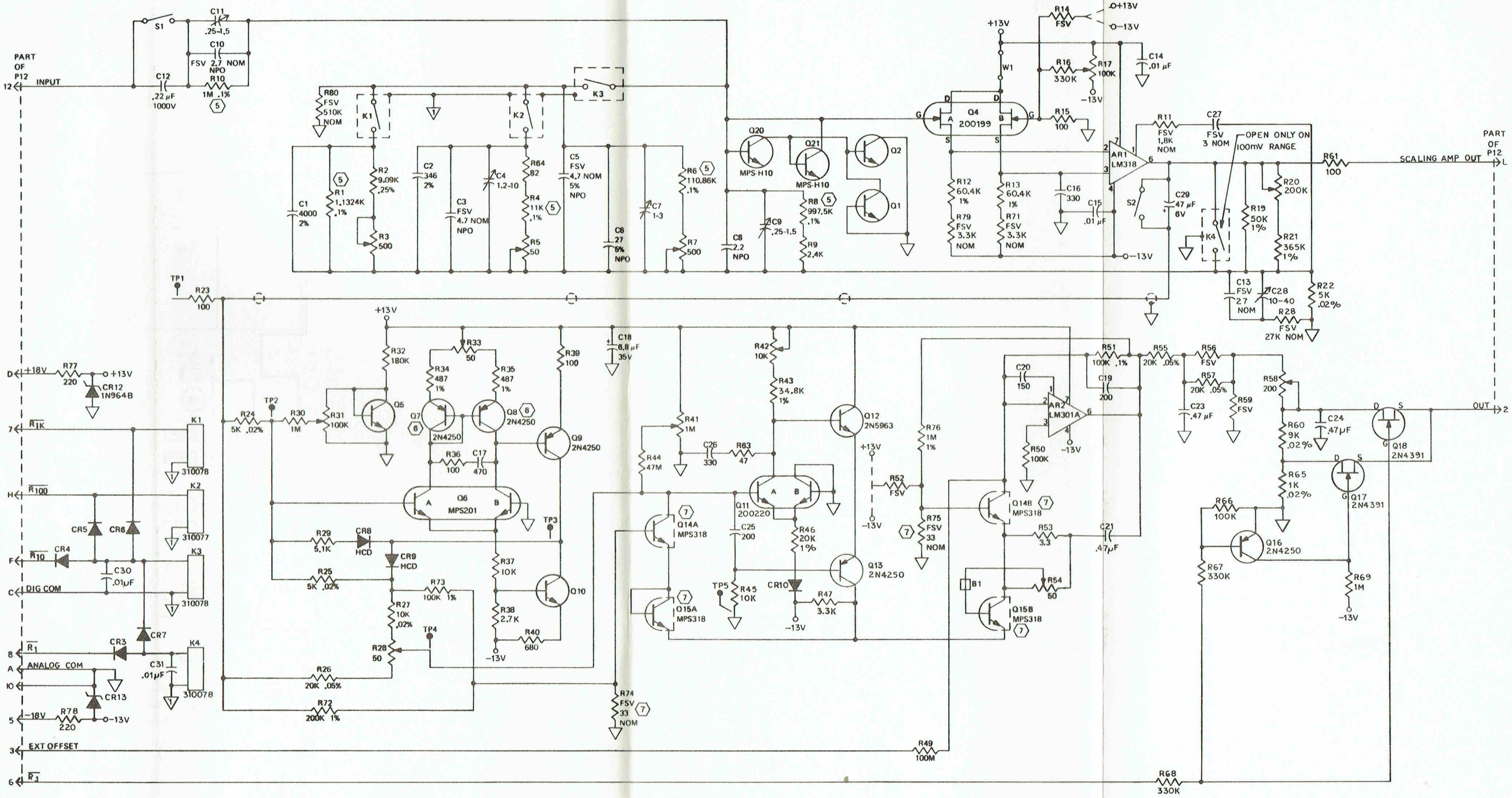


Figure 6.13 - Schematic, DIAC Converter



ASSY 403773 REV B

Figure 6.14 - Layout, RMS AC Converter



8. ASSY 403773-C

7. Q14 AND Q15, R74 AND R75, ARE LOG TRANSISTOR KIT 403819

6. Q7 AND Q8 ARE MATCHED PAIR 200112

5. R1, R4, R6, R8, AND R10 ARE RESISTOR SET 010721

4. TRANSISTORS ARE 200200

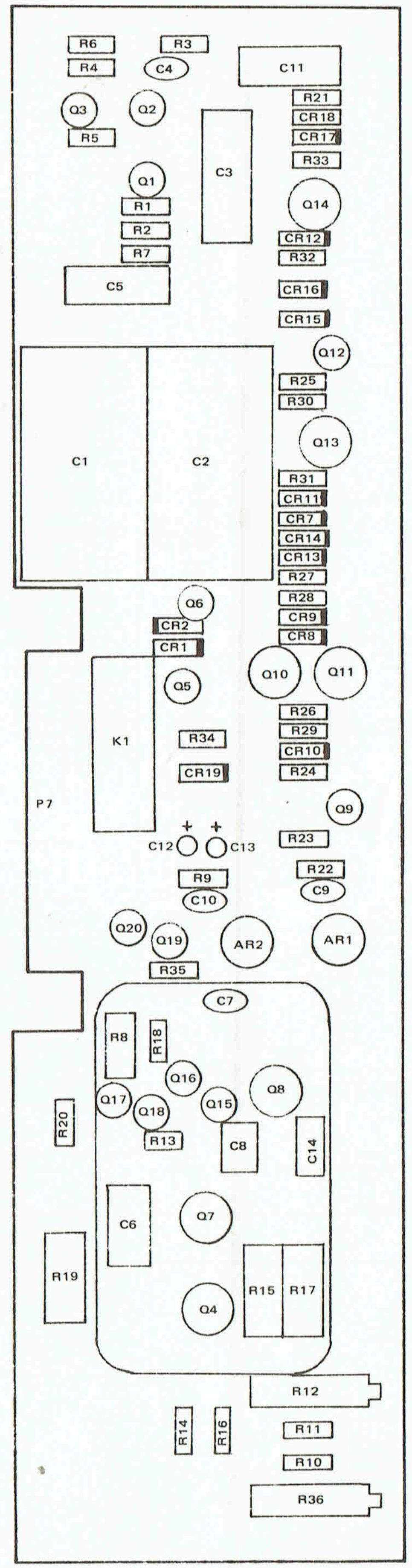
3. DIODES ARE 018

2. CAPACITORS ARE IN pF

1. RESISTORS ARE IN OHMS, ±5%, 1/4W

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 6.15 - Schematic, RMS AC Converter



ASSY 403434 REV M

Figure 6.16 - Layout, Isolator

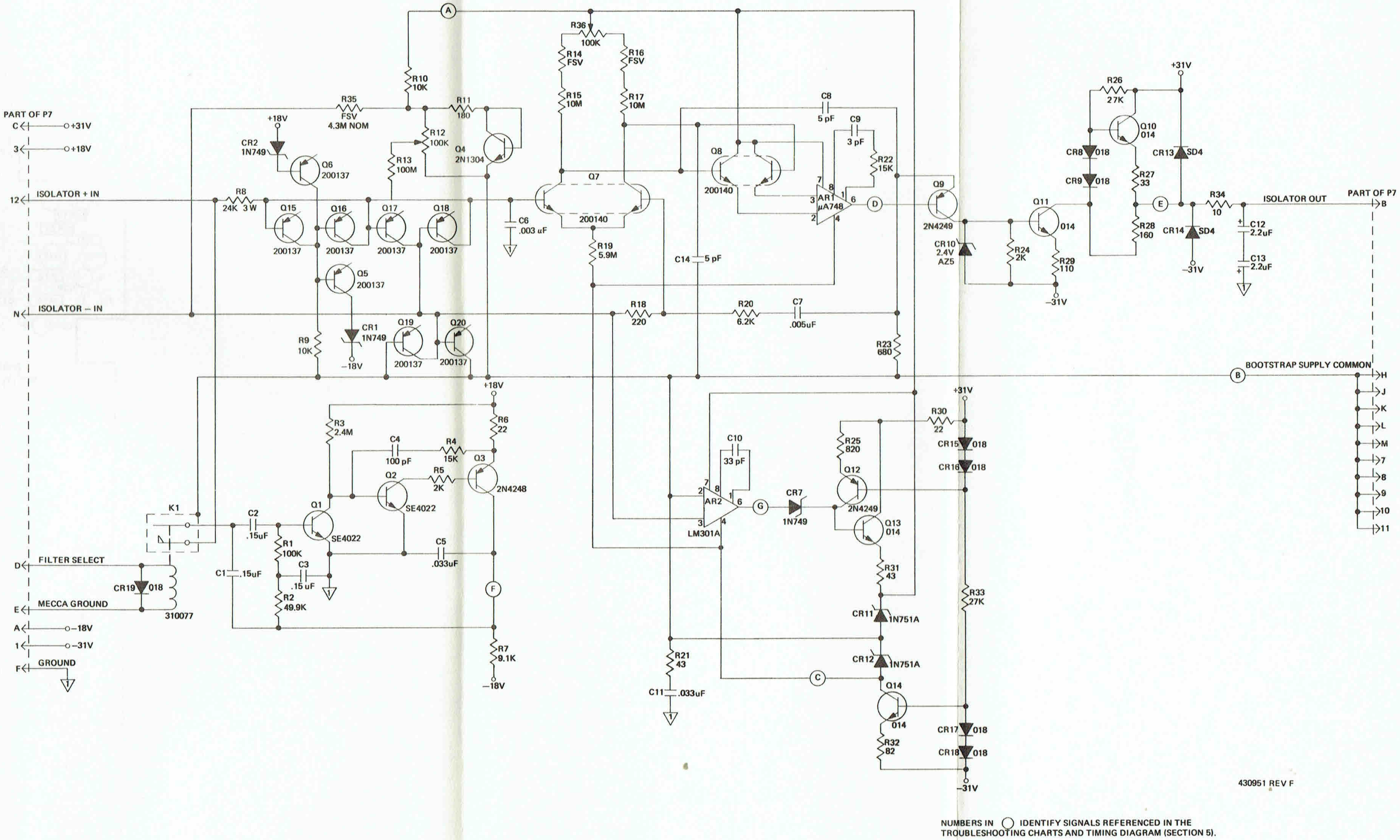


Figure 6.17 - Schematic, Isolator

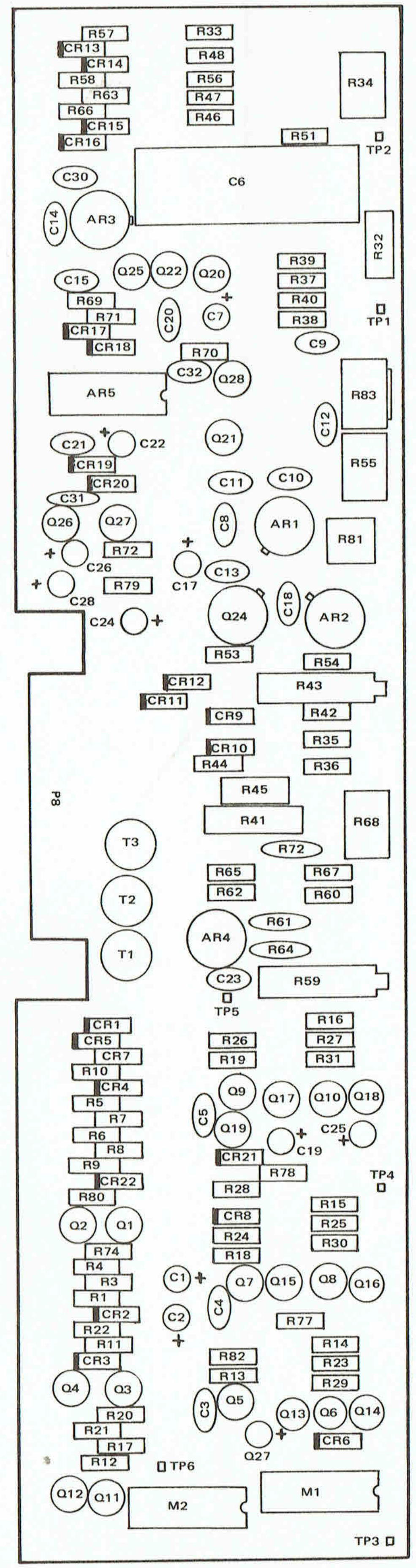
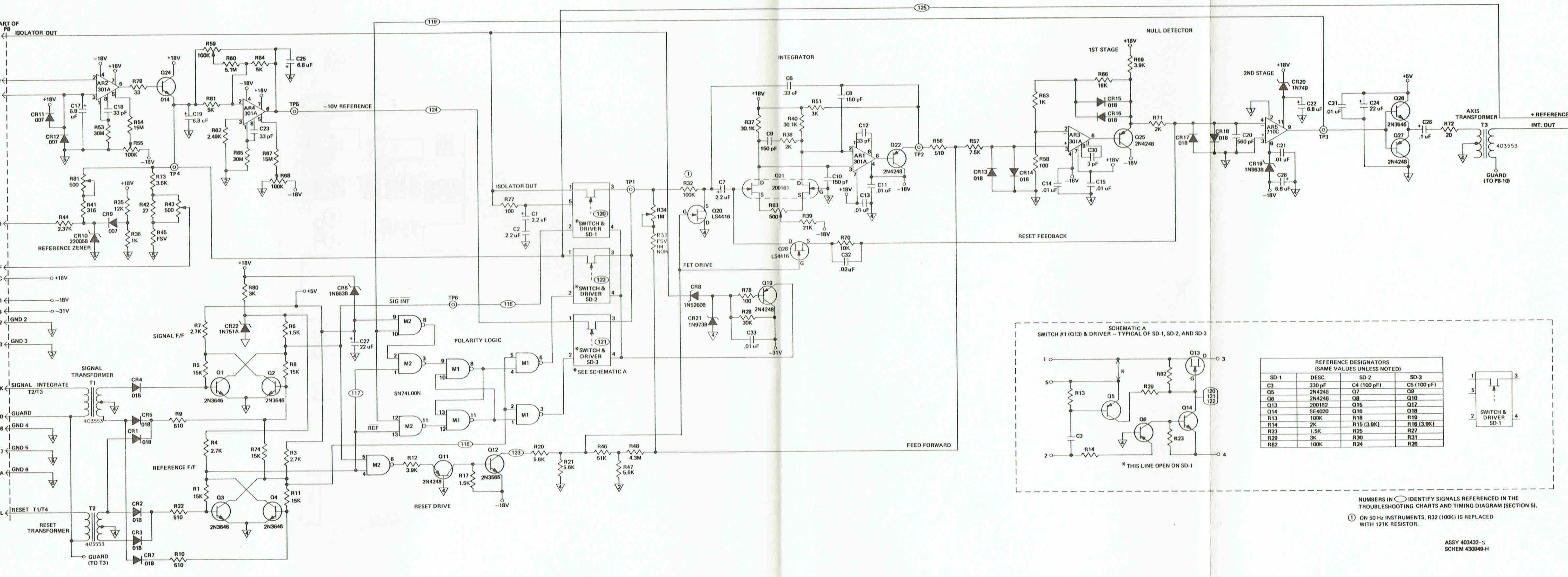


Figure 6.18 - Layout, Digitizer



REFERENCE DESIGNATORS (SAME VALUES UNLESS NOTED)			
SD-1	DESC.	SD-2	SD-3
C3	330 pF	C4 (100 pF)	C5 (100 pF)
Q5	2N4248	Q7	Q9
Q6	2N4248	Q8	Q10
Q13	200162	Q15	Q17
Q14	SE4020	Q16	Q18
R13	100K	R18	R19
R14	2K	R15 (3.9K)	R16 (3.9K)
R23	1.5K	R25	R27
R29	3K	R30	R31
R82	100K	R24	R26

NUMBERS IN ◯ IDENTIFY SIGNALS REFERENCED IN THE TROUBLESHOOTING CHARTS AND TIMING DIAGRAM (SECTION 5).

① ON 50 Hz INSTRUMENTS, R32 (100K) IS REPLACED WITH 121K RESISTOR.

ASSY 403432-S
SCHEM 430949-H

Figure 6.19 - Schematic, Digitizer

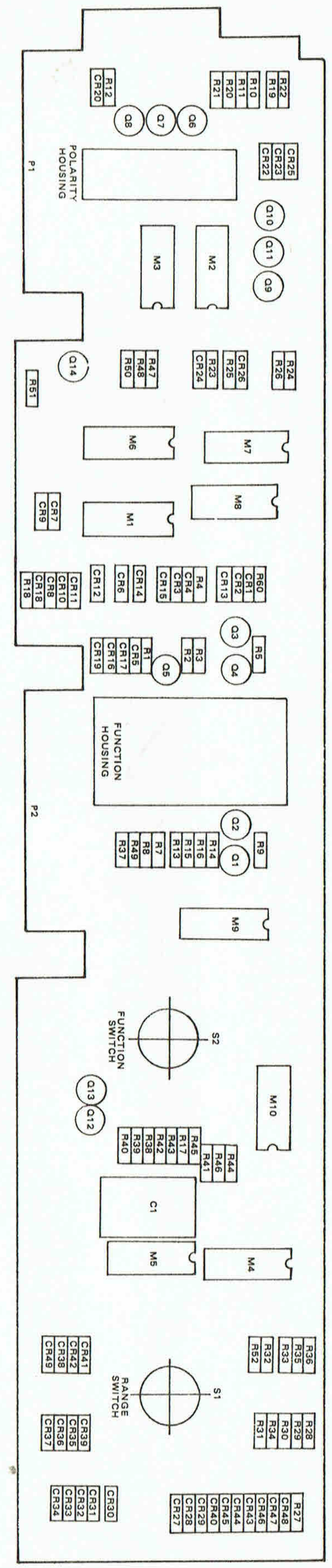


Figure 6.20 - Layout, Display

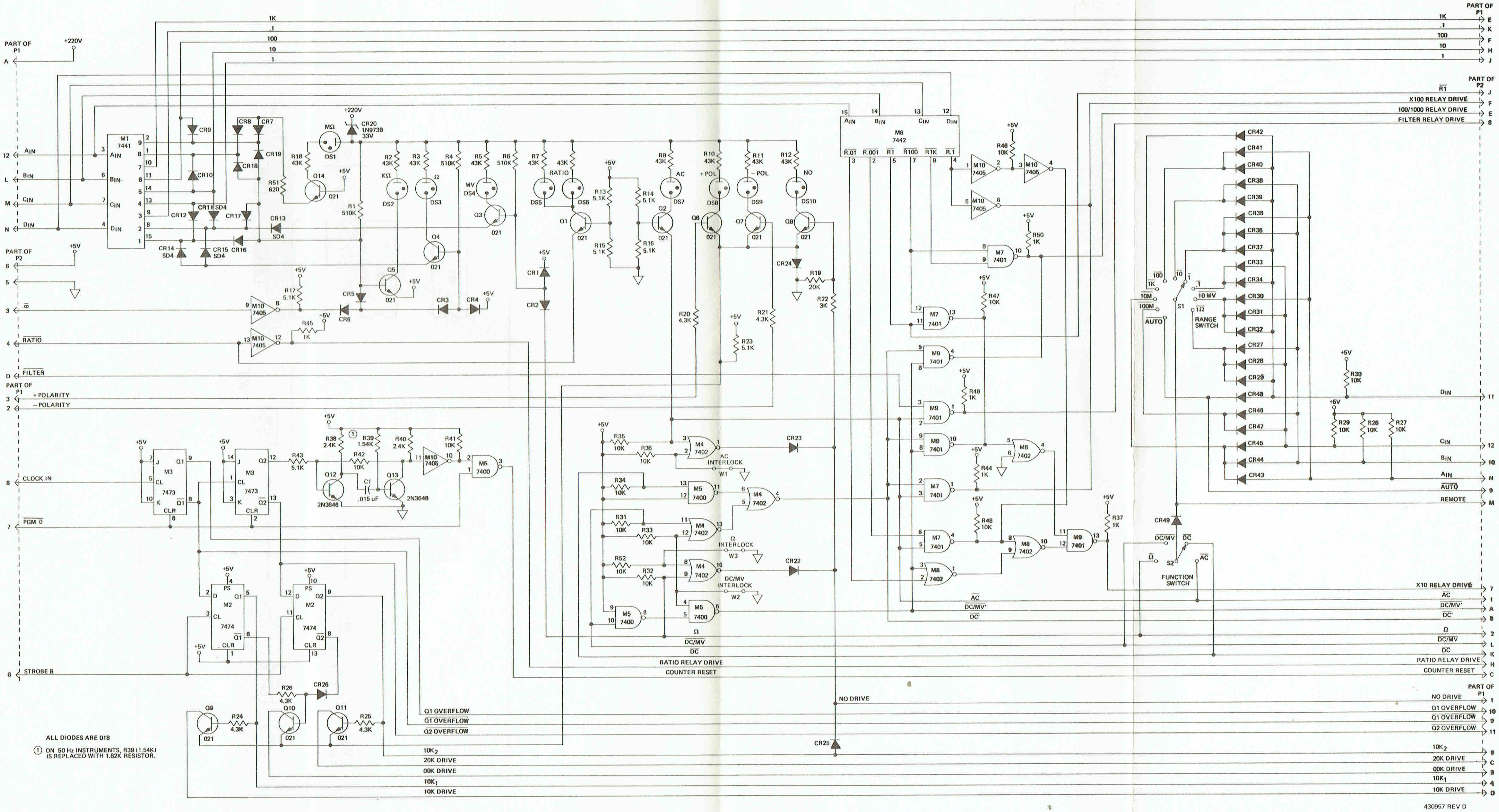


Figure 6.21 - Schematic, Display

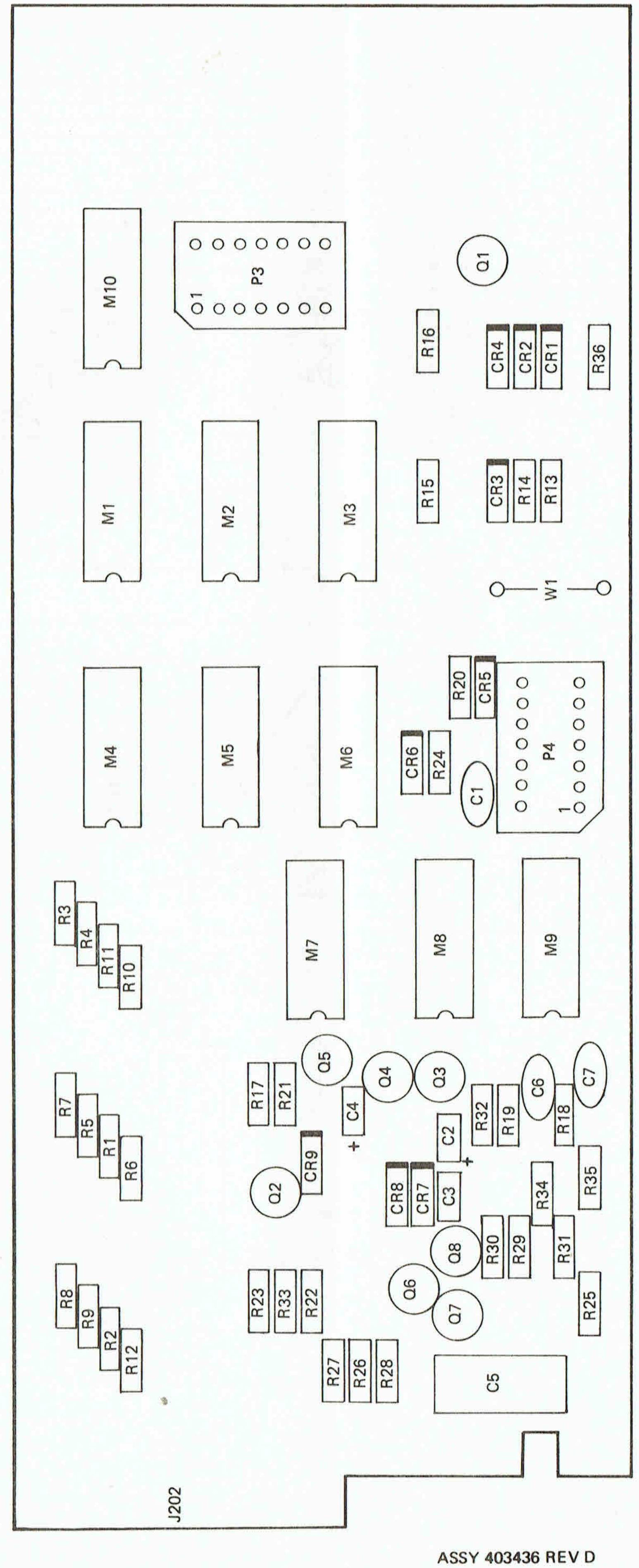


Figure 6.22 - Layout, Program

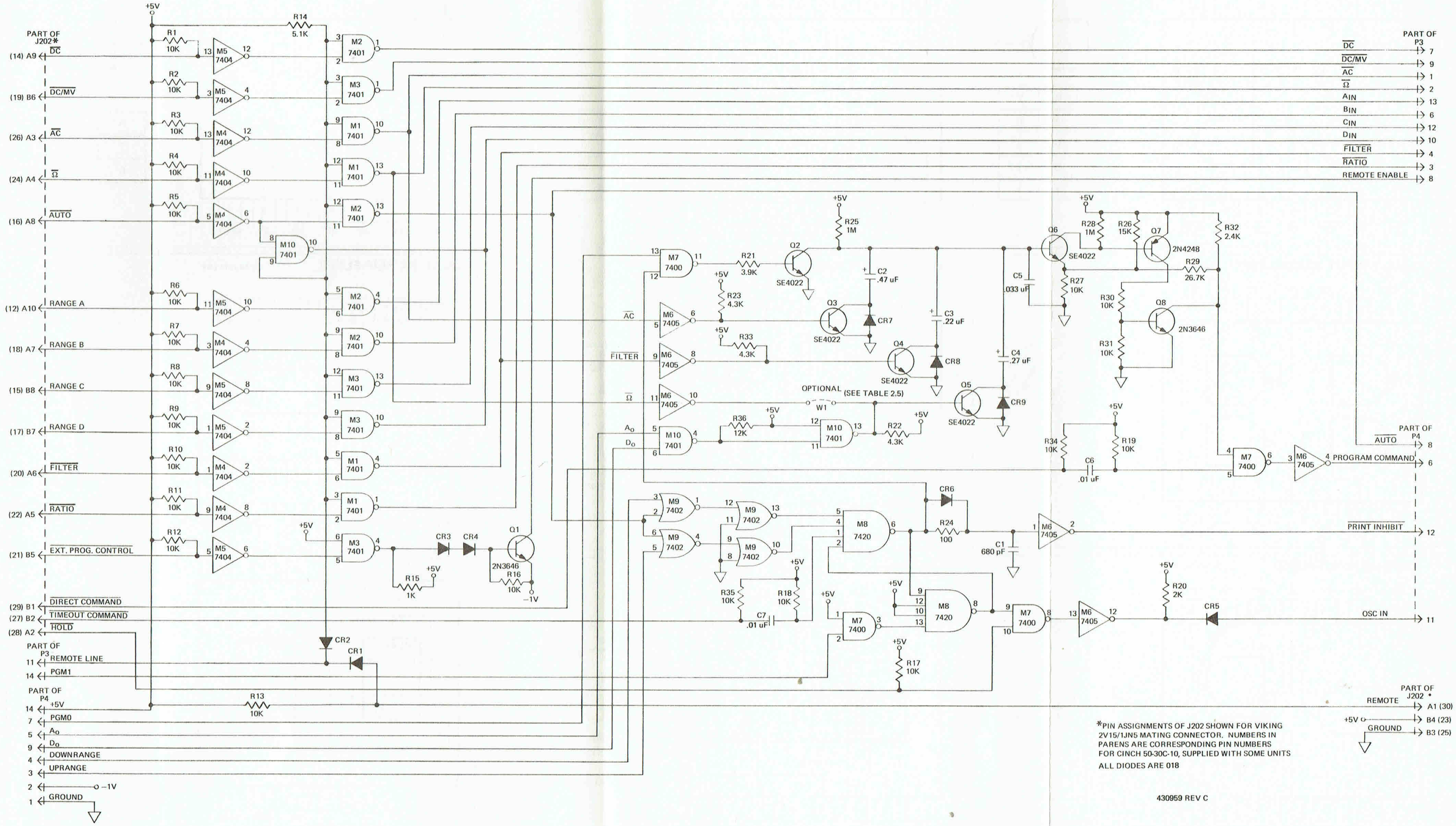
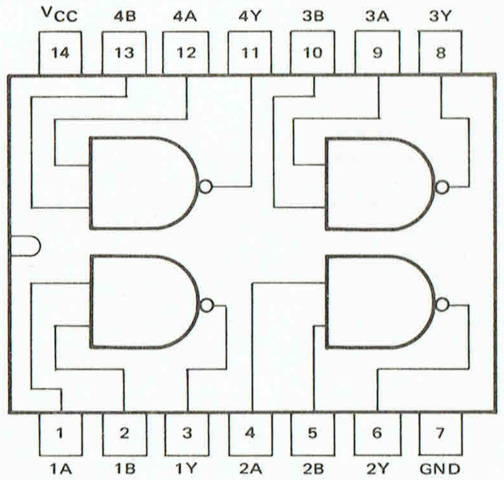
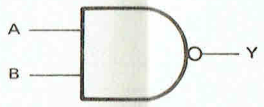


Figure 6.23 - Schematic, Program

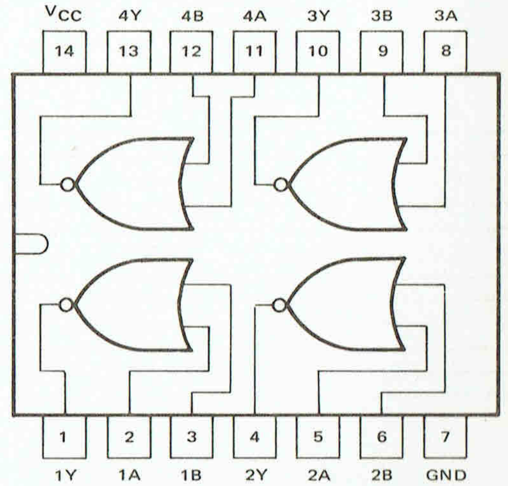
QUAD 2-INPUT NAND GATES SN7400N DIP





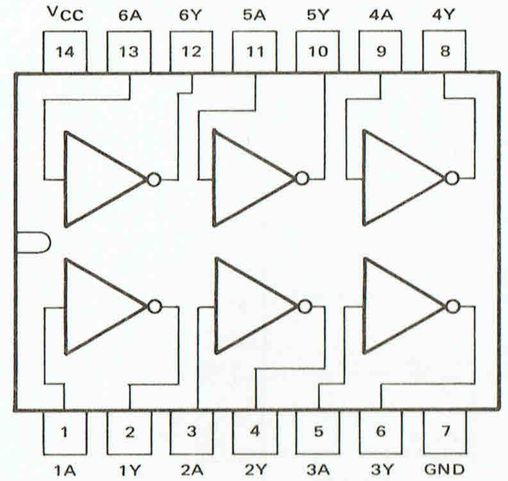
A	B	Y
1	1	0
0	0	1
1	0	1
0	1	1

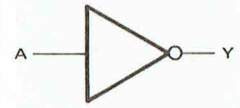
QUAD 2-INPUT NOR GATES SN7402N DIP



A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

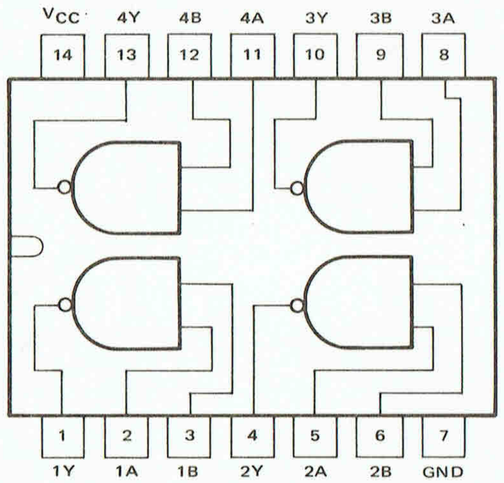
HEX INVERTERS SN7404N DIP SN7405N DIP



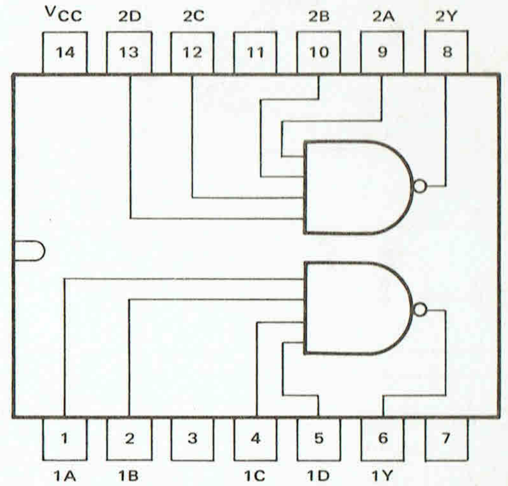


A	Y
1	0
0	1

QUAD 2-INPUT NAND GATES SN7401 DIP

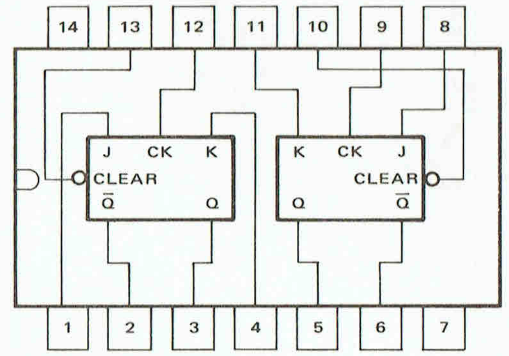


DUAL 4-INPUT NAND GATES SN7440N DIP

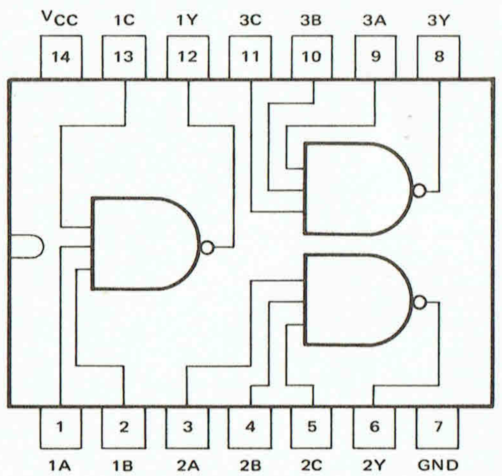


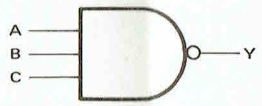
A	B	C	D	Y
1	1	1	1	0
0	1	1	1	1
1	0	1	1	1
1	1	0	1	1
1	1	1	0	1
All other combinations				1

DUAL J-K FLIP-FLOPS SN7473N DIP



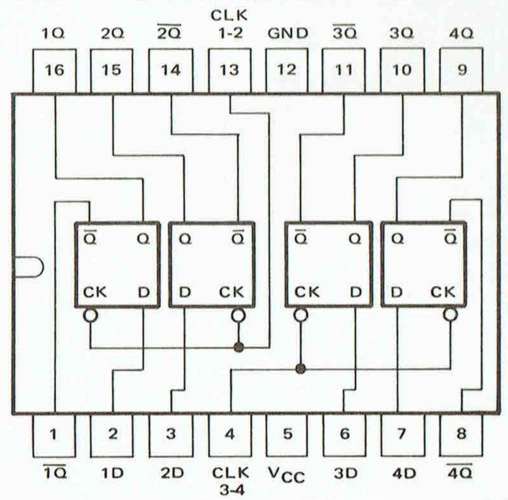
TRIPLE 3-INPUT NAND SN7410N DIP





A	B	C	Y
1	1	1	0
1	1	0	1
1	0	1	1
0	1	1	1
All other combinations			1

4-BIT BISTABLE LATCHES SN7475N DIP

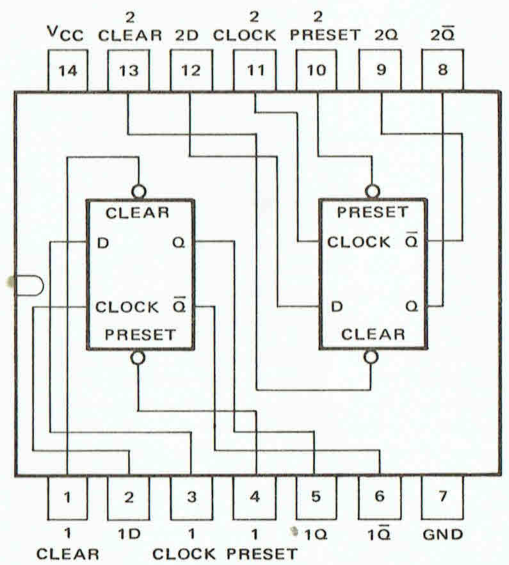


t_n	$t_n + 1$
D	Q
1	1
0	0

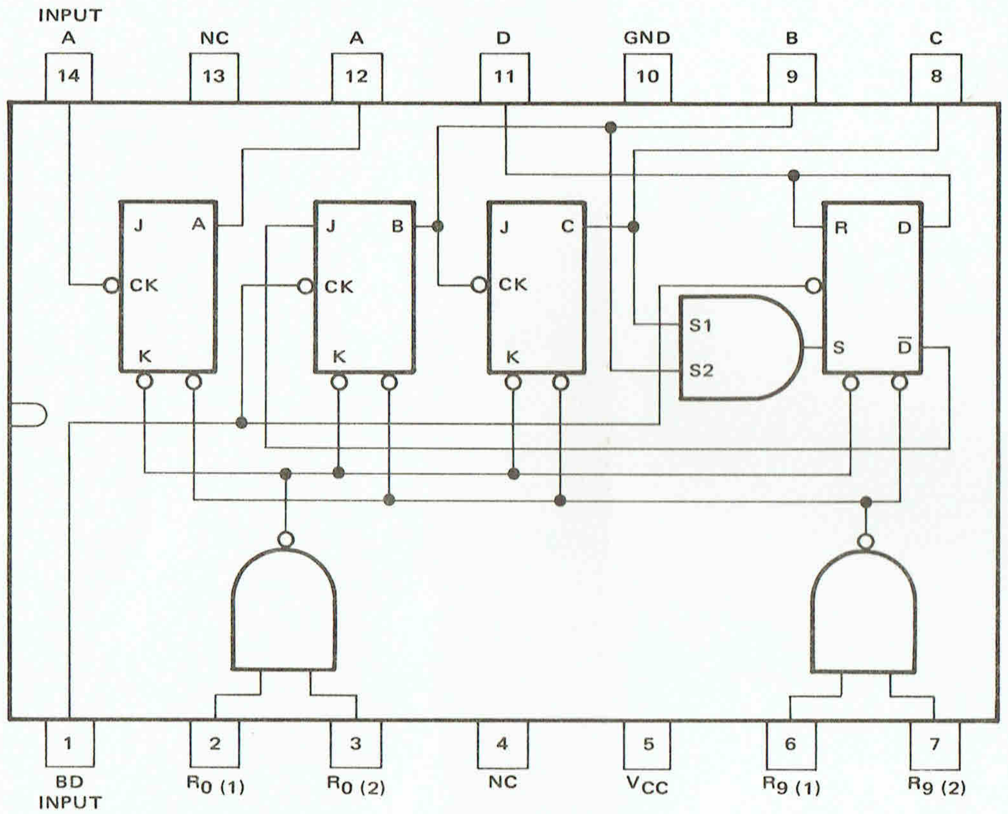
t_n = bit time before clock negative-going transition.

$t_n + 1$ = bit time after t_n

DUAL D-TYPE FLIP-FLOPS SN7474N DIP



DECADE COUNTER SN7490N DIP



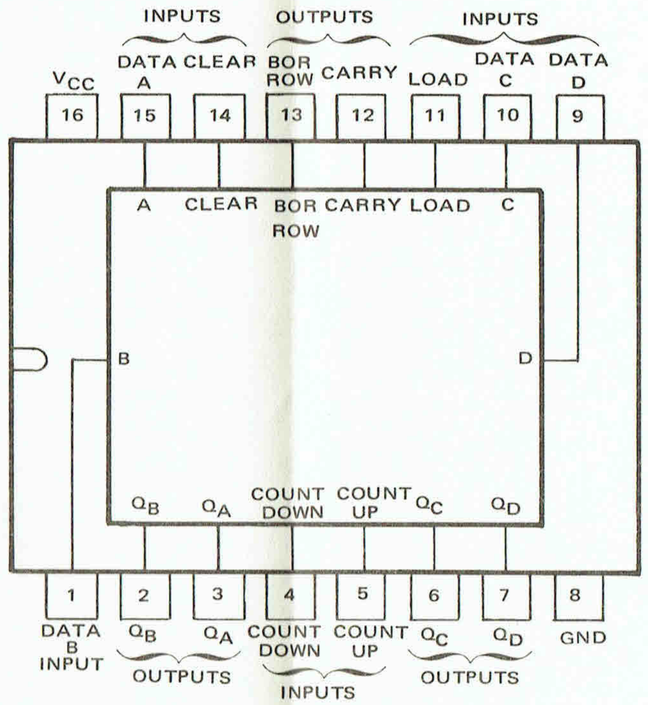
Count	OUTPUT			
	D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

Output A connected to Input BD for BCD count

RESET INPUTS				OUTPUT			
R_0 (1)	R_0 (2)	R_9 (1)	R_9 (2)	A	B	C	D
1	1	0	X	0	0	0	0
1	1	X	0	0	0	0	0
X	X	1	1	1	0	0	1
X	0	X	0	COUNT			
0	X	0	X	COUNT			
0	X	X	0	COUNT			
X	0	0	X	COUNT			

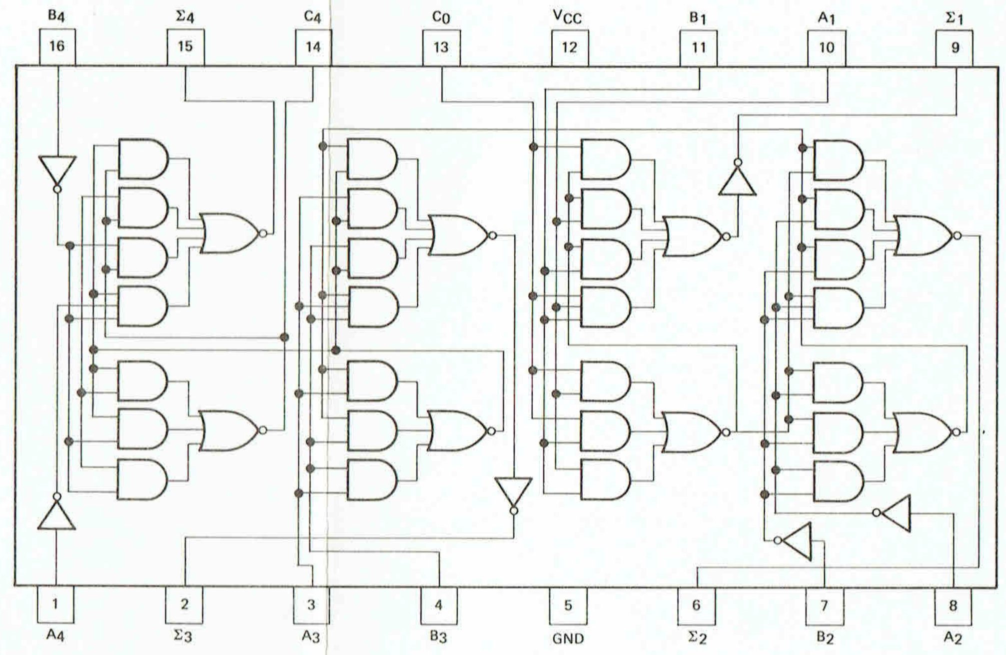
X indicates either a logical 1 or logical 0 may be present

UP/DOWN COUNTER SN74192N DIP



LOGIC: LOW INPUT TO LOAD SETS QA = A, QB = B, QC = C, AND QD = D

4-BIT FULL ADDER SN7483 DIP



Input conditions at A_1, A_2, B_1, B_2, and C_0 are used to determine outputs Σ_1 and Σ_2, and the value of the internal carry C_2. The values at C_2, A_3, B_3, A_4, and B_4 are then used to determine outputs Σ_3, Σ_4, and C_4.

Figure 6.24 - Integrated Circuits

SECTION 7 PARTS LIST

7.1 This section contains lists of replaceable parts arranged in the order of the following subassemblies:

	Page
Interconnection & Logic	7-3
Switching	7-10
Preamp (mV)	7-12
Preamp/Ohms Converter	7-14
Scaling Amp	7-18
AC Converter	7-21
RMS AC Converter	7-27
Isolator	7-31
Digitizer	7-34
Display	7-39
Program	7-43
Chassis-Mounted Parts	7-45

7.2 Manufacturers are identified by FSC numbers listed in table 7.2, "List of Suppliers". The code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1, H4-2, and their supplements.

7.3 Certain parts having 21793 (Dana) listed in the "FSC" column are specially-selected semiconductors. For some of these, standard commercial parts will serve as satisfactory replacements. These Dana parts are identified in table 7.1 along with the commercial equivalent.

Table 7.1

Semiconductor Type:		Equivalent:
009	Transistor	Motorola 2N2905
014	Transistor	Motorola 2N3501
018	Diode	Texas Instruments 1N4448
021	Transistor	MPS A92

Table 7.2 - List of Suppliers

FSC	NAME
01295	TEXAS INSTRUMENTS, INC. (Components Group) DALLAS, TEXAS
02111	SPECTROL ELECTRONICS CORP. CITY OF INDUSTRY, CALIFORNIA
02114	FERROXCUBE CORP. SAUGERTIES, NEW YORK
03888	PYROFILM CORP. WHIPPANY, NEW JERSEY
04713	MOTOROLA, INC. (Semiconductor Products Division) PHOENIX, ARIZONA
05397	UNION CARBIDE CORP. (Materials Systems Division) CLEVELAND, OHIO
05574	VIKING INDUSTRIES, INC. CHATSWORTH, CALIFORNIA
05591	GENERAL RESISTANCE, INC. (Division of Chronetics, Inc.) MT. VERNON, NEW YORK
06665	PRECISION MONOLITHICS SANTA CLARA, CALIFORNIA
07263	FAIRCHILD SEMICONDUCTOR (Division of Fairchild Camera & Instrument Corp.) MOUNTAIN VIEW, CALIFORNIA
07716	TRW ELECTRONIC COMPONENTS (IRC) BURLINGTON, IOWA
08257	NPC ELECTRONICS CANOGA PARK, CALIFORNIA
09023	CORNELL-DUBILEAR ELECTRONICS (Division Federal Pacific Electric Co.) SANFORD, NORTH CAROLINA
10389	CHICAGO SWITCH, INC. CHICAGO, ILLINOIS
11237	CTS KEENE, INC. PASO ROBLES, CALIFORNIA
12060	DIODES, INC. CHATSWORTH, CALIFORNIA
13571	ELECTRONIC RESEARCH CO. OVERLAND PK, KANSAS
15636	ELEC-TROL, INC. SAUGUS, CALIFORNIA

Table 7.2 - List of Suppliers (Continued)

FSC	NAME	FSC	NAME
17856	SILICONIX, INC. SANTA CLARA, CALIFORNIA	72136	ELECTRO MOTIVE MFG. CO., INC. WILLIMANTIC, CONNECTICUT
18612	VISHAY RESISTOR PRODUCTS (Division Vishay Intertechnology, Inc.) MALVERN, PENNSYLVANIA	72982	ERIE TECHNOLOGICAL PRODUCTS, INC. ERIE, PENNSYLVANIA
21551	C-F ELECTRONICS, INC. VAN NUYS, CALIFORNIA	73138	BECKMAN INSTRUMENTS, INC. (Helipot Division) FULLERTON, CALIFORNIA
21793	DANA LABORATORIES, INC. IRVINE, CALIFORNIA	73445	AMPEREX ELECTRONIC CORP. HICKSVILLE, LONG ISLAND, NEW YORK
22045	JORDAN ELECTRIC CO. VAN NUYS, CALIFORNIA	74970	E. F. JOHNSON CO. WASECA, MINNESOTA
23095	AZTEC ELECTRONICS, INC. ANAHEIM, CALIFORNIA	77342	AMERICAN MACHINE & FOUNDRY CO. (Potter & Brumfield Division) SAN JUAN CAPISTRANO, CALIFORNIA
24796	PARELCO, INC. SAN JUAN CAPISTRANO, CALIFORNIA	79727	C-W INDUSTRIES WARMINSTER, PENNSYLVANIA
27014	NATIONAL SEMI-CONDUCTOR CORP. SANTA CLARA, CALIFORNIA	80131	ELECTRONICS INDUSTRIES ASSOC. WASHINGTON, D.C.
27556	IMB ELECTRONIC PRODUCTS, INC. SANTA FE SPRINGS, CALIFORNIA	81349	MILITARY SPECIFICATION
34553	AMPEREX/MEPCO-ELECTRA HAUPPAUGE, NEW YORK	82389	SWITCHCRAFT, INC. CHICAGO, ILLINOIS
50434	HEWLETT-PACKARD CO. (HP Associates) PALO ALTO, CALIFORNIA	87730	UNITED MINERAL & CHEMICAL CORP. NEW YORK CITY, NEW YORK
56289	SPRAGUE ELECTRIC CO. (Pacific Division) LOS ANGELES, CALIFORNIA	89110	AMP, INC. (Capitron Division) ELIZABETHTOWN, PENNSYLVANIA
71468	ITT CANNON ELECTRIC SANTA ANA, CALIFORNIA	91293	JOHANSON MFG. CO. BOONTON, NEW JERSEY
71471	AEROVOX CORP. (Cinema Plant) MONCKS CORNER, SOUTH CAROLINA	91506	AUGAT, INC. ATTLEBORO, MASSACHUSETTS
71590	CENTRALAB ELECTRONICS (Division of Globe-Union, Inc.) MILWAUKEE, WISCONSIN	91637	DALE ELECTRONICS, INC. COLUMBUS, NEBRASKA
71785	TRW ELECTRONICS COMPONENTS (Cinch Division) ELK GROVE VILLAGE, ILLINOIS	95275	VITRAMON, INC. BRIDGEPORT, CONNECTICUT
		99800	AMERICAN PRECISION INDUSTRIES, INC. (Delevan Division) EAST AURORA, NEW YORK

403433 – Assy., PCB, INTERCONNECTION & LOGIC

REF DES	DANA P/N	DESCRIPTION				FSC	MANU P/N
CR1	211083	DIODE	SILICO		018	21793	211083
CR2	211083	DIODE	SILICO		018	21793	211083
CR3	211083	DIODE	SILICO		018	21793	211083
CR6	211083	DIODE	SILICO		018	21793	211083
CR7	211083	DIODE	SILICO		018	21793	211083
CR8	211083	DIODE	SILICO		018	21793	211083
CR9	211083	DIODE	SILICO		018	21793	211083
CR10	211083	DIODE	SILICO		018	21793	211083
CR11	211083	DIODE	SILICO		018	21793	211083
CR12	211083	DIODE	SILICO		018	21793	211083
CR13	211083	DIODE	SILICO		018	21793	211083
CR14	211083	DIODE	SILICO		018	21793	211083
CR15	210004	DIODE	SILICO		1N4004	81349	1N4004
CR16	210004	DIODE	SILICO		1N4004	81349	1N4004
CR17	210004	DIODE	SILICO		1N4004	81349	1N4004
CR18	210004	DIODE	SILICO		1N4004	81349	1N4004
CR19	220015	DIODE	SILICO	ZENER	1N967B	81349	1N967B
CR20	211083	DIODE	SILICO		018	21793	211083
CR21	211083	DIODE	SILICO		018	21793	211083
CR22	220015	DIODE	SILICO	ZENER	1N967B	81349	1N967B
CR23	211083	DIODE	SILICO		018	21793	211083
CR25	210004	DIODE	SILICO		1N4004	81349	1N4004
CR26	210004	DIODE	SILICO		1N4004	81349	1N4004
CR27	210004	DIODE	SILICO		1N4004	81349	1N4004
CR28	210004	DIODE	SILICO		1N4004	81349	1N4004
CR29	210004	DIODE	SILICO		1N4004	81349	1N4004
CR30	210004	DIODE	SILICO		1N4004	81349	1N4004
CR31	210004	DIODE	SILICO		1N4004	81349	1N4004
CR32	220007	DIODE	SILICO	ZENER	1N751A	81349	1N751A
CR33	211083	DIODE	SILICO		018	21793	211083
CR34	220040	DIODE	ZENER		1N753A	81349	1N753A
CR35	211083	DIODE	SILICO		018	21793	211083

403433 – Assy., PCB, INTERCONNECTION & LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
C1	101145	CAP CERAM 100 PFD 10%	71471	ETCD-DI-1(N5600)
C2	101099	CAP CERAM 680 PFD 10%	71471	SCD2X5F
C3	110071	CAP TANTA 1 MFD 35 V 10%	05397	T368A105K035
C4	110129	CAP TANTA .1 MFD 35 V	05397	T368A104M035AS
C5	110129	CAP TANTA .1 MFD 35 V	05397	T368A104M035AS
C6	110067	CAP ELECT 2000 MFD 35 V	87730	2000DXW35
C7	110067	CAP ELECT 2000 MFD 35 V	87730	2000DXW35
C8	110036	CAP ELECT 22 MFD 63 V	34553	ET220X063A5
C9	110036	CAP ELECT 22 MFD 63 V	34553	ET220X063A5
C10	110036	CAP ELECT 22 MFD 63 V	34553	ET220X063A5
C11	110036	CAP ELECT 22 MFD 63 V	34553	ET220X063A5
C18	110069	CAP TANTA 10 MFD 10 V 10%	05397	K10P10K
C19	110127	CAP TANTA 22 MFD 6 V	05397	T368B226M006AS
C20*	130076	CAP MICA 200 PFD 500 V 5%	72136	DM15-201J
C21	100017	CAP CERAM .01 MFD 100 V 20%	56289	TG-S10
C23	110128	CAP ELECT 6000 MFD 10 V –10%+75%	56289	36D602G010AA2A
C24	110127	CAP TANTA 22 MFD 6 V	05397	T368B226M006AS
C25	110127	CAP TANTA 22 MFD 6 V	05397	T368B226M006AS
C36	100017	CAP CERAM .01 MFD 100 V 20%	56289	TG-S10
J1	453505	CONN 12 P 453505	21793	453505
J2	600280	CONN 12 P 252-12-30-160	71785	252-12-30-160
J3	920460	INTEGRATED CIRCUIT SOCKET 14 PIN		CA-14CS-TSD
J4	920460	INTEGRATED CIRCUIT SOCKET 14 PIN		CA-14CS-TSD
J5	600228	CONN 18 P 252-18-30-160	71785	252-18-30-160
J6	600671	CONN 252-06-30-160	71785	252-06-30-160
J7	600280	CONN 12 P 252-12-30-160	71785	252-12-30-160
J8	600670	CONN 10 P 252-10-30-160	71785	252-10-30-160
J9	600280	CONN 12 P 252-12-30-160	71785	252-12-30-160
J11	600280	CONN 12 P 252-12-30-160	71785	252-12-30-160
J12	600280	CONN 12 P 252-12-30-160	71785	252-12-30-160
K1	310063	RELAY COIL 150 OHM R10E1221-1	24796	R10E1221-1
K2	310063	RELAY COIL 150 OHM R10E1221-1	24796	R10E1221-1
K3	310063	RELAY COIL 150 OHM R10E1221-1	24796	R10E1221-1
K4	310076	RELAY 1000V CONTACTS 28 V	24796	R10E-1297-2
L1	310062	CHOKE 22 UH 1537-44	99800	1537-44

*In 50 Hz units, C20 is:

C20 130144 CAP MICA 270 pF 100 V 5% 72136 DM10271J

403433 – Assy., PCB, INTERCONNECTION & LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION		FSC	MANU P/N
M1	230034	INTEGRATED CIRCUIT	SN74141N	01295	SN74141N
M1-M3	920419	INTEGRATED CIRCUIT SOCKET	CA-16CS-TSD		CA-16CS-TSD
M2	230034	INTEGRATED CIRCUIT	SN74141N	01295	SN74141N
M3	230034	INTEGRATED CIRCUIT	SN74141N	01295	SN74141N
M4	230034	INTEGRATED CIRCUIT	SN74141N	01295	SN74141N
M4	920419	INTEGRATED CIRCUIT SOCKET	CA-16CS-TSD		CA-16CS-TSD
M5	230038	INTEGRATED CIRCUIT QUAD 2	SN74H11N	01295	SN74H11N
M5	920460	INTEGRATED CIRCUIT SOCKET	14 PIN		CA-14CS-TSD
M6	230028	INTEGRATED CIRCUIT	SN7400N	01295	SN7400N
M6	920460	INTEGRATED CIRCUIT SOCKET	14 PIN		CA-14CS-TSD
M7	230065	INTEGRATED CIRCUIT	SN7475N	01295	SN7475N
M7-M9	920419	INTEGRATED CIRCUIT SOCKET	CA-16CS-TSD		CA-16CS-TSD
M8	230065	INTEGRATED CIRCUIT	SN7475N	01295	SN7475N
M9	230065	INTEGRATED CIRCUIT	SN7475N	01295	SN7475N
M10	230065	INTEGRATED CIRCUIT	SN7475N	01295	SN7475N
M10	920419	INTEGRATED CIRCUIT SOCKET	CA-16CS-TSD		CA-16CS-TSD
M11	230030	INTEGRATED CIRCUIT	SN7402N	01295	SN7402N
M11-M27	920460	INTEGRATED CIRCUIT SOCKET	14 PIN		CA-14CS-TSD
M12	230035	INTEGRATED CIRCUIT	SN7473N	01295	SN7473N
M13	230037	INTEGRATED CIRCUIT	SN7490N	01295	SN7490N
M14	230037	INTEGRATED CIRCUIT	SN7490N	01295	SN7490N
M15	230037	INTEGRATED CIRCUIT	SN7490N	01295	SN7490N
M16	230037	INTEGRATED CIRCUIT	SN7490N	01295	SN7490N
M17	230028	INTEGRATED CIRCUIT	SN7400N	01295	SN7400N
M18	230030	INTEGRATED CIRCUIT	SN7402N	01295	SN7402N
M19	230072	INTEGRATED CIRCUIT	SN7474N	01295	SN7474N
M20	230035	INTEGRATED CIRCUIT	SN7473N	01295	SN7473N
M21	230028	INTEGRATED CIRCUIT	SN7400N	01295	SN7400N
M22	230063	INTEGRATED CIRCUIT	SN7440N	01295	SN7440N
M23	230029	INTEGRATED CIRCUIT	SN7401N	01295	SN7401N
M24	230064	INTEGRATED CIRCUIT	SN7404N	01295	SN7404N
M25	230030	INTEGRATED CIRCUIT	SN7402N	01295	SN7402N
M26	230072	INTEGRATED CIRCUIT	SN7474N	01295	SN7474N
M27	230031	INTEGRATED CIRCUIT	SN7410N	01295	SN7410N
M28	230064	INTEGRATED CIRCUIT	SN7404N	01295	SN7404N
M28	920460	INTEGRATED CIRCUIT SOCKET	14 PIN		CA-14CS-TSD
M29	230036	INTEGRATED CIRCUIT	SN7483N	01295	SN7483N
M29-M30	920419	INTEGRATED CIRCUIT SOCKET	CA-16CS-TSD		CA-16CS-TSD
M30	230067	INTEGRATED CIRCUIT	SN74192	01295	SN74192
M31	230036	INTEGRATED CIRCUIT	SN7483N	01295	SN7483N
M31	920419	INTEGRATED CIRCUIT SOCKET	CA-16CS-TSD		CA-16CS-TSD
M32	230028	INTEGRATED CIRCUIT	SN7400N	01295	SN7400N
M32	920460	INTEGRATED CIRCUIT SOCKET	14 PIN		CA-14CS-TSD

403433 – Assy., PCB, INTERCONNECTION & LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
Q1	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q2	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q3	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q4	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q5	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q6	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q7	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q8	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q9	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q10	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q11	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q12	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q13	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q14	200129	TRANS SILICO NPN SE4020	07263	SE4020
Q17	200129	TRANS SILICO NPN SE4020	07263	SE4020
Q18	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q19	200043	TRANS SILICO NPN 200043	21793	200043
Q20	200043	TRANS SILICO NPN 200043	21793	200043
Q21	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q22	200043	TRANS SILICO NPN 200043	21793	200043
Q23	200154	TRANS SILICO PNP MJE370	04713	MJE370
Q24	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q25	200155	TRANS SILICO NPN MJE520	04713	MJE520
Q26	200075	TRANS 2N4870	81349	2N4870
Q27	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q28	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q29	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q30	200043	TRANS SILICO NPN 200043	21793	200043
Q31	200052	TRANS SILICO PNP 009	21793	200052
OCI-1	250000	ISOLATOR OPTICALLY COUPLED	01295	TIL108
OCI-2	250000	ISOLATOR OPTICALLY COUPLED	01295	TIL108
R1	001681	RES CARBON 7.5 K 5% 1/2W	81349	RC20GF752J
R2	001681	RES CARBON 7.5 K 5% 1/2W	81349	RC20GF752J
R3	000750	RES CARBON 75 OHM 5% 1/4W	81349	RC07GF750J
R4	000750	RES CARBON 75 OHM 5% 1/4W	81349	RC07GF750J
R5	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R6	001681	RES CARBON 7.5 K 5% 1/2W	81349	RC20GF752J
R7	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R8	000432	RES CARBON 4.3 K 5% 1/4W	81349	RC07GF432J

403433 – Assy., PCB, INTERCONNECTION & LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R9	001681	RES CARBON 7.5 K 5% 1/2W	81349	RC20GF752J
R10	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R11	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R12	001681	RES CARBON 7.5 K 5% 1/2W	81349	RC20GF752J
R13	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R14	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R15	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R16	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R17	000432	RES CARBON 4.3 K 5% 1/4W	81349	RC07GF432J
R18	000822	RES CARBON 8.2 K 5% 1/4W	81349	RC07GF822J
R19	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R20	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R21	000201	RES CARBON 200 OHM 5% 1/4W	81349	RC07GF201J
R22	000201	RES CARBON 200 OHM 5% 1/4W	81349	RC07GF201J
R23	000101	RES CARBON 100 OHM 5% 1/4W	81349	RC07GF101J
R24	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R25	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R26	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R27	000200	RES CARBON 20 OHM 5% 1/4W	81349	RC07GF200J
R28	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R29	000200	RES CARBON 20 OHM 5% 1/4W	81349	RC07GF200J
R30	030015	RES WW 100 K 1% 10 W	21551	M-100
R31	000203	RES CARBON 20 K 5% 1/4W	81349	RC07GF203J
R32	010334	RES METAL MATCHED SET	21793	010334
R33	040187	POT CERMET 500 OHM 20%	11237	360T501B
R34	010334	RES METAL MATCHED SET	21793	010334
R35	000203	RES CARBON 20 K 5% 1/4W	81349	RC07GF203J
R36	000182	RES CARBON 1.8 K 5% 1/4W	81349	RC07GF182J
R37	040187	POT CERMET 500 OHM 20%	11237	360T501B
R38	010607	RES METAL 17.999 K .05%	18612	V53-1
R39	001721	RES CARBON 2.2 OHM 5% 1/2W	81349	RC20GF020J
R40	010608	RES METAL 1.7989 OHM .05%	18612	V53-1
R41	010658	RES METAL 199.8 OHM .05%	18612	V53-1
R42	000106	RES CARBON 10 M 5% 1/4W	81349	RC07GF106J
R43	000106	RES CARBON 10 M 5% 1/4W	81349	RC07GF106J
R44	040113	POT CERMET 100 K 10%	73138	89PV100K
R45	010645	RES METAL 2.37 K T-0 1%	81349	RN55D2371F
R46	000516	RES CARBON 51 M 5% 1/4W	81349	RC07GF516J
R47	040113	POT CERMET 100 K 10%	73138	89PV100K
R48	000332	RES CARBON 3.3 K 5% 1/4W	81349	RC07GF332J

403433 – Assy., PCB, INTERCONNECTION & LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R49	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R50	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R51	000122	RES CARBON 1.2 K 5% 1/4W	81349	RC07GF122J
R52	000122	RES CARBON 1.2 K 5% 1/4W	81349	RC07GF122J
R53	000183	RES CARBON 18 K 5% 1/4W	81349	RC07GF183J
R54	001738	RES CARBON 1.5 OHM 5% 1/2W	81349	RC20GF010J
R55	001738	RES CARBON 1.5 OHM 5% 1/2W	81349	RC20GF010J
R56	001737	RES CARBON FSV* 5% 1/4W	21793	001737
R57	000151	RES CARBON 150 OHM 5% 1/4W	81349	RC07GF151J
R58	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R59	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R60	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R61	000121	RES CARBON 120 OHM 5% 1/4W	81349	RC07GF121J
R62	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R63	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R64	000511	RES CARBON 510 OHM 5% 1/4W	81349	RC07GF511J
R65	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R66	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R67	020576	RES WW .24 OHM 5% 2 W	07716	BWH Series
R68	040188	POT CERMET 100 K 20%	11237	360T104B
R69	010645	RES METAL 2.37 K T-0 1%	81349	RN55D2371F
R70	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R71	040113	POT CERMET 100 K 10%	73138	89PV100K
R72	001737	RES CARBON FSV* 5% 1/4W	21793	001737
R73	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R74	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R75	000101	RES CARBON 100 OHM 5% 1/4W	81349	RC07GF101J
R76	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R77	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
S1	600684	SWITCH PUSHBUTTON PART OF 600684 SWITCH ASSY.	21793	600684
S2	600684	SWITCH PUSHBUTTON PART OF 600684 SWITCH ASSY.	21793	600684
S3	600682	SWITCH PUSHBUTTON 600682	21793	600682
S4	600682	SWITCH PUSHBUTTON 600682	21793	600682
S5	600683	SWITCH PUSHBUTTON 600683	21793	600683
S6	600683	SWITCH PUSHBUTTON 600683	21793	600683
TP1-TP7	600591	POST TEST POINT 85931-6	89110	85931-6
TP8	600591	POST TEST POINT 85931-6	89110	85931-6
T1	403553	TRANSFORMER PULSE 403553	21793	403553
T2	403553	TRANSFORMER PULSE 403553	21793	403553
T3	403553	TRANSFORMER PULSE 403553	21793	403553

*Factory Selected Value

403431 – Assy., PCB, SWITCHING

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
CR5	211083	DIODE	SILICO		018		21793	211083
CR6	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
CR7	211083	DIODE	SILICO		018		21793	211083
CR8	211083	DIODE	SILICO		018		21793	211083
CR10	211083	DIODE	SILICO		018		21793	211083
CR11	211083	DIODE	SILICO		018		21793	211083
CR15	211083	DIODE	SILICO		018		21793	211083
C1	100040	CAP	CERAM	200 PFD	1000 V	20%	56289	5GA-T20
K1	310110	RELAY			5 V		24796	R10E2445-1
K2	310110	RELAY			5 V		24796	R10E2445-1
K3	310110	RELAY			5 V		24796	R10E2445-1
M1	230073	INTEGRATED CIRCUIT			SN7405N		01295	SN7405N
M2	230029	INTEGRATED CIRCUIT			SN7401N		01295	SN7401N
M3	230073	INTEGRATED CIRCUIT			SN7405N		01295	SN7405N
M4	230034	INTEGRATED CIRCUIT			SN74141N		01295	SN74141N
Q1	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q2	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q3	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q4	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q5	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q6	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q7	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q8	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q9	200043	TRANS	SILICO	NPN	200043		21793	200043
Q10	200043	TRANS	SILICO	NPN	200043		21793	200043
Q11	200043	TRANS	SILICO	NPN	200043		21793	200043
Q12	200043	TRANS	SILICO	NPN	200043		21793	200043
Q13	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q14	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q15	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
R1	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R2	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R3	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R4	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R5	000182	RES	CARBON	1.8 K		5% 1/4W	81349	RC07GF182J
R6	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R7	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J

403433 – Assy., PCB, INTERCONNECTION & LOGIC *continued*

REF DES	DANA P/N	DESCRIPTION				FSC	MANU P/N
V1	920466	TUBE	READOUT		ZM1005	73445	ZM1005
V2	920466	TUBE	READOUT		ZM1005	73445	ZM1005
V3	920466	TUBE	READOUT		ZM1005	73445	ZM1005
V4	920466	TUBE	READOUT		ZM1005	73445	ZM1005
V5	920466	TUBE	READOUT		ZM1005	73445	ZM1005
W1	600245	JUMPER			L-2007-1		L-2007-1
Y1	920513	CRYSTAL		2.4 MHz	(60 Hz units only)	13571	2.4 MHz
Y1	920599	CRYSTAL		2.0 MHz	(50 Hz units only)	13571	2.0 MHz

403431 – Assy., PCB, SWITCHING *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R8	000750	RES CARBON 75 OHM 5% 1/4W	81349	RC07GF750J
R9	000750	RES CARBON 75 OHM 5% 1/4W	81349	RC07GF750J
R10	000750	RES CARBON 75 OHM 5% 1/4W	81349	RC07GF750J
R11	000750	RES CARBON 75 OHM 5% 1/4W	81349	RC07GF750J
R12	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R13	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R14	000203	RES CARBON 20 K 5% 1/4W	81349	RC07GF203J
R15	000203	RES CARBON 20 K 5% 1/4W	81349	RC07GF203J
R16	000203	RES CARBON 20 K 5% 1/4W	81349	RC07GF203J
R17	000203	RES CARBON 20 K 5% 1/4W	81349	RC07GF203J
R18	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R19	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R20	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R21	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R22	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R23	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R24	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R25	001758	RES CARBON 330 OHM 5% 1 W	81349	RC32GF331J
R26	001784	RES CARBON 910 OHM 5% 1/2W		
R27	000472	RES CARBON 4.7 K 5% 1/4W	81349	RC07GF472J
R28	000472	RES CARBON 4.7 K 5% 1/4W	81349	RC07GF472J
R29	000472	RES CARBON 4.7 K 5% 1/4W	81349	RC07GF472J
R30	000472	RES CARBON 4.7 K 5% 1/4W	81349	RC07GF472J
R31	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R32	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R33	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R34	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R35	000305	RES CARBON 3 M 5% 1/4W	81349	RC07GF305J
OCI1	250000	ISOLATOR OPTICALLY COUPLED	01295	TIL108
OCI2	250000	ISOLATOR OPTICALLY COUPLED	01295	TIL108
OCI3	250000	ISOLATOR OPTICALLY COUPLED	01295	TIL108
OCI4	250000	ISOLATOR OPTICALLY COUPLED	01295	TIL108

403464 – Assy., PCB, PREAMP (MV)

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
CR1	211083	DIODE	SILICO		018			21793	211083
CR2	211083	DIODE	SILICO		018			21793	211083
CR3	220007	DIODE	SILICO	ZENER	1N751A			81349	1N751A
CR4	220007	DIODE	SILICO	ZENER	1N751A			81349	1N751A
C1	121091	CAP	MYLAR	.033 MFD	100 V	10%		09023	WMF1S33
C2	100008	CAP	CERAM	82 PFD		10%		71471	ETCD-DI-1(N5600)
C3	120001	CAP	MYLAR	.0033 MFD	100 V	10%		09023	WMF1D33
C4	121093	CAP	MYLAR	.047 MFD	100 V	10%		09023	WMF1S47
C5	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	TG-S10
C6	100012	CAP	CERAM	33 PFD		10%		71471	TCD-DI-1(N750)
C7	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	TG-S10
C8	100012	CAP	CERAM	33 PFD		10%		71471	TCD-DI-1(N750)
M1	403494	AMP KIT	FSV*				1/4W	21793	403494
M2	230054	INTEGRATED CIRCUIT			LM301A			27014	LM301A
M3	230054	INTEGRATED CIRCUIT			LM301A			27014	LM301A
Q1	200137	TRANS	SELECTED		2N4248			80131	2N4248
Q2	200137	TRANS	SELECTED		2N4248			80131	2N4248
Q3	200088	TRANS	SILICO	PNP	2N4248			80131	2N4248
Q4	200035	TRANS	SILICO	NPN	014			21793	200035
Q5	200035	TRANS	SILICO	NPN	014			21793	200035
Q6	201084	TRANS	GERMAN	PNP	2N1304			81349	2N1304
Q7	200137	TRANS	SELECTED		2N4248			80131	2N4248
Q8	200137	TRANS	SELECTED		2N4248			80131	2N4248
R1	403494	AMP KIT	FSV*				1/4W	21793	403494
R2	021154	RES	WW	10 K		3%	3 W	21551	M-200
R3	021154	RES	WW	10 K		3%	3 W	21551	M-200
R4	020611	RES	WW	200 OHM		.02%	1/8W	18612	V53-3M
R5	020614	RES	WW	19.81 K		.02%	1/8W	22045	J-11
R6	010732	RES	METAL	4.8 K		1%		18612	V53-1M Series
R7	011178	RES	CARBON	4.99 M		1%	1/2W	81349	RN20X4994F
R8	403494	AMP KIT	FSV*				1/4W	21793	403494
R9	000514	RES	CARBON	510 K		5%	1/4W	81349	RC07GF514J
R10	040085	POT	CERMET	500 K		30%		73138	89PV500K
R11	000106	RES	CARBON	10 M		5%	1/4W	81349	RC07GF106J
R12	000472	RES	CARBON	4.7 K		5%	1/4W	81349	RC07GF472J

*Factory Selected Value

403464 – Assy., PCB, PREAMP (MV) *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R13	040113	POT	CERMET	100 K	10%		73138	89PV100K
R14	000182	RES	CARBON	1.8 K	5%	1/4W	81349	RC07GF182J
R15	000202	RES	CARBON	2 K	5%	1/4W	81349	RC07GF202J
R16	000563	RES	CARBON	56 K	5%	1/4W	81349	RC07GF563J
R17	000101	RES	CARBON	100 OHM	5%	1/4W	81349	RC07GF101J
R18	000101	RES	CARBON	100 OHM	5%	1/4W	81349	RC07GF101J
R19	000221	RES	CARBON	200 OHM	5%	1/4W	81349	RC07GF221J
R20	040113	POT	CERMET	100 K	10%		73138	89PV100K
R21	000472	RES	CARBON	4.7 K	5%	1/4W	81349	RC07GF472J
R22	000181	RES	CARBON	180 OHM	5%	1/4W	81349	RC07GF181J
R23	001100	RES	CARBON	2.2 K	5%	1/2W	81349	RC20GF222J
R24	001100	RES	CARBON	2.2 K	5%	1/2W	81349	RC20GF222J
R25	010654	RES	METAL	20 K	.05%		18612	V53-1
R26	000682	RES	CARBON	6.8 K	5%	1/4W	81349	RC07GF682J
R27	010615	RES	METAL	10 K	.02%		18612	V53-1M
R28	010615	RES	METAL	10 K	.02%		18612	V53-1M
R68	403494	AMP KIT	FSV*			1/4W	21793	403494
R69	403494	AMP KIT	FSV*			1/4W	21793	403494

*Factory Selected Value

403435 – Assy., PCB, PREAMP/OHMS CONVERTER

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
CR1	220022	DIODE	SILICO	ZENER	1N965B		81349	1N965B
CR2	211083	DIODE	SILICO		018		21793	211083
CR3	211083	DIODE	SILICO		018		21793	211083
CR4	211236	DIODE	SILICO		007		21793	211236
CR5	211083	DIODE	SILICO		018		21793	211083
CR6	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
CR7	211083	DIODE	SILICO		018		21793	211083
CR8	211083	DIODE	SILICO		018		21793	211083
CR10	211083	DIODE	SILICO		018		21793	211083
CR11	211083	DIODE	SILICO		018		21793	211083
CR12	211083	DIODE	SILICO		018		21793	211083
CR13	211083	DIODE	SILICO		018		21793	211083
CR14	211083	DIODE	SILICO		018		21793	211083
CR15	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
CR16	211083	DIODE	SILICO		018		21793	211083
CR17	211083	DIODE	SILICO		018		21793	211083
CR18	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
CR19	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
CR20	220022	DIODE	SILICO	ZENER	1N965B		81349	1N965B
CR21	220060	DIODE		ZENER	24 V	5%	81349	1N970B
C1	120034	CAP	POLY	100 PFD	630 V	5%	08257	KSO Series
C2	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C3	121091	CAP	MYLAR	.033 MFD	100 V	10%	09023	WMF1S33
C4	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C5	100008	CAP	CERAM	82 PFD		10%	71471	ETCD-DI-1(N5600)
C6	120001	CAP	MYLAR	.0033 MFD	100 V	10%	09023	WMF1D33
C7	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C8	121093	CAP	MYLAR	.047 MFD	100 V	10%	09023	WMF1S47
C9	120001	CAP	MYLAR	.0033 MFD	100 V	10%	09023	WMF1D33
C10	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C11	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C12	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C13	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C14	110129	CAP	TANTA	.1 MFD	35 V		05397	T368A104M035AS
K1	310077	REED	RELAY	SHIELD	R2691-3		15636	R2691-3
K2	310078	REED	RELAY	SHIELD	R2690-3		15636	R2690-3
K3	310077	REED	RELAY	SHIELD	R2691-3		15636	R2691-3
K4	310077	REED	RELAY	SHIELD	R2691-3		15636	R2691-3

403435 – Assy., PCB, PREAMP/OHMS CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
K5	310077	REED RELAY SHIELD R2691-3	15636	R2691-3
M1	230054	INTEGRATED CIRCUIT LM301A	27014	LM301A
M2	403494	AMP KIT FSV* 1/4W	21793	403494
M3	230054	INTEGRATED CIRCUIT LM301A	27014	LM301A
M4	230054	INTEGRATED CIRCUIT LM301A	27014	LM301A
M5	230054	INTEGRATED CIRCUIT LM301A	27014	LM301A
Q1	200160	TRANS FET E-304	17856	E-304
Q2	200137	TRANS SELECTED 2N4248	80131	2N4248
Q3	200137	TRANS SELECTED 2N4248	80131	2N4248
Q4	200137	TRANS SELECTED 2N4248	80131	2N4248
Q5	200137	TRANS SELECTED 2N4248	80131	2N4248
Q6	200135	FET KIT 200135	21793	200135
Q7	200068	TRANS 2N4250	80131	2N4250
Q8	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q9	200043	TRANS SILICO NPN 200043	21793	200043
Q10	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q11	200035	TRANS SILICO NPN 014	21793	200035
Q12	200160	TRANS FET E304	17856	E-304
Q13	200035	TRANS SILICO NPN 014	21793	200035
Q14	201084	TRANS GERMAN PNP 2N1304	81349	2N1304
Q15	200011	TRANS SILICO PNP 009	21793	200011
Q16	200011	TRANS SILICO PNP 009	21793	200011
Q17	200137	TRANS SELECTED 2N4248	80131	2N4248
Q18	200137	TRANS SELECTED 2N4248	80131	2N4248
Q19	200137	TRANS SELECTED 2N4248	80131	2N4248
R1	403494	AMP KIT FSV* 1/4W	21793	403494
R2	021154	RES WW 10 K 3% 3 W	21551	M-200
R3	020614	RES WW 19.81 K .02% 1/8W	22045	J-11
R4	011178	RES CARBON 4.99 M 1% 1/2W	81349	RN20X4994F
R5	021154	RES WW 10 K 3% 3 W	21551	M-200
R6	021154	RES WW 10 K 3% 3 W	21551	M-200
R7	010671	RES METAL 494.8 K T-0 .25%	03888	PME60
R8	403494	AMP KIT FSV* 1/4W	21793	403494
R9	010615	RES METAL 10 K .02%	18612	V53-1M
R10	020611	RES WW 200 OHM .02% 1/8W	18612	V53-3M
R11	020615	RES WW 4.8 K 1% .12W	18612	V53-3M
R12	010621	RES METAL 49.9 K T-0 1%	81349	RN55C4992F

*Factory Selected Value

403435 – Assy., PCB, PREAMP/OHMS CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
R13	010621	RES	METAL	49.9 K	T-0	1%		81349	RN55C4992F
R14	200135	KIT	FET		200135			21793	200135
R15	200135	KIT	FET		200135			21793	200135
R16	000203	RES	CARBON	20 K		5%	1/4W	81349	RC07GF203J
R17	000472	RES	CARBON	4.7 K		5%	1/4W	81349	RC07GF472J
R18	000151	RES	CARBON	150 OHM		5%	1/4W	81349	RC07GF151J
R19	040173	POT	CERMET	5 K	89PV5K			73138	89PV5K
R20	000106	RES	CARBON	10 M		5%	1/4W	81349	RC07GF106J
R21	000514	RES	CARBON	510 K		5%	1/4W	81349	RC07GF514J
R22	010615	RES	METAL	10 K		.02%		18612	V53-1M
R23	040169	POT	CERMET	20 OHM		20%	3/4W	73138	89PV20
R24	010652	RES	METAL	4.99 K		.05%		18612	V53-1
R25	040113	POT	CERMET	100 K		10%		73138	89PV100K
R26	000244	RES	CARBON	240 K		5%	1/4W	81349	RC07GF244J
R27	010091	RES	METAL	11 K	T-0	1%		81349	RN60D1102F
R28	000182	RES	CARBON	1.8 K		5%	1/4W	81349	RC07GF182J
R29	040113	POT	CERMET	100 K		10%		73138	89PV100K
R30	010703	RES	METAL	555.50 OHM		.05%		18612	V53-1
R31	000113	RES	CARBON	11 K		5%	1/4W	81349	RC07GF113J
R32	000202	RES	CARBON	2 K		5%	1/4W	81349	RC07GF202J
R33	000563	RES	CARBON	56 K		5%	1/4W	81349	RC07GF563J
R34	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R35	040168	POT	CERMET	200 OHM		10%	3/4W	73138	89PR200
R36	020604	RES	WW	100 K		.05%	1/8W	22045	J-110
R37	040182	POT	CERMET	250 K		20%		11237	360S254B
R38	010682	RES	CARBON	9.8 M		1%		91637	DCS1/2
R39	000203	RES	CARBON	20 K		5%	1/4W	81349	RC07GF203J
R40	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R41	000221	RES	CARBON	220 OHM		5%	1/4W	81349	RC07GF221J
R42	040112	POT	CERMET	2 K		10%		73138	89PV2K
R43	020612	RES	WW	1.009 M		.05%	1/4W	22045	J-120
R44	040172	POT	CERMET	50 K	89PV50K			73138	89PV50K
R45	010655	RES	METAL	11.086 M	T-9	.1%		03888	PME70
R46	000511	RES	CARBON	510 OHM		5%	1/4W	81349	RC07GF511J
R47	010654	RES	METAL	20 K		.05%		18612	V53-1
R48	000682	RES	CARBON	6.8 K		5%	1/4W	81349	RC07GF682J
R49	010615	RES	METAL	10 K		.02%		18612	V53-1M
R50	040113	POT	CERMET	100 K		10%		73138	89PV100K
R51	010656	RES	METAL	19.948 M	T-9	.1%		03888	PME75
R52	010615	RES	METAL	10 K		.02%		18612	V53-1M

403435 – Assy., PCB, PREAMP/OHMS CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R53	010586	RES	METAL	5 K	.02%		18612	V53-1M
R54	040113	POT	CERMET	100 K	10%		73138	89PV100K
R55	000472	RES	CARBON	4.7 K	5%	1/4W	81349	RC07GF472J
R56	000181	RES	CARBON	180 OHM	5%	1/4W	81349	RC07GF181J
R57	001100	RES	CARBON	2.2 K	5%	1/2W	81349	RC20GF222J
R58	010654	RES	METAL	20 K	.05%		18612	V53-1
R59	000202	RES	CARBON	2 K	5%	1/4W	81349	RC07GF202J
R60	000101	RES	CARBON	100 OHM	5%	1/4W	81349	RC07GF101J
R61	000273	RES	CARBON	27 K	5%	1/4W	81349	RC07GF273J
R62	000331	RES	CARBON	330 OHM	5%	1/4W	81349	RC07GF331J
R63	000680	RES	CARBON	68 OHM	5%	1/4W	81349	RC07GF680J
R64	000222	RES	CARBON	2.2 K	5%	1/4W	81349	RC07GF222J
R65	001100	RES	CARBON	2.2 K	5%	1/2W	81349	RC20GF222J
R66	040085	POT	CERMET	500 K	30%		73138	89PV500K
R67	000202	RES	CARBON	2 K	5%	1/4W	81349	RC07GF202J
R68	403494	AMP KIT	FSV*			1/4W	21793	403494
R69	403494	AMP KIT	FSV*			1/4W	21793	403494
R70	403494	AMP KIT	FSV*			1/4W	21793	403494
R71	403494	AMP KIT	FSV*			1/4W	21793	403494

*Factory Selected Value

403472 – Assy., PCB, SCALING AMPLIFIER

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
CR1	211083	DIODE	SILICO		018		21793	211083
CR2	211083	DIODE	SILICO		018		21793	211083
CR6	211083	DIODE	SILICO		018		21793	211083
CR7	211083	DIODE	SILICO		018		21793	211083
CR8	211083	DIODE	SILICO		018		21793	211083
CR9	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
CR10	211083	DIODE	SILICO		018		21793	211083
CR11	211083	DIODE	SILICO		018		21793	211083
CR12	211083	DIODE	SILICO		018		21793	211083
CR13	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
C1	130116	CAP	MICA	4000 PFD	500 V	2%	72136	DM19F402G0
C2	120275	CAP	POLY	1000 PFD	630 V	2.5%	08257	KSC Series
C3	130115	CAP	MICA	346 PFD	500 V	2%	72136	DM15F3460G0
C4	120274	CAP	POLY	87 PFD	630 V	2.5%	08257	KSO Series
C5	100074	CAP	CERAM	FSV* (5 PFD)	1 KV		21793	100074
C6	100075	CAP	CERAM	FSV* (10 PFD)	1 KV	5%	21793	100075
C7	130124	CAP	CERAM	1.2-10 PFD	250 V			R-TR1K0-122-09SD
C8	100100	CAP	CERAM	FSV			21793	100100
C9	130123	CAP	CERAM	1-3 PFD	250 V			R-TR1K0-122-09SD
C10	100050	CAP	CERAM	2.2 PFD	1000 V	5%	56289	10TCC-V22
C11	100061	CAP	CERAM	39 PFD	1000 V	5%	56289	10TCC-Q39
C12	100077	CAP	GLASS	7.5 PFD	500 V	5%	95275	VY10CA7R5JA
C13	100075	CAP	CERAM	10 PFD	1 KV	5%	56289	10TCCQ10
C14	100075	CAP	CERAM	10 PFD	1 KV	5%	56289	10TCCQ10
C15	100077	CAP	GLASS	7.5 PFD	500 V	5%	95275	VY10CA7R5JA
C16	130125	CAP	PORCE	.8-10 PFD	250 V		91293	JMC2951
C17	130125	CAP	PORCE	.8-10 PFD	250 V		91293	JMC2951
C18	120090	CAP	MYLAR	.22 MFD	600 V	5%	27556	ZA1101J
C19	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C20	130127	CAP	TRIMMER	10-40 PFD				10S-TR1K0-24N750
C23	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C25	110140	CAP	TANTA	47 MFD	6 V		05397	T368B476M006AS
C26	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C27	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C28	100079	CAP	CERAM	3.9 PFD	1000 V		56289	10TCCV39
C29	100084	CAP	CERAM	FSV* (1.5 PFV)			21793	100084

*Factory Selected Value

403472 – Assy., PCB, SCALING AMPLIFIER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
C32	110126	CAP	TANTA	6.8 MFD	35 V			05397	T368B685M035AS
C33	101174	CAP	CERAM	.001 MFD	500 V	10%		71471	SCD3X5F
C34	110140	CAP	TANTA	47 MFD	6 V			05397	T368B476M006AS
C35	110140	CAP	TANTA	47 MFD	6 V			05397	T368B476M006AS
C36	110140	CAP	TANTA	47 MFD	6 V			05397	T368B476M006AS
C37	110141	CAP	TANTA	22 MFD	15 V			05397	T368B226M015AS
C39	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	TG-S10
C40	100051	CAP	CERAM	3 PFD	500 V			71471	TCD-B1-0
K1	310078	REED	RELAY	SHIELD	R2690-3			15636	R2690-3
K2	310077	REED	RELAY	SHIELD	R2691-3			15636	R2691-3
K3	310078	REED	RELAY	SHIELD	R2690-3			15636	R2690-3
L1	310068	CHOKE		1 UH				99800	1537-12
Q1	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q2	200161	TRANS	FET		E-415			17856	E-415
Q3	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q4	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q5	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q6	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q7	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q8	200151	TRANS	SILICO		2N5179			81349	2N5179
Q9	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q10	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
R1	010721	RES	MATCHED SET		RN75			81349	RN75
R2	010720	RES	METAL	9.09 K	T-2	.25%		81349	RN55C
R3	040195	POT		500 OHM				73138	79PR500
R4	010721	RES	MATCHED SET		RN75			81349	RN75
R5	040176	POT	CERMET	50 OHM	89PV50			73138	89PV50
R6	010721	RES	MATCHED SET		RN75			81349	RN75
R7	040195	POT		500 OHM				73138	79PR500
R8	010721	RES	MATCHED SET		RN75			81349	RN75
R9	010721	RES	MATCHED SET		RN75			81349	RN75
R10	041179	POT	WW	5 K				02111	50-1-1-502
R11	000163	RES	CARBON	16 K		5%	1/4W	81349	RC07GF163J
R12	000202	RES	CARBON	2 K		5%	1/4W	81349	RC07GF202J
R13	000510	RES	CARBON	51 OHM		5%	1/4W	81349	RC07GF510J
R14	000241	RES	CARBON	240 OHM		5%	1/4W	81349	RC07GF241J
R15	000202	RES	CARBON	2 K		5%	1/4W	81349	RC07GF202J
R16	010583	RES	METAL	182 OHM		1%		81349	RN55D
R17	000822	RES	CARBON	8.2 K		5%	1/4W	81349	RC07GF822J

403472 – Assy., PCB, SCALING AMPLIFIER *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R18	000241	RES	CARBON	240 OHM	5%	1/4W	81349	RC07GF241J
R19	010719	RES	METAL	16.2 K	1%		81349	RN55D1622F
R20	010583	RES	METAL	182 OHM	1%		81349	RN55D
R21	000510	RES	CARBON	51 OHM	5%	1/4W	81349	RC07GF510J
R22	000101	RES	CARBON	100 OHM	5%	1/4W	81349	RC07GF101J
R23	000183	RES	CARBON	18 K	5%	1/4W	81349	RC07GF183J
R24	000183	RES	CARBON	18 K	5%	1/4W	81349	RC07GF183J
R25	000102	RES	CARBON	1 K	5%	1/4W	81349	RC07GF102J
R26	000183	RES	CARBON	18 K	5%	1/4W	81349	RC07GF183J
R27	000432	RES	CARBON	4.3 K	5%	1/4W	81349	RC07GF432J
R28	000510	RES	CARBON	51 OHM	5%	1/4W	81349	RC07GF510J
R29	000160	RES	CARBON	16 OHM	5%	1/4W	81349	RC07GF160J
R31	001469	RES	CARBON	1.2 K	5%	1/2W	81349	RC20GF122J
R32	000474	RES	CARBON	FSV* (470 K)	5%	1/4W	21793	000474
R33	000152	RES	CARBON	1.5 K	5%	1/4W	81349	RC07GF152J
R34	010798	RES	METAL	82.5 OHM	1%		81349	RN55C
R35	040258	POT	CERMET	100 OHM	20%	.5W	73138	72XW100

*Factory Selected Value

403470 – Assy., PCB, AC CONVERTER

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
B1	920563	BEAD			56-59065-4B		02114	56-59065-4B
B2	920563	BEAD			56-59065-4B		02114	56-59065-4B
B3	920563	BEAD			56-59065-4B		02114	56-59065-4B
B4	920563	BEAD			56-59065-4B		02114	56-59065-4B
B5	920563	BEAD			56-59065-4B		02114	56-59065-4B
B6	920563	BEAD			56-59065-4B		02114	56-59065-4B
CR1	211083	DIODE	SILICO		018		21793	211083
CR2	220016	DIODE	SILICO	ZENER	1N964B		81349	1N964B
CR3	220004	DIODE	SILICO	ZENER	1N961B		81349	1N961B
CR4	220004	DIODE	SILICO	ZENER	1N961B		81349	1N961B
CR5	220004	DIODE	SILICO	ZENER	1N961B		81349	1N961B
CR6	220004	DIODE	SILICO	ZENER	1N961B		81349	1N961B
CR7	210015	DIODE			5082-2800		50434	5082-2800
CR8	210015	DIODE			5082-2800		50434	5082-2800
CR9	210015	DIODE			5082-2800		50434	5082-2800
CR10	210015	DIODE			5082-2800		50434	5082-2800
CR11	220004	DIODE	SILICO	ZENER	1N961B		81349	1N961B
CR12	220004	DIODE	SILICO	ZENER	1N961B		81349	1N961B
CR13	210015	DIODE			5082-2800		50434	5082-2800
CR14	210015	DIODE			5082-2800		50434	5082-2800
C4	130131	CAP	TRIMMER	2-20 PFD	100 V		73445	C010KA/20E
C5	100085	CAP	CERAM	6.8 PFD	1 KV		56289	10TCC-V68
C6	100081	CAP	CERAM	4.7 PFD	1000 V		56289	C030B102E4R7D
C7	100085	CAP	CERAM	6.8 PFD	1 KV		56289	10TCC-V68
C8	130131	CAP	TRIMMER	2-20 PFD	100 V		73445	C010KA/20E
C9	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C10	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C11	100080	CAP	CERAM	.05 MFD	100 V	20%	56289	TG-S50
C12	100080	CAP	CERAM	.05 MFD	100 V	20%	56289	TG-S50
C13	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C14	100081	CAP	CERAM	4.7 PFD	1000 V		56289	C030B102E4R7D
C15	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C16	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035A
C17	100080	CAP	CERAM	.05 MFD	100 V	20%	56289	TG-S50
C18	100080	CAP	CERAM	.05 MFD	100 V	20%	56289	TG-S50
C19	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C20	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C21	101098	CAP	CERAM	330 PFD		10%	56289	C016B102E331K

403470 – Assy., PCB, AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C22	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C23	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C24	101098	CAP	CERAM	330 PFD		10%	56289	C016B102E331K
C25	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C26	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C27	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C29	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C30	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C32	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C33	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C34	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C35	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C36	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C38	110151	CAP	TANTA	10 MFD	35 V	20%	05397	T362C106M035A
C40	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C41	130131	CAP	TRIMMER	2-20 PFD	100 V		73445	C010KA/20E
C42	120025	CAP	MYLAR	1.5 MFD	100 V	10%	27556	XA2B155K
C43	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C44	100080	CAP	CERAM	.05 MFD	100 V	20%	56289	TG-S50
C45	100068	CAP	CERAM	.02 MFD	100 V	20%	56289	TG-S20
C46	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C47	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C48	100080	CAP	CERAM	.05 MFD	100 V	20%	56289	TG-S50
C49	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C50	100081	CAP	CERAM	4.7 PFD	1000 V		56289	C030B102E4R7D
C51	100080	CAP	CERAM	.05 MFD	100 V	20%	56289	TG-S50
C52	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C53	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C54	101098	CAP	CERAM	330 PFD		10%	56289	C016B102E331K
C55	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C56	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C58	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C59	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C60	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C61	110151	CAP	TANTA	10 MFD	35 V		05397	T362C106M035A
C62	100084	CAP	CERAM	1.5 PFD	1 KV		56289	10TCC-V15
C63	100084	CAP	CERAM	1.5 PFD	1 KV		56289	10TCC-V15
C64	100086	CAP	CERAM	.04 MFD	500 V	20%	56289	44C124A
C65	100051	CAP	CERAM	3 PFD	500 V		71471	TCD-B1-0

403470 – Assy., PCB, AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
Q1	200179	TRANS	FET		KE4391			27014	KE4391
Q2	200129	TRANS	SILICO	NPN	SE4020			07263	SE4020
Q3	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q4	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q5	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q6	200178	TRANS		PNP	2N5910			81349	2N5910
Q7	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q8	200178	TRANS		PNP	2N5910			81349	2N5910
Q9	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q10	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q11	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q12	200178	TRANS		PNP	2N5910			81349	2N5910
Q13	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q14	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q15	200178	TRANS		PNP	2N5910			81349	2N5910
Q16	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q17	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q18	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q19	200178	TRANS		PNP	2N5910			81349	2N5910
Q20	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q21	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
Q22	200178	TRANS		PNP	2N5910			81349	2N5910
Q23	200197	TRANS	SILICO	NPN	MPS H10			04713	MPS H10
AR1	230127	INTEGRATED CIRCUIT			SSS725C			06665	SSS725C
AR2	230127	INTEGRATED CIRCUIT			SSS725C			06665	SSS725C
AR3	230127	INTEGRATED CIRCUIT			SSS725C			06665	SSS725C
AR4	230127	INTEGRATED CIRCUIT			SSS725C			06665	SSS725C
R1	010727	RES	METAL	2.5 K		.01%		18612	V53-1M
R2	010615	RES	METAL	10 K		.02%		18612	V53-1M
R3	020628	RES	WW	120.42 K		.02%	.05W	22045	J-90
R4	000100	RES	CARBON	10 OHM		5%	1/4W	81349	RC07GF100J
R5	020629	RES	WW	438.19 K		.02%	1/8W	22045	J-110
R6	010586	RES	METAL	5 K		.02%		18612	V53-1M
R7	010727	RES	METAL	2.5 K		.01%		18612	V53-1M
R8	010615	RES	METAL	10 K		.02%		18612	V53-1M
R9	000513	RES	CARBON	51 K		5%	1/4W	81349	RC07GF513J
R10	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R11	000102	RES	CARBON	1 K		5%	1/4W	81349	RC07GF102J
R12	000561	RES	CARBON	560 OHM		5%	1/4W	81349	RC07GF561J

403470 – Assy., PCB, AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R13	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R14	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R15	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R16	000621	RES	CARBON	620 OHM		5% 1/4W	81349	RC07GF621J
R17	000561	RES	CARBON	560 OHM		5% 1/4W	81349	RC07GF561J
R18	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R19	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R20	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R21	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R22	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R23	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R24	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R25	000362	RES	CARBON	3.6 K		5% 1/4W	81349	RC07GF362J
R26	040191	POT	CERMET	1 M	89PV1M		73138	89PV1M
R27	040112	POT	CERMET	2 K		10%	73138	89PV2K
R29	000100	RES	CARBON	10 OHM		5% 1/4W	81349	RC07GF100J
R30	040191	POT	CERMET	1 M	89PV1M		73138	89PV1M
R31	040112	POT	CERMET	2 K		10%	73138	89PV2K
R32	000150	RES	CARBON	15 OHM		5% 1/4W	81349	RC07GF150J
R34	000100	RES	CARBON	10 OHM		5% 1/4W	81349	RC07GF100J
R35	000303	RES	CARBON	30 K		5% 1/4W	81349	RC07GF303J
R36	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R37	000303	RES	CARBON	30 K		5% 1/4W	81349	RC07GF303J
R38	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R39	000163	RES	CARBON	16 K		5% 1/4W	81349	RC07GF163J
R40	000303	RES	CARBON	30 K		5% 1/4W	81349	RC07GF303J
R41	000163	RES	CARBON	16 K		5% 1/4W	81349	RC07GF163J
R42	000303	RES	CARBON	30 K		5% 1/4W	81349	RC07GF303J
R43	010529	RES	METAL	10 K	T-0	1%	81349	RN55D
R44	000151	RES	CARBON	150 OHM		5% 1/4W	81349	RC07GF151J
R45	010529	RES	METAL	10 K	T-0	1%	81349	RN55D
R46	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R47	000303	RES	CARBON	30 K		5% 1/4W	81349	RC07GF303J
R48	000303	RES	CARBON	30 K		5% 1/4W	81349	RC07GF303J
R49	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R50	000510	RES	CARBON	51 OHM		5% 1/4W	81349	RC07GF510J
R51	000201	RES	CARBON	200 OHM		5% 1/4W	81349	RC07GF201J
R52	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R53	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R54	000510	RES	CARBON	51 OHM		5% 1/4W	81349	RC07GF510J

403470 – Assy., PCB, AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
R55	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R56	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R57	000161	RES	CARBON	160 OHM		5%	1/4W	81349	RC07GF161J
R58	000911	RES	CARBON	910 OHM		5%	1/4W	81349	RC07GF911J
R59	000161	RES	CARBON	160 OHM		5%	1/4W	81349	RC07GF161J
R60	000911	RES	CARBON	910 OHM		5%	1/4W	81349	RC07GF911J
R61	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R62	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R63	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R64	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R65	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R66	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R67	010615	RES	METAL	10 K		.02%		18612	V53-1M
R68	040123	POT	CERMET	1 K	62-1-1-102			73138	62-1-1-102
R69	020627	RES	WW	81.73 K		.02%	.05W	22045	J-90
R70	010586	RES	METAL	5 K		.02%		18612	V53-1M
R71	010726	RES	METAL	10.71 K	T-2	.1%		03888	PME55
R72	010730	RES	METAL	5.355 K		.01%		18612	V53-1M
R73	010729	RES	METAL	31.31 K		.02%		18612	V53-1M
R74	040191	POT	CERMET	1 M	89PV1M			73138	89PV1M
R75	000107	RES	CARBON	100 M		5%	1/4W	81349	RC07GF107J
R76	000107	RES	CARBON	100 M		5%	1/4W	81349	RC07GF107J
R77	000392	RES	CARBON	3.9 K		5%	1/4W	81349	RC07GF392J
R78	010728	RES	METAL	33.91 K		.02%		18612	V53-1M
R79	010615	RES	METAL	10 K		.02%		18612	V53-1M
R80	000561	RES	CARBON	560 OHM		5%	1/4W	81349	RC07GF561J
R81	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R82	010737	RES	METAL	10.01 K		.01%		18612	V53-1M
R83	040191	POT	CERMET	1 M	89PV1M			73138	89PV1M
R84	000100	RES	CARBON	10 OHM		5%	1/4W	81349	RC07GF100J
R85	000561	RES	CARBON	560 OHM		5%	1/4W	81349	RC07GF561J
R86	000390	RES	CARBON	39 OHM		5%	1/4W	81349	RC07GF390J
R87	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R88	000107	RES	CARBON	100 M		5%	1/4W	81349	RC07GF107J
R89	000107	RES	CARBON	100 M		5%	1/4W	81349	RC07GF107J
R90	000102	RES	CARBON	1 K		5%	1/4W	81349	RC07GF102J
R91	000362	RES	CARBON	3.6 K		5%	1/4W	81349	RC07GF362J
R92	040191	POT	CERMET	1 M	89PV1M			73138	89PV1M
R93	040112	RES	VARI	2 K		10%		73138	89PV2K
R94	000150	RES	CARBON	15 OHM		5%	1/4W	81349	RC07GF150J

403470 – Assy., PCB, AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R95	000100	RES	CARBON	10 OHM		5% 1/4W	81349	RC07GF100J
R96	000303	RES	CARBON	30 K		5% 1/4W	81349	RC07GF303J
R97	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R98	000163	RES	CARBON	16 K		5% 1/4W	81349	RC07GF163J
R99	000303	RES	CARBON	30 K		5% 1/4W	81349	RC07GF303J
R100	010529	RES	METAL	10 K	T-0	1%	81349	RN55D
R101	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R102	000303	RES	CARBON	30 K		5% 1/4W	81349	RC07GF303J
R103	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R104	000510	RES	CARBON	51 OHM		5% 1/4W	81349	RC07GF510J
R105	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R106	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R107	000161	RES	CARBON	160 OHM		5% 1/4W	81349	RC07GF161J
R108	000911	RES	CARBON	910 OHM		5% 1/4W	81349	RC07GF911J
R109	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R110	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R111	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R112	000200	RES	CARBON	20 OHM		5% 1/4W	81349	RC07GF200J
R113	000107	RES	CARBON	100 M		5% 1/4W	81349	RC07GF107J
R114	001737	RES	FSV			5% 1/4W	21793	001737
R115	001737	RES	FSV			5% 1/4W	21793	001737
R116	000151	RES	CARBON	150 OHM		5% 1/4W	81349	RC07GF151J
R117	000151	RES	CARBON	150 OHM		5% 1/4W	81349	RC07GF151J
W1	600245	JUMPER			L-2007-1			L-2007-1
W2	600245	JUMPER			L-2007-1			L-2007-1

403773 – Assy., PCB, RMS AC CONVERTER

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
B1	920563	BEADS			56-59065-4B			02114	56-59065-4B
C1	130116	CAP	MICA	4000 PFD	500 V	2%		72136	DM19F402G0
C2	130115	CAP	MICA	346 PFD	500 V	2%		72136	DM15F3460G0
C3	100002	CAP	CERAM	4.7 PFD		10%		71471	TCD N750
C4	130124	CAP	TRIMMER	1.2-10 PFD	250 V				R-TRIKO-122-09SD
C5	100081	CAP	CERAM	4.7 PFD	1000 V			56289	C030B102E4R7D
C6	100054	CAP	CERAM	27 PFD	1000 V	5%		56289	10TCCQ27
C7	130123	CAP	TRIMMER	1-3 PFD	250 V				R-TRIKO-122-09SD
C8	100050	CAP	CERAM	2.2 PFD	1000 V	5%		56289	10TCCV22
C9	130146	CAP	TRIMMER	.25-1.5 PFD	273-0001-002			74970	273-0001-002
C10	100095	CAP	CERAM	2.7±.5 PFD	500 V			56289	C030B102S2R7D
C11	130146	CAP	TRIMMER	.25-1.5 PFD	273-0001-002			74970	273-0001-002
C12	120280	CAP	MYLAR	.22 MFD	1000 V	10%		27556	ZA2J224K
C13	130084	CAP	MICA	68 PFD	DM5E.680J			72136	DM5E.680J
C14	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	TG-S10
C15	100017	CAP	CERAM	.01 MFD	100 V	20%		56289	TG-S10
C16	101098	CAP	CERAM	330 PFD		10%		56289	C016B102E331K
C17	101641	CAP	CERAM	470 PFD		10%		71471	SCD1X5F
C18	110126	CAP	TANTA	6.8 MFD	35 V			05397	T368B685M035AS
C19	130076	CAP	MICA	200 PFD	500 V	5%		72136	DM15-201J
C20	101642	CAP	CERAM	150 PFD		10%		71471	SCD1X5F
C21	120026	CAP	MYLAR	.47 MFD	100 V	10%		27556	SA2B474K
C23	120026	CAP	MYLAR	.47 MFD	100 V	10%		27556	SA2B474K
C24	120026	CAP	MYLAR	.47 MFD	100 V	10%		27556	SA2B474K
C25	101644	CAP	CERAM	200 PFD	1000 V	20%		71471	GPDX5F201K
C26	101098	CAP	CERAM	330 PFD		10%		56289	C016B102E331K
C27	100051	CAP	CERAM	3 PFD	500 V			71471	TCD-B1-0
C28	130127	CAP	TRIMMER	10-40 PFD	10S-TRIKO-24N750				10S-TRIKO-24N750
C29	110140	CAP	TANTA	47 MFD	6 V			05397	T368B476M006AS
CR1	200197	TRANS	SILICO	NPN	MPS-H10			04713	MPS-H10
CR2	200197	TRANS	SILICO	NPN	MPS-H10			04713	MPS-H10
CR3	211083	DIODE	SILICO		018			21793	211083
CR4	211083	DIODE	SILICO		018			21793	211083
CR5	211083	DIODE	SILICO		018			21793	211083
CR6	211083	DIODE	SILICO		018			21793	211083
CR7	211083	DIODE	SILICO		018			21793	211083
CR8	210035	DIODE			5082-2810			50434	5082-2810
CR9	210035	DIODE			5082-2810			50434	5082-2810
CR10	211083	DIODE	SILICO		018			21793	211083

403773 – Assy., PCB, RMS AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
CR12	220016	DIODE SILICO ZENER 1N964B	81349	1N964B
CR13	220016	DIODE SILICO ZENER 1N964B	81349	1N964B
K1	310078	REED RELAY SHIELD 28 V	15636	R2690-3
K2	310078	REED RELAY SHIELD 28 V	15636	R2690-3
K3	310078	REED RELAY SHIELD 28 V	15636	R2690-3
K4	310078	REED RELAY SHIELD 28 V	15636	R2690-3
Q1	200200	TRANS NPN 200200	21793	200200
Q2	200200	TRANS NPN 200200	21793	200200
Q4	200199	TRANS DUAL 200199	21793	200199
Q5	200200	TRANS NPN 200200	21793	200200
Q6	200201	TRANS DUAL NPN 200201	21793	200201
Q7	200112	TRANS MATCHED PAIR 200112	21793	200112
Q8	200112	TRANS MATCHED PAIR 200112	21793	200112
Q9	200068	TRANS 2N4250	80131	2N4250
Q10	200200	TRANS NPN 200200	21793	200200
Q11	200220	TRANS DUAL 200220	21793	200220
Q12	200136	TRANS 2N5963	81349	2N5963
Q13	200068	TRANS 2N4250	80131	2N4250
Q14	403819	LOG TRANSISTOR KIT 403819	21793	403819
Q15	403819	LOG TRANSISTOR KIT 403819	21793	403819
Q16	200068	TRANS 2N4250	80131	2N4250
Q17	200179	TRANS FET KE4391	27014	KE4391
Q18	200179	TRANS FET KE4391	27014	KE4391
AR1	230180	INTEGRATED CIRCUIT LM318H	27014	LM318H
AR2	230054	INTEGRATED CIRCUIT LM301A	27014	LM301A
R1	010721	RES METAL MATCHED SET	81349	RN75
R2	010720	RES METAL 9.09 K T-2 .25%	81349	RN55C
R3	040228	POT CERMET 500 OHM 10%	73138	89PR500
R4	010721	RES METAL MATCHED SET	81349	RN75
R5	040225	POT CERMET 50 OHM 20%	73138	89P Series
R6	010721	RES METAL MATCHED SET	81349	RN75
R7	040228	POT CERMET 500 OHM 10%	73138	89P Series
R8	010721	RES METAL MATCHED SET	81349	RN75
R9	000242	RES CARBON 2.4 K 5% 1/4W	81349	RC07GF242J
R10	010721	RES METAL MATCHED SET	81349	RN75
R11	000182	RES CARBON 1.8 K 5% 1/4W	81349	RC07GF182J
R12	010678	RES METAL 60.4 K 1%	81349	RN55C
R13	010678	RES METAL 60.4 K 1%	81349	RN55C

403773 – Assy., PCB, RMS AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
R14	001737	RES	CARBON	FSV		5%	1/4W	21793	001737
R15	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R16	000334	RES	CARBON	330 K		5%	1/4W	81349	RC07GF334J
R17	040235	POT	CERMET	100 K	89PR100K			73138	89PR100K
R19	010670	RES	METAL	50 K		1%		81349	RN55E
R20	040236	POT	CERMET	200 K		10%		73138	89P200K
R21	010257	RES	METAL	365 K	T-2	1%		81349	RN60C3653F
R22	010586	RES	METAL	5 K		.02%		18612	V53-1M
R23	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R24	010586	RES	METAL	5 K		.02%		18612	V53-1M
R25	010586	RES	METAL	5 K		.02%		18612	V53-1M
R26	010654	RES	METAL	20 K		.05%		18612	V53-1
R27	010615	RES	METAL	10 K		.02%		18612	V53-1M
R28	040225	POT	CERMET	50 OHM		20%		73138	89P Series
R29	000512	RES	CARBON	5.1 K		5%	1/4W	81349	RC07GF512J
R30	000105	RES	CARBON	1 M		5%	1/4W	81349	RC07GF105J
R31	040235	POT	CERMET	100 K	89PR100K			73138	89PR100K
R32	000184	RES	CARBON	180 K		5%	1/4W	81349	RC07GF184J
R33	040225	POT	CERMET	50 OHM		20%		73138	89P Series
R34	010684	RES	METAL	487 OHM	T-9	1%		81349	RN55E4870F
R35	010684	RES	METAL	487 OHM	T-9	1%		81349	RN55E4870F
R36	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R37	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R38	000272	RES	CARBON	2.7 K		5%	1/4W	81349	RC07GF272J
R39	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R40	000681	RES	CARBON	680 OHM		5%	1/4W	81349	RC07GF681J
R41	040239	POT	CERMET	1 M		20%		73138	89PR1M
R42	040232	POT	CERMET	10 K		10%		73138	89PR10K
R43	010635	RES	METAL	34.8 K		1%		81349	RN55D3482F
R44	000476	RES	CARBON	47 M		5%	1/4W	81349	RC07GF476J
R45	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R46	010392	RES	METAL	20 K	T-2	.1%		03888	PME55
R47	000392	RES	CARBON	3.9 K		5%	1/4W	81349	RC07GF392J
R48	001737	RES	CARBON	FSV		5%	1/4W	21793	001737
R49	000107	RES	CARBON	100 M		5%	1/4W	81349	RC07GF107J
R50	000104	RES	CARBON	100 K		5%	1/4W	81349	RC07GF104J
R51	020667	RES	WW	100 K		.1%	1/8W	22045	J-110
R52	001737	RES	CARBON	FSV		5%	1/4W	21793	001737
R53	001768	RES	CARBON	3.3 OHM		5%	1/4W		
R54	040225	POT	CERMET	50 OHM		20%		73138	89P Series
R55	010654	RES	METAL	20 K		.05%		18612	V53-1
R56	001737	RES	CARBON	FSV		5%	1/4W	21793	001737
R57	010654	RES	METAL	20 K		.05%		18612	V53-1

403773 – Assy., PCB, RMS AC CONVERTER *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R58	040227	POT CERMET 200 OHM 10%	73138	89P Series
R59	001737	RES CARBON FSV 5% 1/4W	21793	001737
R60	010614	RES METAL 9 K .02%	18612	V53-1
R61	000101	RES CARBON 100 OHM 5% 1/4W	81349	RC07GF101J
R63	000470	RES CARBON 47 OHM 5% 1/4W	81349	RC07GF470J
R64	000820	RES CARBON 82 OHM 5% 1/4W	81349	RC07GF820J
R65	010613	RES METAL 1 K .02%	18612	V53-1
R66	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R67	000334	RES CARBON 330 K 5% 1/4W	81349	RC07GF334J
R68	000334	RES CARBON 330 K 5% 1/4W	81349	RC07GF334J
R69	000105	RES CARBON 1 M 5% 1/4W	81349	RC07GF105J
R71	000332	RES CARBON 3.3 K 5% 1/4W	81349	RC07GF332J
R72	010618	RES METAL 200 K .25%	81349	RN55C
R73	010536	RES METAL 100 K T-0 1%	81349	RN55D1003F
R74	403819	LOG TRANSISTOR KIT 403819	21793	403819
R75	403819	LOG TRANSISTOR KIT 403819	21793	403819
R76	010496	RES METAL 1 M T-0 1% 1/8W	81349	RN60D
R77	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R78	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R79	000332	RES CARBON 3.3 K 5% 1/4W	81349	RC07GF332J
R80	000474	RES CARBON 470 K 5% 1/4W	81349	RC07GF474J
S1	600742	SWITCH SLIDE G-111	79727	G-111
S2	600742	SWITCH SLIDE G-111	79727	G-111
TP1	600591	POST TEST POINT 85931-6	89110	85931-6
TP2	600591	POST TEST POINT 85931-6	89110	85931-6
TP3	600591	POST TEST POINT 85931-6	89110	85931-6
TP4	600591	POST TEST POINT 85931-6	89110	85931-6
TP5	600591	POST TEST POINT 85931-6	89110	85931-6
W1	600245	JUMPER L-2007-1		L-2007-1

403434 – Assy., PCB, ISOLATOR

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
CR1	220027	DIODE	SILICO	ZENER	1N749A		81349	1N749A
CR2	220027	DIODE	SILICO	ZENER	1N749A		81349	1N749A
CR7	220027	DIODE	SILICO	ZENER	1N749A		81349	1N749A
CR8	211083	DIODE	SILICO		018		21793	211083
CR9	211083	DIODE	SILICO		018		21793	211083
CR10	221177	DIODE	SILICO	ZENER	1/4M.2.4AZ5		04713	1/4M.2.4AZ5
CR11	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
CR12	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
CR13	210004	DIODE	SILICO		1N4004		81349	1N4004
CR14	210004	DIODE	SILICO		1N4004		81349	1N4004
CR15	211083	DIODE	SILICO		018		21793	211083
CR16	211083	DIODE	SILICO		018		21793	211083
CR17	211083	DIODE	SILICO		018		21793	211083
CR18	211083	DIODE	SILICO		018		21793	211083
CR19	211083	DIODE	SILICO		018		21793	211083
C1	120237	CAP	POLY	.15 MFD	100 V	5%	08257	KSC Series
C2	120237	CAP	POLY	.15 MFD	100 V	5%	08257	KSC Series
C3	121394	CAP	MYLAR	.15 MFD	100 V	10%	09023	WMF1P15
C4	101145	CAP	CERAM	100 PFD		10%	71471	ETCD-DI-1(N5600)
C5	121091	CAP	MYLAR	.033 MFD	100 V	10%	09023	WMF1S33
C6	120070	CAP	POLY	3000 PFD	100 V	5%	08257	KSC Series
C7	100025	CAP	CERAM	.005 MFD	100 V	20%	72982	835-000-X5V0502Z
C8	120257	CAP	POLY	5 PFD	500 V		08257	KSO Series
C9	100051	CAP	CERAM	3 PFD	500 V		71471	TCD-B1-0
C10	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C11	121091	CAP	MYLAR	.033 MFD	100 V	10%	09023	WMF1S33
C12	110125	CAP	TANTA	2.2 MFD	35 V		05397	T368B225M035AS
C13	110125	CAP	TANTA	2.2 MFD	35 V		05397	T368B225M035AS
C14	120257	CAP	POLY	5 PFD	500 V		08257	KSO Series
K1	310077	REED	RELAY	SHIELD	R2691-3		15636	R2691-3
Q1	200136	TRANS	SILICO	NPN	2N5963		81349	2N5963
Q2	200136	TRANS	SILICO	NPN	2N5963		81349	2N5963
Q3	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q4	200222	TRANS			200222		21793	200222
Q5	200137	TRANS	SELECTED		2N4248		80131	2N4248
Q6	200137	TRANS	SELECTED		2N4248		80131	2N4248
Q7	200140	TRANS	DUAL	NPN	200140		21793	200140

403434 – Assy., PCB, ISOLATOR *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
Q8	200140	TRANS DUAL NPN 200140	21793	200140
Q9	200142	TRANS PNP 2N4249	81349	2N4249
Q10	200035	TRANS SILICO NPN 014	21793	200035
Q11	200035	TRANS SILICO NPN 014	21793	200035
Q12	200142	TRANS PNP 2N4249	81349	2N4249
Q13	200035	TRANS SILICO NPN 014	21793	200035
Q14	200035	TRANS SILICO NPN 014	21793	200035
Q15	200137	TRANS SELECTED 2N4248	80131	2N4248
Q16	200137	TRANS SELECTED 2N4248	80131	2N4248
Q17	200137	TRANS SELECTED 2N4248	80131	2N4248
Q18	200137	TRANS SELECTED 2N4248	80131	2N4248
Q19	200137	TRANS SELECTED 2N4248	80131	2N4248
Q20	200137	TRANS SELECTED 2N4248	80131	2N4248
AR1	230075	INTEGRATED CIRCUIT UA748C	07263	UA748C
AR2	230054	INTEGRATED CIRCUIT LM301A	27014	LM301A
R1	010536	RES METAL 100 K T-0 1%	81349	RN55D1003F
R2	010621	RES METAL 49.9 K T-0 1%	81349	RN55C4992F
R3	000245	RES CARBON 2.4 M 5% 1/4W	81349	RC07GF245J
R4	000153	RES CARBON 15 K 5% 1/4W	81349	RC07GF153J
R5	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R6	000220	RES CARBON 22 OHM 5% 1/4W	81349	RC07GF220J
R7	000912	RES CARBON 9.1 K 5% 1/4W	81349	RC07GF912J
R8	020639	RES WW 24 K 5% 3 W	21551	M-200
R9	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R10	010529	RES METAL 10 K T-0 1%	81349	RN55D
R11	000181	RES CARBON 180 OHM 5% 1/4W	81349	RC07GF181J
R12	040113	POT CERMET 100 K 10%	73138	89PV100K
R13	000107	RES CARBON 100 M 5% 1/4W	81349	RC07GF107J
R14	001737	RES FSV 5% 1/4W	21793	001737
R15	010584	RES METAL, SET 10 M T-2 1%	03888	PME70
R16	001737	RES FSV 5% 1/4W	21793	001737
R17	010584	RES METAL, SET 10 M T-2 1%	03888	PME70
R18	000221	RES CARBON 220 OHM 5% 1/4W	81349	RC07GF221J
R19	010750	RES CARBON 5.9 M 1% 1/2W	81349	RN20X
R20	000622	RES CARBON 6.2 K 5% 1/4W	81349	RC07GF622J
R21	000430	RES CARBON 43 OHM 5% 1/4W	81349	RC07GF430J
R22	000153	RES CARBON 15 K 5% 1/4W	81349	RC07GF153J
R23	000681	RES CARBON 680 OHM 5% 1/4W	81349	RC07GF681J

403434 – Assy., PCB, ISOLATOR *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R24	000202	RES	CARBON	2 K	5%	1/4W	81349	RC07GF202J
R25	000821	RES	CARBON	820 OHM	5%	1/4W	81349	RC07GF821J
R26	000273	RES	CARBON	27 K	5%	1/4W	81349	RC07GF273J
R27	000330	RES	CARBON	33 K	5%	1/4W	81349	RC07GF330J
R28	000161	RES	CARBON	160 OHM	5%	1/4W	81349	RC07GF161J
R29	000111	RES	CARBON	110 OHM	5%	1/4W	81349	RC07GF111J
R30	000220	RES	CARBON	22 OHM	5%	1/4W	81349	RC07GF220J
R31	000430	RES	CARBON	43 OHM	5%	1/4W	81349	RC07GF430J
R32	000820	RES	CARBON	82 OHM	5%	1/4W	81349	RC07GF820J
R33	000273	RES	CARBON	27 K	5%	1/4W	81349	RC07GF273J
R34	000100	RES	CARBON	10 OHM	5%	1/4W	81349	RC07GF100J
R35	000435	RES	CARBON	4.3 M	5%	1/4W	81349	RC07GF435J
R36	040113	POT	CERMET	100 K	10%		73138	89PV100K

403432 – Assy., PCB, DIGITIZER

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
CR1	211083	DIODE	SILICO		018		21793	211083
CR2	211083	DIODE	SILICO		018		21793	211083
CR3	211083	DIODE	SILICO		018		21793	211083
CR4	211083	DIODE	SILICO		018		21793	211083
CR5	211083	DIODE	SILICO		018		21793	211083
CR6	220026	DIODE	ZENER		1N963B		81349	1N963B
CR7	211083	DIODE	SILICO		018		21793	211083
CR8	220054	DIODE	ZENER		1N5260B		81349	1N5260B
CR9	211236	DIODE	SILICO		007		21793	211236
CR10	403423	ASSEMBLY		ZENER	403423		21793	403423
CR11	211236	DIODE	SILICO		007		21793	211236
CR12	211236	DIODE	SILICO		007		21793	211236
CR13	211083	DIODE	SILICO		018		21793	211083
CR14	211083	DIODE	SILICO		018		21793	211083
CR15	211083	DIODE	SILICO		018		21793	211083
CR16	211083	DIODE	SILICO		018		21793	211083
CR17	211083	DIODE	SILICO		018		21793	211083
CR18	211083	DIODE	SILICO		018		21793	211083
CR19	220026	DIODE	ZENER		1N963B		81349	1N963B
CR20	220027	DIODE	SILICO	ZENER	1N749A		81349	1N749A
CR21	220059	DIODE	ZENER		33 V	5%	81349	1N973B
CR22	220007	DIODE	SILICO	ZENER	1N751A		81349	1N751A
C1	110125	CAP	TANTA	2.2 MFD	35 V		05397	T368B225M035AS
C2	110125	CAP	TANTA	2.2 MFD	35 V		05397	T368B225M035AS
C3	101098	CAP	CERAM	330 PFD		10%	56289	C016B102E331K
C4	101145	CAP	CERAM	100 PFD		10%	71471	ETCD-DI-1(N5600)
C5	101145	CAP	CERAM	100 PFD		10%	71471	ETCD-DI-1(N5600)
C6	120253	CAP	POLY	.33 MFD	100 V	5%	07716	863UW
C7	110125	CAP	TANTA	2.2 MFD	35 V		05397	T368B225M035AS
C8	101642	CAP	CERAM	150 PFD		10%	71471	SCD1X5F
C9	101642	CAP	CERAM	150 PFD		10%	71471	SCD1X5F
C10	101642	CAP	CERAM	150 PFD		10%	71471	SCD1X5F
C11	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C12	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C13	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C14	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C15	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C17	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C18	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)

403432 – Assy., PCB, DIGITIZER *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
C19	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C20	100038	CAP	CERAM	560 PFD	500 V	10%	71590	DD561
C21	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C22	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C23	100012	CAP	CERAM	33 PFD		10%	71471	TCD-DI-1(N750)
C24	110127	CAP	TANTA	22 MFD	6 V		05397	T368B226M006AS
C25	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C26	110129	CAP	TANTA	.1 MFD	35 V		05397	T368A104M035AS
C27	110127	CAP	TANTA	22 MFD	6 V		05397	T368B226M006AS
C28	110126	CAP	TANTA	6.8 MFD	35 V		05397	T368B685M035AS
C30	100051	CAP	CERAM	3 PF	500 V		71471	TCD-B1-0
C31	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
C32	100068	CAP	CERAM	.02 MFD	100 V	20%	56289	TG-S20
C33	100017	CAP	CERAM	.01 MFD	100 V	20%	56289	TG-S10
M1	230076	INTEGRATED CIRCUIT			SN74L00N		01295	SN74L00N
M2	230076	INTEGRATED CIRCUIT			SN74L00N		01295	SN74L00N
Q1	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q2	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q3	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q4	200037	TRANS	SILICO	NPN	2N3646		80131	2N3646
Q5	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q6	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q7	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q8	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q9	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q10	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q11	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q12	200043	TRANS	SILICO	NPN	200043		21793	200043
Q13	200162	SWITCHES		FET	MATCHED SET		21793	200162
Q14	200129	TRANS	SILICO	NPN	SE4020		07263	SE4020
Q15	200162	SWITCHES		FET	MATCHED SET		21793	200162
Q16	200129	TRANS	SILICO	NPN	SE4020		07263	SE4020
Q17	200162	SWITCHES		FET	MATCHED SET		21793	200162
Q18	200129	TRANS	SILICO	NPN	SE4020		07263	SE4020
Q19	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q20	200160	TRANS	FET		E-304		17856	E-304
Q21	200161	TRANS	FET		E-415		17856	E-415
Q22	200088	TRANS	SILICO	PNP	2N4248		80131	2N4248
Q24	200035	TRANS	SILICO	NPN	014		21793	200035

403432 – Assy., PCB, DIGITIZER *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
Q25	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q26	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q27	200088	TRANS SILICO PNP 2N4248	80131	2N4248
Q28	200160	TRANS FET E-304	17856	E-304
AR1	230054	INTEGRATED CIRCUIT LM301A	27014	LM301A
AR2	230109	INTEGRATED CIRCUIT SELECTED LM301A	21793	230109
AR3	230054	INTEGRATED CIRCUIT LM301A	27014	LM301A
AR4	230109	INTEGRATED CIRCUIT SELECTED LM301A	21793	230109
AR5	230056	INTEGRATED CIRCUIT UA710C	07263	U6A7710393
R1	000153	RES CARBON 15 K 5% 1/4W	81349	RC07GF153J
R3	000272	RES CARBON 2.7 K 5% 1/4W	81349	RC07GF272J
R4	000272	RES CARBON 2.7 K 5% 1/4W	81349	RC07GF272J
R5	000153	RES CARBON 15 K 5% 1/4W	81349	RC07GF153J
R6	000152	RES CARBON 1.5 K 5% 1/4W	81349	RC07GF152J
R7	000272	RES CARBON 2.7 K 5% 1/4W	81349	RC07GF272J
R8	000153	RES CARBON 15 K 5% 1/4W	81349	RC07GF153J
R9	000511	RES CARBON 510 OHM 5% 1/4W	81349	RC07GF511J
R10	000511	RES CARBON 510 OHM 5% 1/4W	81349	RC07GF511J
R11	000153	RES CARBON 15 K 5% 1/4W	81349	RC07GF153J
R12	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
R13	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R14	000202	RES CARBON 2 K 5% 1/4W	81349	RC07GF202J
R15	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
R16	000392	RES CARBON 3.9 K 5% 1/4W	81349	RC07GF392J
R17	000152	RES CARBON 1.5 K 5% 1/4W	81349	RC07GF152J
R18	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R19	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R20	000562	RES CARBON 5.6 K 5% 1/4W	81349	RC07GF562J
R21	000362	RES CARBON 3.6 K 5% 1/4W	81349	RC07GF362J
R22	000511	RES CARBON 510 OHM 5% 1/4W	81349	RC07GF511J
R23	000152	RES CARBON 1.5 K 5% 1/4W	81349	RC07GF152J
R24	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R25	000152	RES CARBON 1.5 K 5% 1/4W	81349	RC07GF152J
R26	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R27	000152	RES CARBON 1.5 K 5% 1/4W	81349	RC07GF152J
R28	000303	RES CARBON 30 K 5% 1/4W	81349	RC07GF303J
R29	000302	RES CARBON 3 K 5% 1/4W	81349	RC07GF302J
R30	000302	RES CARBON 3 K 5% 1/4W	81349	RC07GF302J

403432 – Assy., PCB, DIGITIZER *continued*

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
R31	000302	RES	CARBON	3 K		5%	1/4W	81349	RC07GF302J
R32*	010169	RES	METAL	100 K	T-0	1%		81349	RN60D1003F
R33	000105	RES	CARBON	(1 M)	FSV**	5%	1/4W	21793	000105
R34	040180	POT		1 M		20%		11237	360S105B
R35	000123	RES	CARBON	12 K		5%	1/4W	81349	RC07GF123J
R36	000102	RES	CARBON	1 K		5%	1/4W	81349	RC07GF102J
R37	010633	RES	METAL	30.1 K		1%		81349	RN55D3012F
R38	000202	RES	CARBON	2 K		5%	1/4W	81349	RC07GF202J
R39	010580	RES	METAL	21 K	T-0	1%		81349	RN55D2102F
R40	010633	RES	METAL	30.1 K		1%		81349	RN55D3012F
R41	010647	RES	METAL	316 OHM	T-9	1%		81349	RN65E3160F
R42	000270	RES	CARBON	27 OHM		5%	1/4W	81349	RC07GF270J
R43	040174	POT	CERMET	500 OHM	89PV500			73138	89PV500
R44	010645	RES	METAL	2.37 K	T-0	1%		81349	RN55D2371F
R45	403423	ASSEMBLY		ZENER	403423			21793	403423
R46	000513	RES	CARBON	51 K		5%	1/4W	81349	RC07GF513J
R47	000562	RES	CARBON	5.6 K		5%	1/4W	81349	RC07GF562J
R48	000435	RES	CARBON	4.3 M		5%	1/4W	81349	RC07GF435J
R51	000302	RES	CARBON	3 K		5%	1/4W	81349	RC07GF302J
R53	000306	RES	CARBON	30 M		5%	1/4W	81349	RC07GF306J
R54	000156	RES	CARBON	15 M		5%	1/4W	81349	RC07GF156J
R55	040210	POT	CERMET	100 K			1 W	11237	360S104B
R56	000511	RES	CARBON	510 OHM		5%	1/4W	81349	RC07GF511J
R57	000752	RES	CARBON	7.5 K		5%	1/4W	81349	RC07GF752J
R58	000101	RES	CARBON	100 OHM		5%	1/4W	81349	RC07GF101J
R59	040113	POT	CERMET	100 K		10%		73138	89PV100K
R60	000515	RES	CARBON	5.1 M		5%	1/4W	81349	RC07GF515J
R61	010586	RES	METAL	5 K		.02%		18612	V53-1M
R62	010646	RES	METAL	2.49 K	T-0	1%		81349	RN55D2491F
R63	000102	RES	CARBON	1 K		5%	1/4W	81349	RC07GF102J
R64	010586	RES	METAL	5 K		.02%		18612	V53-1M
R65	000306	RES	CARBON	30 M		5%	1/4W	81349	RC07GF306J
R66	000183	RES	CARBON	18 K		5%	1/4W	81349	RC07GF183J
R67	000156	RES	CARBON	15 M		5%	1/4W	81349	RC07GF156J
R68	040210	POT	CERMET	100 K			1 W	11237	360S104B
R69	000392	RES	CARBON	3.9 K		5%	1/4W	81349	RC07GF392J
R70	000103	RES	CARBON	10 K		5%	1/4W	81349	RC07GF103J
R71	000202	RES	CARBON	2 K		5%	1/4W	81349	RC07GF202J
R72	000200	RES	CARBON	20 OHM		5%	1/4W	81349	RC07GF200J
R73	010585	RES	METAL	3.6 K		.02%		18612	V53-1

*In 50 Hz units, R32 is:

R32	010706	RES	METAL	121 K	1%	81349	RN60D1213F

**Factory Selected Value

403432 – Assy., PCB, DIGITIZER *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R74	000153	RES CARBON 15 K 5% 1/4W	81349	RC07GF153J
R77	000101	RES CARBON 100 OHM 5% 1/4W	81349	RC07GF101J
R78	000101	RES CARBON 100 OHM 5% 1/4W	81349	RC07GF101J
R79	000330	RES CARBON 33 OHM 5% 1/4W	81349	RC07GF330J
R80	000302	RES CARBON 3 K 5% 1/4W	81349	RC07GF302J
R81	040190	POT CERMET 500 OHM	73138	62PAR500
R82	000104	RES CARBON 100 K 5% 1/4W	81349	RC07GF104J
R83	040211	POT CERMET 500 OHM 20%	11237	360S Series
T1	403553	TRANSFORMER PULSE 403553	21793	403553
T2	403553	TRANSFORMER PULSE 403553	21793	403553
T3	403553	TRANSFORMER PULSE 403553	21793	403553

403430 – Assy., PCB, DISPLAY

REF DES	DANA P/N	DESCRIPTION				FSC	MANU P/N
CR1	211083	DIODE	SILICO	018		21793	211083
CR2	211083	DIODE	SILICO	018		21793	211083
CR3	211083	DIODE	SILICO	018		21793	211083
CR4	211083	DIODE	SILICO	018		21793	211083
CR5	211083	DIODE	SILICO	018		21793	211083
CR6	211083	DIODE	SILICO	018		21793	211083
CR7	211083	DIODE	SILICO	018		21793	211083
CR8	211083	DIODE	SILICO	018		21793	211083
CR9	211083	DIODE	SILICO	018		21793	211083
CR10	211083	DIODE	SILICO	018		21793	211083
CR11	210004	DIODE	SILICO	1N4004		81349	1N4004
CR12	211083	DIODE	SILICO	018		21793	211083
CR13	210004	DIODE	SILICO	1N4004		81349	1N4004
CR14	210004	DIODE	SILICO	1N4004		81349	1N4004
CR15	210004	DIODE	SILICO	1N4004		81349	1N4004
CR16	211083	DIODE	SILICO	018		21793	211083
CR17	211083	DIODE	SILICO	018		21793	211083
CR18	211083	DIODE	SILICO	018		21793	211083
CR19	211083	DIODE	SILICO	018		21793	211083
CR20	220059	DIODE	ZENER	33 V	5%	81349	1N973B
CR22	211083	DIODE	SILICO	018		21793	211083
CR23	211083	DIODE	SILICO	018		21793	211083
CR24	211083	DIODE	SILICO	018		21793	211083
CR25	211083	DIODE	SILICO	018		21793	211083
CR26	211083	DIODE	SILICO	018		21793	211083
CR27	211083	DIODE	SILICO	018		21793	211083
CR28	211083	DIODE	SILICO	018		21793	211083
CR29	211083	DIODE	SILICO	018		21793	211083
CR30	211083	DIODE	SILICO	018		21793	211083
CR31	211083	DIODE	SILICO	018		21793	211083
CR32	211083	DIODE	SILICO	018		21793	211083
CR33	211083	DIODE	SILICO	018		21793	211083
CR34	211083	DIODE	SILICO	018		21793	211083
CR35	211083	DIODE	SILICO	018		21793	211083
CR36	211083	DIODE	SILICO	018		21793	211083
CR37	211083	DIODE	SILICO	018		21793	211083
CR38	211083	DIODE	SILICO	018		21793	211083
CR39	211083	DIODE	SILICO	018		21793	211083
CR40	211083	DIODE	SILICO	018		21793	211083
CR41	211083	DIODE	SILICO	018		21793	211083

403430 – Assy., PCB, DISPLAY *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
CR42	211083	DIODE SILICO 018	21793	211083
CR43	211083	DIODE SILICO 018	21793	211083
CR44	211083	DIODE SILICO 018	21793	211083
CR45	211083	DIODE SILICO 018	21793	211083
CR46	211083	DIODE SILICO 018	21793	211083
CR47	211083	DIODE SILICO 018	21793	211083
CR48	211083	DIODE SILICO 018	21793	211083
CR49	211083	DIODE SILICO 018	21793	211083
C1	120230	CAP POLY .015 MFD 33 V 1%	08257	KSC Series
M1	230034	INTEGRATED CIRCUIT SN74141N	01295	SN74141N
M2	230072	INTEGRATED CIRCUIT SN7474N	01295	SN7474N
M3	230035	INTEGRATED CIRCUIT SN7473N	01295	SN7473N
M4	230030	INTEGRATED CIRCUIT SN7402N	01295	SN7402N
M5	230028	INTEGRATED CIRCUIT SN7400N	01295	SN7400N
M6	230074	INTEGRATED CIRCUIT SN7442N	07716	SN7442N
M7	230029	INTEGRATED CIRCUIT SN7401N	01295	SN7401N
M8	230030	INTEGRATED CIRCUIT SN7402N	01295	SN7402N
M9	230029	INTEGRATED CIRCUIT SN7401N	01295	SN7401N
M10	230073	INTEGRATED CIRCUIT SN7405N	01295	SN7405N
Q1	200087	TRANS SILICO 021	21793	200087
Q2	200087	TRANS SILICO 021	21793	200087
Q3	200087	TRANS SILICO 021	21793	200087
Q4	200087	TRANS SILICO 021	21793	200087
Q5	200087	TRANS SILICO 021	21793	200087
Q6	200087	TRANS SILICO 021	21793	200087
Q7	200087	TRANS SILICO 021	21793	200087
Q8	200087	TRANS SILICO 021	21793	200087
Q9	200087	TRANS SILICO 021	21793	200087
Q10	200087	TRANS SILICO 021	21793	200087
Q11	200087	TRANS SILICO 021	21793	200087
Q12	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q13	200037	TRANS SILICO NPN 2N3646	80131	2N3646
Q14	200087	TRANS SILICO 021	21793	200087
R1	000514	RES CARBON 510 K 5% 1/4W	81349	RC07GF514J
R2	000433	RES CARBON 43 K 5% 1/4W	81349	RC07GF433J

403430 – Assy., PCB, DISPLAY *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R3	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R4	000514	RES	CARBON	510 K		5% 1/4W	81349	RC07GF514J
R5	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R6	000514	RES	CARBON	510 K		5% 1/4W	81349	RC07GF514J
R7	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R8	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R9	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R10	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R11	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R12	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R13	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R14	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R15	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R16	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R17	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R18	000433	RES	CARBON	43 K		5% 1/4W	81349	RC07GF433J
R19	000203	RES	CARBON	20 K		5% 1/4W	81349	RC07GF203J
R20	000432	RES	CARBON	4.3 K		5% 1/4W	81349	RC07GF432J
R21	000432	RES	CARBON	4.3 K		5% 1/4W	81349	RC07GF432J
R22	000302	RES	CARBON	3 K		5% 1/4W	81349	RC07GF302J
R23	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R24	000432	RES	CARBON	4.3 K		5% 1/4W	81349	RC07GF432J
R25	000432	RES	CARBON	4.3 K		5% 1/4W	81349	RC07GF432J
R26	000432	RES	CARBON	4.3 K		5% 1/4W	81349	RC07GF432J
R27	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R28	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R29	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R30	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R31	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R32	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R33	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R34	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R35	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R36	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R37	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R38	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R39*	010568	RES	METAL	1.54 K	T-2	.25% 1/4W	81349	RN55C
R40	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R41	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R42	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J

*In 50 Hz units, R39 is:

R39	010555	RES	METAL	1.82 K	T-2	1%	81349	RN55C1821F

403430 – Assy., PCB, DISPLAY *continued*

REF DES	DANA P/N	DESCRIPTION	FSC	MANU P/N
R43	000512	RES CARBON 5.1 K 5% 1/4W	81349	RC07GF512J
R44	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R45	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R46	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R47	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R48	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
R49	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R50	000102	RES CARBON 1 K 5% 1/4W	81349	RC07GF102J
R51	000621	RES CARBON 620 OHM 5% 1/4W	81349	RC07GF621J
R52	000103	RES CARBON 10 K 5% 1/4W	81349	RC07GF103J
S1	600675	SWITCH ROTARY 600675	21793	600675
S2	600674	SWITCH ROTARY 600674	21793	600674

403436 – Assy., PCB, PROGRAM

REF DES	DANA P/N	DESCRIPTION						FSC	MANU P/N
CR1	211083	DIODE	SILICO			018		21793	211083
CR2	211083	DIODE	SILICO			018		21793	211083
CR3	211083	DIODE	SILICO			018		21793	211083
CR4	211083	DIODE	SILICO			018		21793	211083
CR5	211083	DIODE	SILICO			018		21793	211083
CR6	211083	DIODE	SILICO			018		21793	211083
CR7	211083	DIODE	SILICO			018		21793	211083
CR8	211083	DIODE	SILICO			018		21793	211083
CR9	211083	DIODE	SILICO			018		21793	211083
C1	101099	CAP	CERAM	680 PFD			10%	71471	SCD2X5F
C2	110152	CAP	TANTA	.47 MFD		50 V	10%	05397	T368A474K050AS
C3	110148	CAP	TANTA	.22 MFD		50 V	10%	05397	T368A224K050AS
C4	110153	CAP	TANTA	.27 MFD		50 V	10%	05397	KR27P50K
C5	121091	CAP	MYLAR	.033 MFD		100 V	10%	09023	WMF1S33
C6	100017	CAP	CERAM	.01 MFD		100 V	20%	56289	TG-S10
C7	100017	CAP	CERAM	.01 MFD		100 V	20%	56289	TG-S10
J3	920460	INTEGRATED CIRCUIT SOCKET				14 PIN			CA-14CS-TSD
J4	920460	INTEGRATED CIRCUIT SOCKET				14 PIN			CA-14CS-TSD
M1	230029	INTEGRATED CIRCUIT				SN7401N		01295	SN7401N
M2	230029	INTEGRATED CIRCUIT				SN7401N		01295	SN7401N
M3	230029	INTEGRATED CIRCUIT				SN7401N		01295	SN7401N
M4	230064	INTEGRATED CIRCUIT				SN7404N		01295	SN7404N
M5	230064	INTEGRATED CIRCUIT				SN7404N		01295	SN7404N
M6	230073	INTEGRATED CIRCUIT				SN7405N		01295	SN7405N
M7	230028	INTEGRATED CIRCUIT				SN7400N		01295	SN7400N
M8	230032	INTEGRATED CIRCUIT				SN7420N		01295	SN7420N
M9	230030	INTEGRATED CIRCUIT				SN7402N		01295	SN7402N
M10	230029	INTEGRATED CIRCUIT				SN7401N		01295	SN7401N
Q1	200037	TRANS	SILICO	NPN		2N3646		80131	2N3646
Q2	200136	TRANS	SILICO	NPN		2N5963		81349	2N5963
Q3	200136	TRANS	SILICO	NPN		2N5963		81349	2N5963
Q4	200136	TRANS	SILICO	NPN		2N5963		81349	2N5963
Q5	200136	TRANS	SILICO	NPN		2N5963		81349	2N5963
Q6	200136	TRANS	SILICO	NPN		2N5963		81349	2N5963
Q7	200088	TRANS	SILICO	PNP		2N4248		80131	2N4248
Q8	200037	TRANS	SILICO	NPN		2N3646		80131	2N3646

403436 – Assy., PCB, PROGRAM *continued*

REF DES	DANA P/N	DESCRIPTION					FSC	MANU P/N
R1	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R2	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R3	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R4	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R5	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R6	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R7	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R8	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R9	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R10	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R11	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R12	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R13	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R14	000512	RES	CARBON	5.1 K		5% 1/4W	81349	RC07GF512J
R15	000102	RES	CARBON	1 K		5% 1/4W	81349	RC07GF102J
R16	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R17	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R18	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R19	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R20	000202	RES	CARBON	2 K		5% 1/4W	81349	RC07GF202J
R21	000392	RES	CARBON	3.9 K		5% 1/4W	81349	RC07GF392J
R22	000432	RES	CARBON	4.3 K		5% 1/4W	81349	RC07GF432J
R23	000432	RES	CARBON	4.3 K		5% 1/4W	81349	RC07GF432J
R24	000101	RES	CARBON	100 OHM		5% 1/4W	81349	RC07GF101J
R25	010650	RES	METAL	1 M		1%	81349	RN55E
R26	010676	RES	METAL	15 K		1%	81349	RN55C1502F
R27	010529	RES	METAL	10 K	T-0	1%	81349	RN55D
R28	000105	RES	CARBON	1 M		5% 1/4W	81349	RC07GF105J
R29	010697	RES	METAL	26.7 K		1%	81349	RN55D
R30	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R31	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R32	000242	RES	CARBON	2.4 K		5% 1/4W	81349	RC07GF242J
R33	000432	RES	CARBON	4.3 K		5% 1/4W	81349	RC07GF432J
R34	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R35	000103	RES	CARBON	10 K		5% 1/4W	81349	RC07GF103J
R36	000123	RES	CARBON	12 K		5% 1/4W	81349	RC07GF123J

CHASSIS-MOUNTED PARTS

REF DES	DANA P/N	DESCRIPTION				FSC	MANU P/N
J203	600619	RECEPTACLE		POWER	EAC-301	82389	EAC-301
J204	600673	CONN	REAR INPUT		TKR7-101	05574	TKR7-101
K8	310096	RELAY	FRONT/REAR		R10-E2033-1	24796	R10-E2033-1
Q32	200130	TRANS	SILICO	NPN	MJE-3055	04713	MJE-3055
S8	920457	SWITCH	FRONT/REAR		GF-126	79727	GF-126
S9	600583	SWITCH	POWER		26-099-100	10389	26-099-100
T4	300059	TRANSFORMER		POWER	11615	23095	11615