OPERATING & MAINTENANCE MANUAL
FOR
MODEL 225
DIGITAL PHASE ANGLE VOLTMETER

NAI TM 5001

NOTE

THE FOLLOWING FREQUENCIES ARE
INCLUDED IN THIS MANUAL:
400Hz, 19.2KHz

CIRCUITS IN THIS INSTRUMENT ARE COVERED UNDER
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STATUS OF CHANGE PAGES

Following is a list of all pages in this manual, their change status and the date of change. A zero (0) in the Change Status column indicates an original issue. Changed text is indicated by a vertical bar in the margin. Changed illustrations are indicated by a vertical bar next to the title.

Original - June 1981
Change 1 - November 1981
Change 2 - February 1982
Change 3 - May 1982
Change 4 - July 1982
Change 5 - February 1983
Change 6 - June 1983

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5-12, 5-13	0	7-17	C5	8-7/(8-8)	C5	D-12, D-13	C2
5-14	C6	7-18	0	8-9/(8-10)	0	D-14	0
5-15	0	7-19	C1	8-11 thru (8-14)	C5	D-15	C1
5-16	C6	7-20, 7-21	C5	8-15	C1	D-16	0
5-17	C5	7-22	0	8-16, 8-18	0	D-17	C6
5-18	C2	7-23 thru 7-25	C6	8-19	C5	E-1/(E-2)	0
5-19 thru 5-22	0	7-26	0	8-20, 8-21	0	F-1	0
5-23, 5-24	C6	7-27, 7-28	C5	8-22	C6	F-2	C3
5-25	C2	7-29	C4	8-23, 8-24	0	F-3, F-4	0
5-26	0	7-30	0	A-1/(A-2)	0	G-1	C6
5-27	C5	7-31	C6	B-1, B-2	0	G-2 thru G-4	C5
5-28 thru 5-30	0	7-32, 7-33	C6	B-3	C1		

CAUTION

High voltage exists at several points in the instrument. Normal precautions with good practice should be taken to reduce shock hazard.

A potential shock hazard exists when ungrounded power source or ungrounded case operation is employed. Persons operating the instrument should be made aware of and take precautions against this condition.

North Atlantic Industries, Inc. cannot be held responsible for damage to person or property in the process of or as a result of maintenance, calibration, or setting up of the instrument.

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MODEL 225 (NAI TM 5001) - Product Revision Sheet 7 August 1983

A. PCRS COVERED BY THIS PRS: 22958

B. ASSEMBLIES AND REV LEVELS AFFECTED:

Main Board 500869, Rev KW2 and up

C. PURPOSE:

To meet autorange specification for low frequency.

D. CHANGES:

1. In the main board parts list, change C85 from NAI P/N 807392 (4.7uf, 20V) to NAI P/N 883783 (22uf, 35V).

2. In figure 8-2 (sheet 2), change C85 from 4.7uf to 22uf.

A. PCRS COVERED BY THIS PRS: 23122

B. ASSEMBLIES AND REV LEVELS AFFECTED:

Main Board 500869, Rev KY1 and up

C. PURPOSE:

To meet DC offset requirements.

D. CHANGES:

1. In the main board parts list, change R274 from NAI P/N 803389 (10M ohm) to NAI P/N 807102 (7.5M ohm).

2. In figure 8-2 (sheet 5), change R274 from 10M ohm to 7.5M ohm.

Make the following changes to the Model 225 Operating and Maintenance Manual.

Replace paragraph 3.3.7 with the following:

3.3.7 Null Meter Application

The null meter provides a more precise and convenient method of detecting null voltage than reading the digital display. Not only is the indication more stable, but as the signal voltage approaches zero, the sensitivity of the null meter is greatly increased. The null meter is operative in Total, Fundamental, Inphase, and Quadrature modes. Selecting the mode and the frequency to be measured will automatically engage the null circuit. Refer to paragraphs 3.3.1 to 3.3.4 for mode operation and setup.

Nulling may be accomplished from either direction; deflection to the right of zero indicates positive voltage and deflection to the left indicates either negative inphase or negative quadrature voltage.

NOTE

Because the null meter operates in quadrature and inphase modes, it will be engaged whenever reference offset or variable scale is engaged. The meter operation will be affected by the setting of the reference offset or variable scale potentiometer, as will the readout. (Refer to paragraph 3.3.6 and appendix F.)

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SECTION 1

GENERAL DESCRIPTION

1.1 GENERAL

This manual contains a general description, installation and operating instructions, theory of operation, maintenance and troubleshooting procedures, parts lists, and schematics for the Digital Phase Angle Voltmeter, Model 225 (herein after referred to as the DPAV).

1.2 PHYSICAL DESCRIPTION

The DPAV (fig. 1-1) is housed in a 5-7/32-inch rack panel. It is designed to be rack mounted or used on a desk top.

1.3 FUNCTIONAL DESCRIPTION

The DPAV is a completely solid state instrument, combining the ability to measure both phase angle and magnitude of complex ac signals and vector components with respect to a reference input.

An automatic gain control (AGC) circuit, in the reference channel, eliminates the necessity for manual adjustment of the proper level of operation. It accepts and controls signal levels from 200 mV to 200 V rms automatically.

The reference channel isolation feature enables the reference input voltages to float with respect to the circuitry ground, maintaining its independent AGC action.

The primary objective of the DPAV is to measure the following parameters of an ac signal:

- Total - Dc average of the input signal scaled in rms. This voltage includes the fundamental, all harmonics, and noise.
- Fundamental - Signal voltage at the center signal frequency.

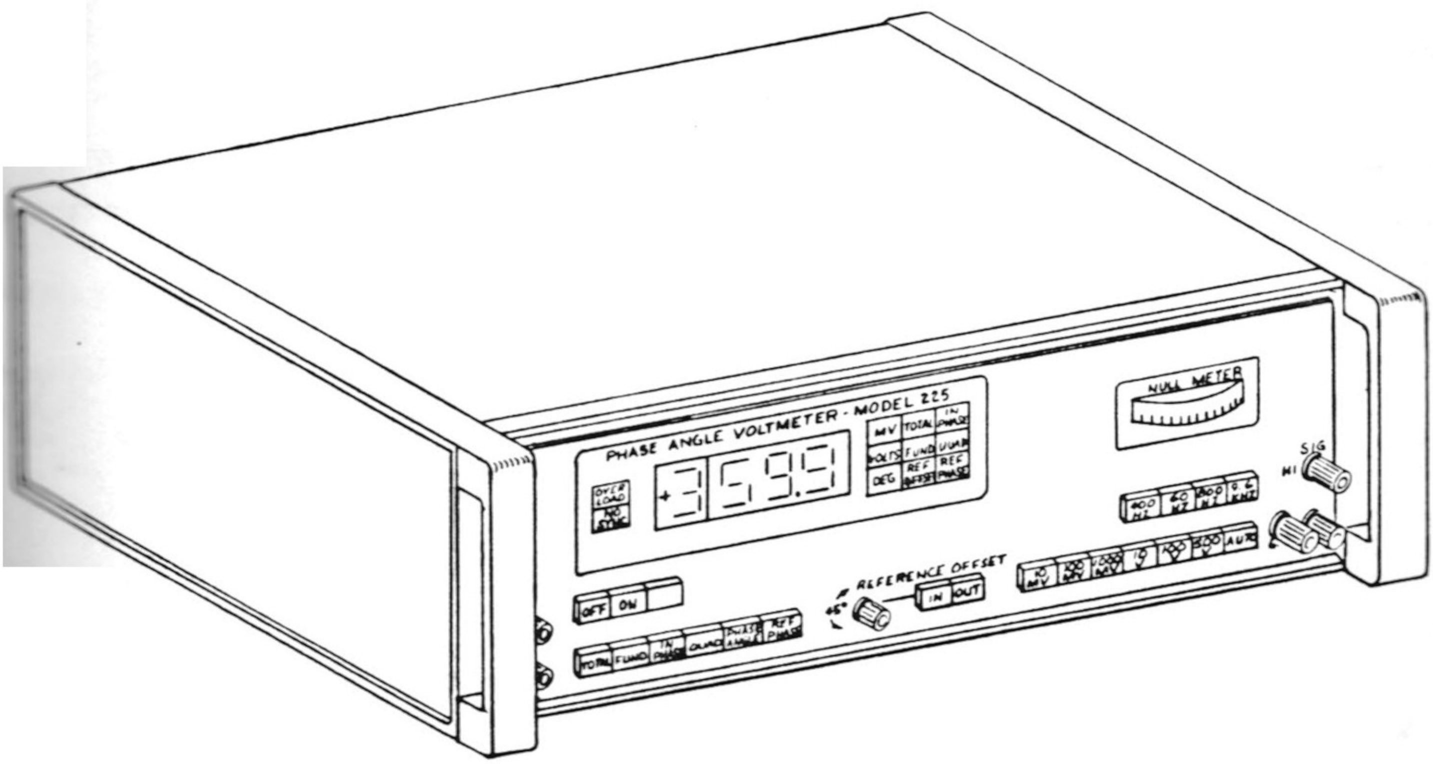


Figure 1-1. Digital Phase Angle Voltmeter, Model 225

- Inphase (0°, 180°) - The magnitude of the signal vector voltage inphase with a reference voltage at the reference frequency.

- Quadrature (90°, 270°) - The magnitude of the signal vector voltage 90° out-of-phase with a reference voltage at the reference frequency.

- Phase - The phase shift, in degrees, by which the signal voltage leads the reference voltage. Phase angle is measured by a unique (patent pending) type of signal processing (TAN^{-1} GO™) angle computation.

- Reference phase - Measures and displays, in degrees, the amount the reference is phase shifted.

- Reference offset - With the IN pushbutton depressed, a reference phase offset is produced, the magnitude of which is controlled by the knob setting. The range is ±45%. The amount of offset can be read when the DPAV is in REF PHASE mode.

Front-panel controls permit easy selection of functions and six input signal ranges from 10 millivolts through 500 volts and autoranging.

The null meter gives the operator an advantage of the relative magnitude and direction of the voltage the DPAV is measuring.

The DPAV responds from 26 Hz to 54 kHz phase-sensitive frequency range. Up to four frequencies can be incorporated per unit.

The seven segment, 1/2-inch-high planar Beckman display provides an easy to read, wide-viewing angle readout. Range, function, and warning lights are also displayed.

The signal channel isolation feature enables the signal input voltage to float with respect to the circuitry ground. Common mode voltage amplitude is frequency dependent.

1.4 SPECIFICATIONS

Table 1-1 provides electrical and mechanical specifications for the DPAV.

1.5 CONFIGURATION

Table 1-2 lists the units comprising the DPAV.

Table 1-1. Specifications

Item	Specification
Voltage range	10 mV to 1000 V rms in six ranges (120% over-range)
Maximum signal input	500 V rms ±400 Vdc (max)
Reference voltage range	0.2 V to 200 V rms, AGC (no adjustment necessary) (±50 V dc max.)
Signal autoranging	Up-ranges at 120% of range. Down-ranges at 10% of range. 330 ms per range change.
Display	0.55-inch Beckman display
Voltage	4-1/2 digits, 0.01% full range resolution
Phase	+0.0° to +359.9° phase lead, 0.1° resolution
Frequency range	
TOTAL mode	26 Hz to 100 kHz
FUND, IN PHASE, QUAD, and ANGLE modes	1, 2, 3, or 4 frequencies from 26 Hz to 54 kHz ±5% bandwidth

Table 1-1. Specifications (Continued)

Item	Specification		
Warm-up time	0.5 hour, for rated accuracy		
Voltage accuracy*	Accuracy (23° ±5°C)		Temp. Coef. (0° to 18°C, 28° to 50°C)
Total mode (isolated)			
26 Hz to 10 kHz	0.25% FS		0.01%/°C
10 kHz to 30 kHz	0.5% FS		0.02%/°C
30 kHz to 100 kHz	1% FS		0.04%/°C
FUND and Phase sensitive modes			
26 Hz to 60 Hz	0.05% FS +0.1% rdg		(0.003% FS +0.01% rdg)/°C
60 Hz to 1.5 kHz	0.05% FS +0.07% rdg		(0.003% FS +0.005% rdg)/°C
1.5 kHz to 20 kHz	0.1% FS +0.15% rdg		(0.004% FS +0.012% rdg)/°C
20 kHz to 32 kHz	0.15% FS +0.2% rdg		(0.005% FS +0.016% rdg)/°C
32 kHz to 54 kHz	0.30% FS +0.6% rdg		(0.010% FS +0.050% rdg)/°C
Phase accuracy			
(Phase Angle and Reference Phase modes)	Accuracy (23° ±5°C)	Arc Tangent**	Temp. Coef. 0° to 18°C, 28° to 50°C
26 Hz to 60 Hz	0.25° ±½ LSB	0.2°	0.15°/°C
60 Hz to 5 kHz	0.2° ±½ LSB	0.13°	0.01°/°C
5 kHz to 20 kHz	0.25° ±½ LSB	0.2°	0.015°/°C
20 kHz to 32 kHz	0.35° ±½ LSB	0.3°	0.02°/°C
32 kHz to 54 kHz	0.75° ±½ LSB	0.7°	0.04°/°C
Harmonic rejection (Fundamental and Phase-sensitive modes)	2nd and 3rd harmonic is 40 to 70 db dependent on frequency. All other harmonics vary with frequency and harmonic order.		

Item	Inphase		Quadrature	
Common mode rejection*** (10 mV range)	0 ohm	100 ohm	0 ohm	100 ohm
26 Hz to 5 kHz (min.)	126 db	100 db	126 db	87 db
5 kHz to 32 kHz (min.)	100 db	92 db	106 db	71 db
400 Hz (typ.)	132 db	126 db	132 db	114 db
32 kHz to 54 kHz (min.)	91 db	83 db	97 db	62 db

Item	Specification
Signal input impedance	10 MΩ shunted, typically, by 75 pf (140 pf with option 07 and 08)
Reference input impedance	500 kΩ shunted, typically, by 25 pf (71 pf with option 07 and 08)
Response time to rated accuracy****	
Phase-sensitive and angle modes	1.5 s, typical; 6 s, maximum
Total modes	1.5 s, typical; 10 s, maximum

Table 1-1. Specifications (Continued)

Item	Specification
Power requirements	115/220 V rms ±15%, 45 to 440 Hz, ±30 Va fused for 1 A at 115 V rms; 1/2 A at 220 V rms
Dimensions	5-1/4"H x 16-3/4"W x 18-1/2"D
Weight	30 pounds (max.)

*Accuracy at zero input in the voltage measurement modes, is defined as the % FS statement in the various specifications. Total mode, 10 mV range, noise specification is 35 μV.

**For signal level above 30% FS.

***Rejection is nominal at upper end of frequency band and is generally higher at lower frequencies. 300 V rms maximum common-mode voltage. Source impedance in signal high lea

****Maximum response time occurs under worst case conditions of mode selection, input overload, and autoranging.

Table 1-2. DPAV Configuration

Name	Part number	Reference designation
Main board	500869	A4
A/D converter	783591-4	A2
Readout board	783590-1 or -2	A3
Signal broadband isolation board	783602-2	
Reference isolation board	783601-2	
Frequency board (2)	783599-	
Null meter	783672	
IEEE interface*	783778, 783777	
Remote control digital output*	783603	
Variable scale adjust*	783707	
Ratio Mode*	783688, 783689, 783690	

*Optional units

1.6 REAR PANEL LABEL FEATURE CODE EXPLANATION

Table 1-3.provides an explanation for the features listed on the rear panel label.

Table 1-3. Rear Panel Label Feature Code Explanation

No.	Feature Description	Option
F1	Input power line voltage	1. 115V 2. 230V
F2	Digital output interface	1. None (local) 2. Remote control & digital output 3. IEEE 488

Table 1-3. Rear Panel Label Feature Code Explanation (Continued)

No.	Feature Description	Option
F3	Rear signal and reference input	1. Terminal strips 2. MS connectors
F4	Mode	1. Standard - non ratiometer 2. Ratiometer 3. Variable scale adjust 4. Variable scale adjust, ratiometer 5. Variable scale adjust, IEEE 6. Variable scale adjust, IEEE, ratiometer
F5	Additional frequencies required (first frequency is 400 Hz)	0. None 1. One 2. Two 3. Three

NOTE: F10-F14 are internal codes for frequencies and ratios specified.

SECTION 2

INSTALLATION

2.1 GENERAL

This section provides instructions for unpacking, inspecting, installing, and checkout of the DPAV.

2.2 UNPACKING

The DPAV is shipped in a cardboard container with the unit cushioned by foam to avoid damage during shipment. Unpack the unit as follows:

a. Place the cardboard container with the shipping label on the top.

b. Cut tapes in the center and two sides to open the top flaps.

c. Remove the top foam cover to expose the unit.

d. Remove the unit from the container.

2.3 INSPECTION

a. Check the contents of the shipping container against the shipping list.

b. Check for damage to the outside surface of the unit and notify the carrier if it is damaged.

c. Unscrew and open the top cover. Check that all cards and modules are in place.

d. Check that nothing is loose or disconnected in the unit.

2.4 INSTALLATION

The DPAV is designed for use on a desk top, bench, or rack mounted. An outline drawing of the DPAV is shown in figure 2-1. The DPAV requires no special cooling equipment. However, the unit should be placed in such a way as to allow free flow of air around it.

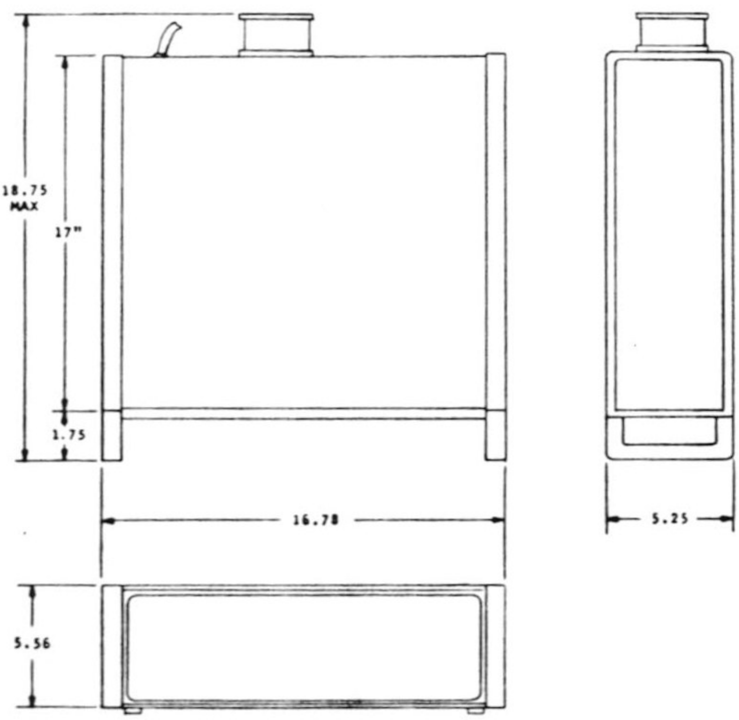


Figure 2-1. DPAV Outline Drawing

2.5 CHECKOUT

After installation, perform the checkout procedure in Section 5 (para. 5.3).

2.6 POWER REQUIREMENTS

The DPAV operates from either 115 V rms (1 A fuse) or 220 V rms (1/2 A fuse), 45 Hz to 440 Hz. The operating line voltage is selected by switch S1 on the power supply (fig. 2-2).

2.7 GROUNDING

The DPAV chassis ground (fig. 2-2) and the power line ground are connected to the screw securing capacitor C88 to the power supply (1, fig. 2-2). The circuit ground (2, fig. 2-2) is connected to the CKT GRD terminal on the rear panel. Both grounds can be connected together by a link (LUG) on the rear panel or externally in the test setup. Caution should be taken whenever the power line ground is disconnected.

Normal DPAV operation is with the link installed on the rear panel. When the link is removed, these two points must be hooked together externally in the test set up.

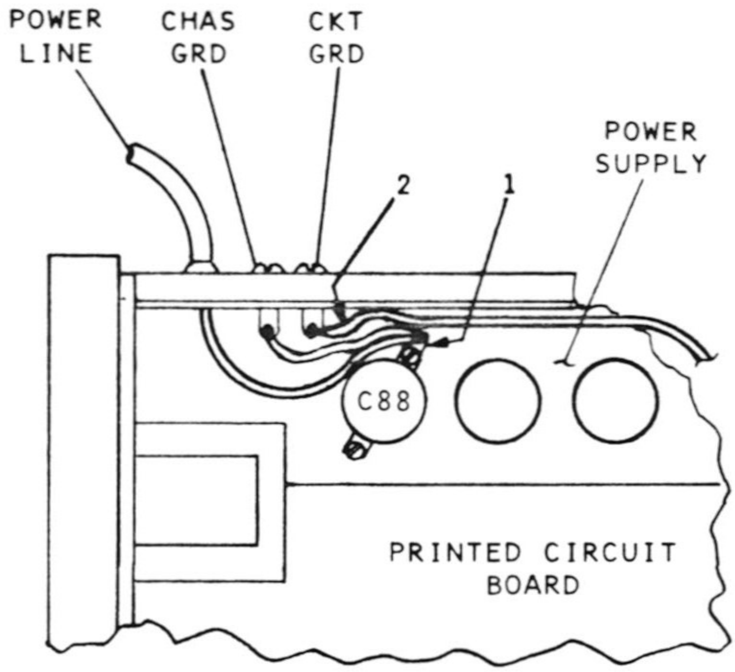


Figure 2-2. Grounding

SECTION 3

OPERATION

3.1 GENERAL

The DPAV provides a digital readout display of the fundamental component of an input signal, the inphase and quadreature voltage components of a signal with respect to a reference voltage, and the phase angle between a signal and a reference voltage, all at any one of four frequencies and in the range of 0 to 500 volts ac. (The frequencies shown in figure 3-1 are only typical.) The DPAV also functions as a total voltmeter over the frequency of 26 Hz to 100 kHz and the voltage range of 0 to 500 volts ac.

3.2 CONTROLS AND INDICATORS

Table 3-1 describes and figure 3-1 illustrates the DPAV controls and indicators.

Table 3-1. Controls and Indicators

Key (fig. 3-1)	Control/indicator	Function
1	NO SYNC lamp (DS13)	Illuminates in absence of reference signal or when reference frequency differs from selected frequency by more than 5%, or, in fundamental mode, if no signal is present.
2	OVER LOAD lamp (DS12)	Flashes when input voltage level exceeds 1.2 times selected scale.
3	Digital Readout display (DS1)	Displays a single digit, 0-9, a one, or a + or a -.
4	Digital Readout display (DS2)	Displays a three digit readout, 0-9.
5-11, 16, 18	Function and Range Selection displays (DS3-DS11)	Display selected mode of operation and unit of measurement.
12	NULL METER (M1)	Provides sensitive means for detecting null voltages.
13	Frequency Range push buttons* (S6) F1, F2, F3, F4	Selects frequency of signal to be measured (in all modes except TOTAL).
14	Voltage Scale push buttons (S1) 10 MV, 100 MV, 1000 MV, 10 V, 100 V, 500 V, AUTO	Permit selection of meter scale ranges. In AUTO, automatic range selection provides appropriate range scale. The correct range is also selected automatically when DPAV is operated in Phase Angle mode.
15	IN-OUT push buttons (S2)	When IN switch depressed, permits phase shifting of reference voltage from 0° by using REFERENCE OFFSET potentiometer.
17	REFERENCE OFFSET potentiometer (R134)	With IN switch depressed, permits ±45° phase shifting of reference voltage.

* F represents a customer specified frequency.

Table 3-1. Controls and Indicators (Continued)

Key (fig. 3-1)	Control/indicator	Function
19	Function Selector push buttons (S3)	Select mode of operation.
	TOTAL	Permits measurement of signal rms value of sinusoidal inputs with harmonics and noise.
	FUND	Permits measurement of fundamental vector of input signal.
	IN PHASE	Permits measurement of inphase vector component of input signal with respect to a reference voltage.
	QUAD	Permits measurement of quadrature vector component of input signal with respect to a reference voltage.
	PHASE ANGLE	Permits measurement of phase angle in degrees by which signal input voltage leads reference voltage.
	REF PHASE	Permits measurement of phase angle in degrees by which reference signal is shifted by REFERENCE OFFSET potentiometer.
20	Power OFF-ON push button (S5)	Permits application of primary power to DPAV.
20	Power OFF-LOCAL-REM push button	Permits local or remote operation (Option -12)
21	IEEE LED*	Lights when DPAV is addressed (Option -12).
22	SCALE ADJUST INPUT push button and control*	Permits unit to operate in scale adjust mode and allows 0 to 100% full scale vernier (optional).
23	RATIO X10^{-2} and X10^{-5} LEDs*	Ratiometer mode indicators (optional).
	REF HI-LO connectors (front and rear)	Permit application of reference signal input.
	SIG HI-LO-GND connectors (front and rear)	Permit application of signal to be measured.
	DC RECORDER output (rear only)	Dc output

*Optional

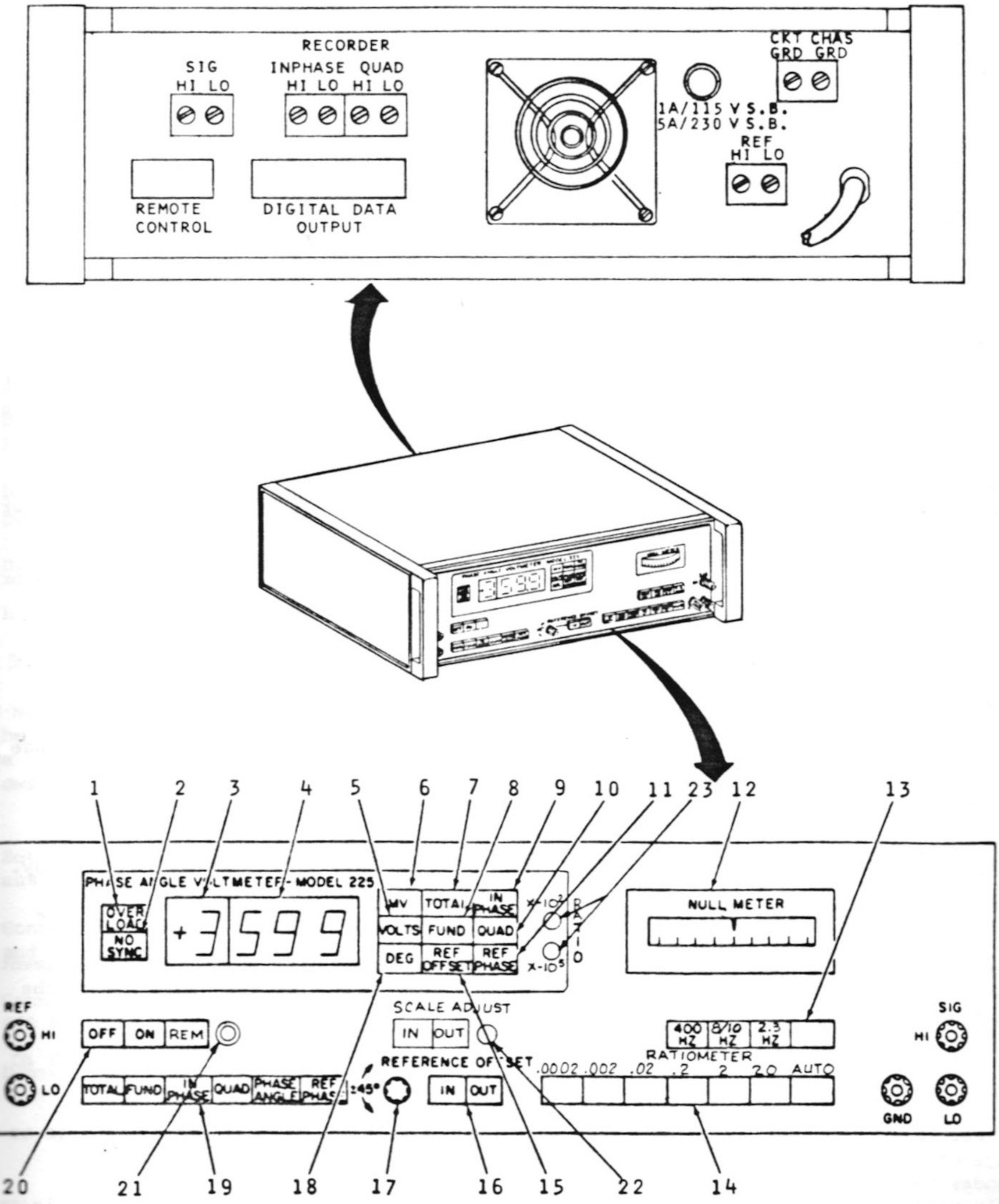


Figure 3-1. DPAV Controls and Indicators

3.3 OPERATING PROCEDURES

Prior to operating DPAV, observe the following precautions:

a. The DPAV chassis is connected to the round ground pin of the three prong power plug. Normal operation of the instrument is with the internal circuit ground connected to chassis ground. Depending on the application, this can be done by a rear panel link or externally in the measurement set-up. Take extreme caution in any special application where the DPAV chassis is not connected to the house ground.

b. Ensure that power cord is properly connected to power source.

c. For more accurate measurements, allow DPAV to warm up for one-half hour. This is accomplished by depressing ON push button.

NOTE

With no input to the DPAV (SIG HI and LO terminals not shorted) the DPAV display will indicate an overload or some voltage when on the lower ranges (10 to 100 MV). This condition is normal and represents a true measurement of stray fields capacitively coupled to the input. Shielding the input by using shielded leads will replace this coupling to a minimum.

Five modes of operation are available at any of four fixed frequencies. The first frequency is 400 Hz. Three additional frequencies can be specified. The five modes are Fundamental, Inphase, Quadrature, Phase Angle, and Reference Phase. Total mode will measure any input from 26 Hz to 100 kHz.

The first three modes of operation measure voltage of an ac input signal; the last two modes measure phase angle. The measurable voltage ranges from 0 volts to 500 volts rms. All controls (except for the REFERENCE OFFSET potentiometer (R134) are front panel push button switches.

3.3.1 Total Mode

This mode permits rms-scaled measurement of the total sinusoidal input signal with its harmonics and noise. Proceed as follows:

a. Depress appropriate Voltage Scale or AUTO push button.

b. Depress TOTAL push button.

c. Read indication on Digital display.

3.3.2 Fundamental Mode

This mode permits rms-scaled measurement of the fundamental vector of the input signal with harmonics and noise filtered. Proceed as follows:

a. Connect ac input signal to be measured to SIG HI and LO connectors.

b. Depress appropriate Voltage Scale or AUTO push button.

NOTE

Signal must be greater than 1% of full scale.

c. Depress appropriate Frequency Range push button.

d. Depress FUND push button.

e. Read indication on digital display.

3.3.3 Inphase Mode

This mode permits rms-scaled measurement of the inphase vector component of the input signal. Proceed as follows:

a. Connect reference voltage to REF HI and LO connectors.

b. Connect ac signal to be measured to SIG HI and LO connectors.

c. Depress appropriate Voltage Scale or AUTO push button.

d. Depress appropriate Frequency Range

push button.

e. Depress IN PHASE push button.

f. Read indication on digital display.

3.3.4 Quadrature Mode

This mode permits rms-scaled measurement of the quadrature vector component of the input signal. Proceed as follows:

a. Connect reference voltage to REF HI and LO connectors.

b. Connect ac input signal to be measured to SIG HI and LO connectors.

c. Depress appropriate Voltage Scale or AUTO push button.

d. Depress appropriate Frequency Range push button.

e. Depress QUAD push button.

f. Read indication on digital display.

3.3.5 Phase Angle Mode

This mode permits measurement, in degrees, of the amount the input signal voltage leads the reference voltage. Proceed as follows:

NOTE

Both reference and signal voltages must be of the same frequency.

a. Connect reference voltage to REF HI and LO connectors.

b. Connect ac input signal voltage to SIG HI and LO connectors.

c. Depress appropriate Frequency Range push button.

d. Depress PHASE ANGLE push button.

e. Read indication on digital display.

3.3.6 Reference Phase Mode

This mode permits measurement, in degrees, of the amount of phase shift of the reference voltage. Proceed as follows:

a. Connect reference voltage to REF HI and LO connectors.

b. Depress appropriate Frequency Range push button.

c. Depress REF PHASE push button.

d. Depress REFERENCE OFFSET IN push button.

e. Rotate REFERENCE OFFSET potentiometer until desired reference phase offset (maximum ±45°) is achieved as indicated on digital display.

3.3.7 Null Meter Application

The null meter provides a more precise and convenient method of detecting null voltage than reading the digital display. Not only is the indication more stable, but as the signal voltage approaches zero, the sensitivity of the null meter is greatly increased. The null meter is operative in Total, Fundamental, Inphase, and Quadrature modes. Nulling may be accomplished from either direction; deflection to the right of zero indicates positive voltage and deflection to the left indicates either negative inphase or negative quadrature voltage. No other front panel push buttons need be depressed.

SECTION 4

THEORY OF OPERATION

4.1 GENERAL

This section provides theory of operation for the DPAV. The theory is written to a functional diagram. Schematics are included in Section 8 for reference.

4.2 BASIC THEORY

The basic measurement task of the phase-sensitive voltmeter can be described in terms of the time domain equation of a sinusoidal voltage containing harmonics and noise, and phase shifted from a reference sinusoidal by θ degrees as follows:

$$E_S = E_1 \sin(\omega t + \theta) + E_2 \sin 2\omega t + E_3 \sin 3\omega t + \ldots + E_n \sin n\omega t + N(t)$$

See figure 4-1 for a vector diagram of the fundamental voltage. The DPAV measures the polar coordinates (E_1 and θ) and the cartesian coordinates ($E_1 \cos\theta$ and $E_1 \sin\theta$) of the input voltage represented as a vector. Effects of harmonics and noise are rejected. The basic phase-sensitive vector voltages are extracted by a process of demodulation and are in the form of dc voltages. The same result could be obtained by multiplication. What follows is a mathematical model of the multiplication of voltages which is the effective equivalent of the demodulation process actually employed. Consider the following trigonometric identities:

$$\sin(x+y) = \sin x \cos y + \cos x \sin y \quad (1)$$
$$\sin(x-y) = \sin x \cos y - \cos x \sin y \quad (2)$$

By adding equations (1) and (2) and then dividing both sides by 2, equation (3) is obtained:

$$\sin x \cos y = \tfrac{1}{2}\sin(x+y) + \tfrac{1}{2}\sin(x-y) \quad (3)$$

If $x = \omega t + \theta$ and $y = \omega t$, and by multiplying through by E_1, equation (4) is obtained.

$$E_1 \sin(\omega t+\theta) \sin \omega t = \frac{E_1}{2} \sin\theta + \frac{E_1}{2} \sin(2\omega t+\theta) \quad (4)$$

The dc component which results from multiplying the unknown input to be measured, $E_1 \sin(\omega t + \theta)$, by a voltage equal to $\sin \omega t$ is $E_1 \sin\theta$. Now consider the trigonometric identities:

$$\cos(x+y) = \cos x \cos y - \sin x \sin y \quad (5)$$
$$\cos(x-y) = \cos x \cos y + \sin x \sin y \quad (6)$$

From this, equations (7) and (8) are obtained:

$$\sin x \sin y = \tfrac{1}{2}\cos(x-y) - \tfrac{1}{2}\cos(x+y) \quad (7)$$
$$E_1 \sin(\omega t+\theta) \sin \omega t = \frac{E_1}{2}\cos\theta - \frac{E_1}{2}\cos(2\omega t)+\theta \quad (8)$$

The dc component which results from multiplying the unknown input by $\sin \omega t$ is $\frac{E_1}{2}\cos\theta$; $\frac{E_S}{2}\sin\theta$ is proportional to the quadrature component and $\frac{E_S}{2}\cos\theta$ is proportional to the inphase component. The cartesian coordinates of the fundamental voltage, therefore, are referred to as the "inphase" and "quadrature" vector components of the input. In the Total mode, a measurement of the average of the rectified input is made. All voltages are calibrated in rms.

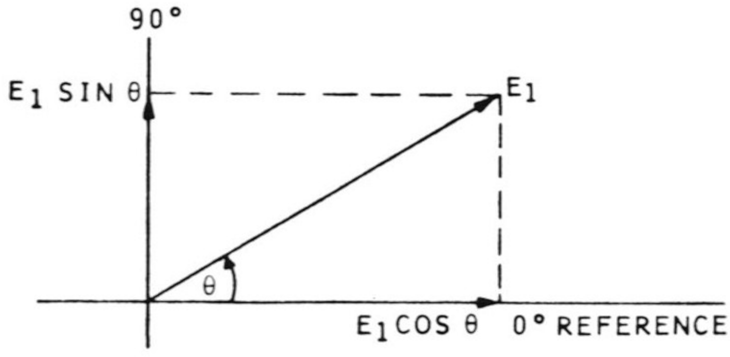


Figure 4-1. Vector Diagram of Fundamental Voltage

4.3 BLOCK DIAGRAM DISCUSSION

A simplified block diagram of the DPAV is shown in figure 4-2. The following is a general description of the function of each

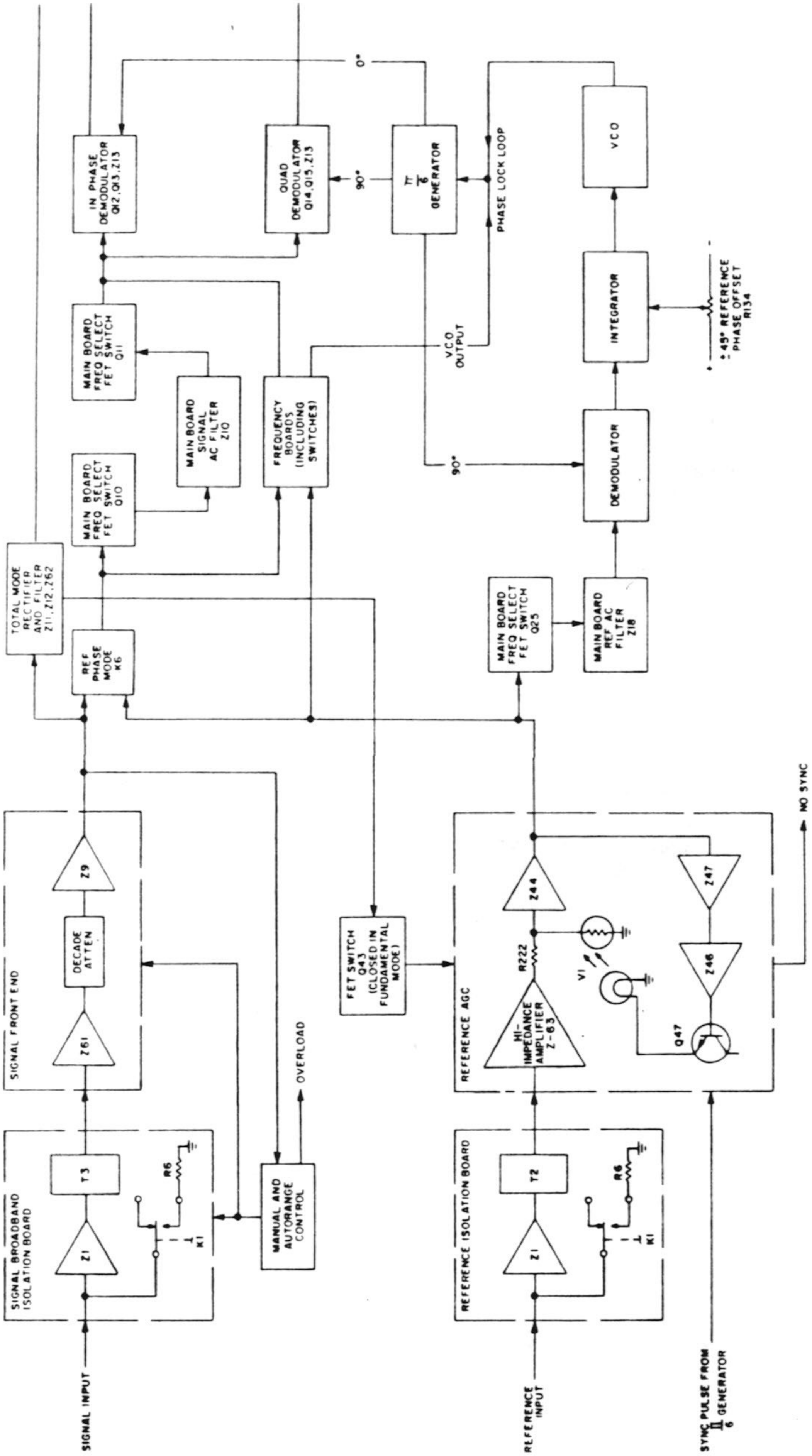


Figure 4-2. DPAV Block Diagram (Sheet 1 of 2)

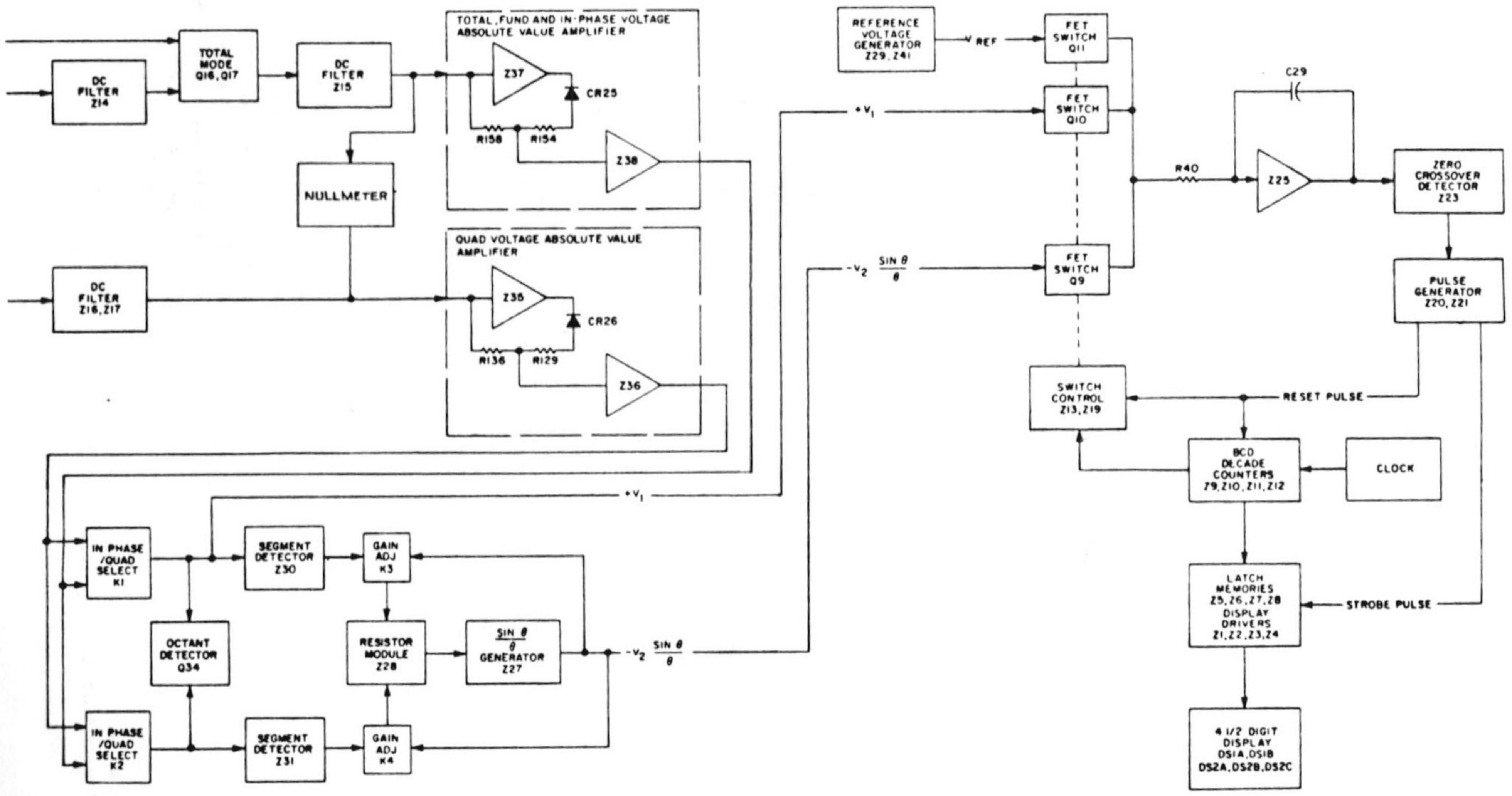


Figure 4-2. DPAV Block Diagram (Sheet 2 of 2)

major circuit block and its interrelation with the other blocks.

4.3.1 Signal Broadband Isolation Board

The signal broadband isolation board isolates signal ground from chassis ground and, with relay K1 closed, provides 1000:1 attenuation. After buffer Z1 has provided impedance transformation and amplification, signal and chassis ground may be connected by a rear panel link. If front panel SIG LO connector jack is connected to GND connector jack, the signal ground will acquire the potential of the chassis ground. If signal ground and chassis ground are connected by the rear panel link, but not by the front panel connector jacks, the chassis ground will acquire the potential of the signal ground. The signal broadband isolation circuit offers overload protection capable of handling 500 V rms on any range.

4.3.2 Signal Channel Front End

The signal channel front end consists of two amplifiers, Z61 and Z9, and a decade attenuating circuit which operates under the control of the autoranging circuit to apply 1:1, 10:1, or 100:1 attenuation, depending upon the range selected. Amplifier Z61 has a gain of 1.67 in any of the four voltage modes and a gain of 5.58 in either angle mode. The higher gain is employed to provide the maximum gain without distortion required in making phase angle measurements. Buffer amplifier Z9 has a gain of 14.7.

4.3.3 Autoranging Circuit

The range changing is controlled by either front panel switches or an autoranging loop which uses the output of Z9 as the sense signal. Ranging occurs at 10% and 120% of full scale.

4.3.4 Signal AC Filter

Analog filtering of the ac signal is accomplished by the two-pole active filter made up of Z10 and its associated resistors and capacitors. As will be shown later, most of the effective filtering will be done in the chopping (demodulating) section. The chief filtering requirement is the attenuation of the fifth harmonic of the input. The actual filter attenuation of the fifth harmonic is roughly 14 dB. The ac voltage gain of the filter is approximately 7.3. Since there is a phase shift in this filter (roughly +150°) and any phase difference between signal and reference channels is a source of error, an identical filter is placed in the reference channel (Z18). The 400 Hz filter is located on the main board. Additional sets of filters are contained in the frequency plug-in cards and are switched in corresponding to the front panel frequency range select switches.

4.3.5 Signal Channel Demodulators

As has been mentioned, the key process in phase-sensitive instrumentation is demodulation (alternately shown as multiplication, detection, chopping, etc.) Whereby dc voltages proportional to the in-phase and quadrature components of the signal input are generated. The in-phase demodulator is made up of two shunt switching transistors. Transistor Q13 demodulates the ac signal coming directly from the ac filter output and Q12 demodulates the inverted ac filter output, thus implementing a full-wave demodulation. The equivalent takes place in the quadrature channel where Q15 and Q14 are the switching transistors. The signals operating the switching transistors are referred to as $\pi/6$ signals because of their waveshapes and duty cycles (fig. 4-3.) The switching signals operating the in-phase channel are in phase with the output of the signal channel ac filter. Those operating the quadrature channel are 90° out of phase with this voltage. These switching waveforms are derived from the $\pi/6$ generator portion of the phase lock loop. The resultant signals are fed to the dc filters.

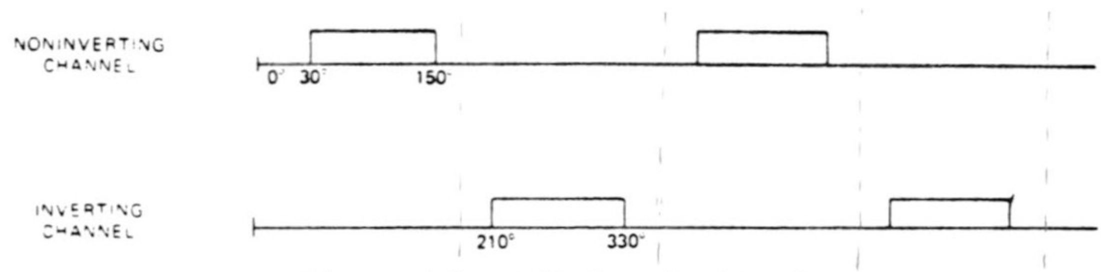


Figure 4-3. π/6 Chopping Waveforms

4.3.6 Signal Channel DC Filters

The inphase dc filter is made up of Z14 and Z15 and associated resistors and capacitors to form a three-pole Bessel filter (fastest rise time filter configuration). The quadrature dc filter is made up of Z16 and Z17 stages. Their full scale output is 8.75 V dc which goes to the A/D converter board for conversion. The second stage of the inphase filter (Z15) is also used in the total mode.

4.3.7 Total Mode Rectifier

The operational amplifier rectifier, made up of Z11 and associated circuitry, converts the signal from Z9 output to a proportional dc voltage. Z12 is a single-pole filter which feeds into the second stage of signal channel dc filter Z15. This total mode rectified voltage is a measure of the combined effects of all components in the ac signal; that is, fundamental, noise, and harmonics.

4.3.8 Reference AGC

The function of this section is to deliver a constant amplitude, zero phase-shifted reference signal to the phase lock loop, independent of reference input amplitude variations between 0.2 V and 200 V rms. To achieve this, with very low phase-shift variations over the frequency range, a combination of a relay-controlled (RC) attenuator and a photocell attenuator is used. The RC attenuator is located on the reference broadband isolation board. With relay K1 open, the input attenuation is 0.157. This condition corresponds to inputs between 0.2 V and 6.3 V rms, approximately. With K1 closed, the attenuation is increased to 0.00506. This condition corresponds to inputs between 6.3 V and 200 V rms, approximately. (Using this configuration, eliminates the need for protection circuitry since buffer Z1 is always in series with the input.) A high impedance amplifier, consisting of Z63 and associated circuitry, feeds the photocell attenuator made up of R222 and V1. The ac voltage on the photocell is stabilized by the feedback control loop made up of Z46, Z47, and Q47 driving the bulb of the photocell. Z44 is a high-impedance buffer amplifier which feeds the phase lock loop and the AGC feedback loop. Z44 output is rectified by Z47 and fed to Z46 which performs integration and servo compensation. Z46 drives Q47, which drives the bulb to close the loop.

4.3.9 Reference Phase Lock Loop, π/6 Chop

The only function of the reference phase lock loop is to provide 0° and 90° chopping signals for the signal channel demodulators. As mentioned, the advantages of this approach are:

- Allows the use of a π/6 chopping waveform over the ±5% bandwidth, providing filtering.
- Ease of generating a substantially error-free 90° chopping signal over the ±5% bandwidth.

The reference input to the loop passes through ac filter Z18, which is identical to that in the signal channel. The signal level out of the filter is about 4.6 V peak-to-peak. The full-wave demodulator is identical to those in the signal channel, two shunt choppers Q27 and Q30, and inverter Z19. The pertinent output of the demodulator is a dc current into integrator Z7, which drives the voltage controlled oscillator (VCO), feeding a pulse train into the $\pi/6$ chopper. This pulse train is 12 times the frequency of the reference. By a process of counting and gating, the $\pi/6$ chopper generates the proper waveforms which feed the demodulator and thus close the feedback loop. If the reference sinusoidal input is represented as $Er \sin \omega t$ (disregarding the balanced phase shift through the ac filter) and the chopping waveform as $\cos (\omega t + \delta)$, where δ is a phase error, then the error current into the integrator is:

$$E = K1 \sin \delta + K2 \sin (2 \omega t + \delta)$$

The ac term is filtered by the integrator. Since the VCO generates a pulse rate output for a constant dc input, it also behaves as an integrator. Thus the loop is a second (double integration) feedback control system providing zero position error for a rate input. The phase lock loop rate input in cycles or radians per second; that is, frequency. The zero position error corresponds to zero phase difference between the input sinusoidal voltage and the chopping signals. Therefore, the loop will drive itself until sin = 0 or 0° corresponding to a constant dc voltage into the VCO, and zero error current into the integrator. The chopping signals are phase locked to the referenece input.

4.3.10 ±45° Reference Offset

Since the phase lock loop settles to a state of zero current into the integrator, if an offset current is injected into the integrator, an equal and opposite current will be generated by the demodulator. This demodulator current is the result of a phase difference between the reference sinusoid and the chopping signals. This phase offset covers a range of ±45° and is controlled by front panel potentiometer R134. The amount of phase offset can be read on the display in the reference phase mode.

4.3.11 Fundamental Frequency Operation

The DPAV used in fundamental frequency mode reads the total magnitude of the fundamental component, E1, of the selected frequency by making a phase-sensitive measurement using the signal as the reference. Phase angle θ is therefore equal to 0°. This is accomplished by using the signal voltage output of Z11 as the reference voltage. Z11 is the total mode rectifier and its output at pin 6 is equivalent to the signal input amplified by an open loop amplifier; that is, the signal here is a square wave in phase with the signal input at the input signal terminals of the DPAV. Thus, angle θ is 0°. This signal is switched into the reference channel in the fundamental mode by means of FET switches Q43, Q45, and Q46. This operation occurs when Q45 and Q46 are opened (thus disconnecting the input reference) and Q43 is closed. This feeds the signal into reference amplifier Z44. Thus, the phase angle between the signal and this derived reference is 0°. Looking at figure 4-1, the following equation is obtained:

$$E_1 = \sqrt{E_1{}^2 \cos^2 \theta + E_1{}^2 \sin^2 \theta}$$

substituting θ = 0°, the following is obtained:

$$E_1 = \sqrt{E_1{}^2 (1)^2 + E_1{}^2 (0)} = \sqrt{E_1{}^2} = E_1$$

The operation of the DPAV is then the same as if it were reading an inphase voltage with ± = 0°. The active filtering and the $\pi/6$ generator are thus used to provide an accurate reading of the fundamental frequency voltage.

4.3.12 Frequency Card Description

The components for the 400 Hz frequency are on the main board and the others on a plug-in card (one card per frequency). The signal processing is the same as previously described. The card contains:

- Signal and reference ac filters
- Phase lock loop demodulator, compensation, and VCO
- Enable-disable switches

4.3.13 A/D Converter and Readout Board

The lower main board can, in general terms, be described as an ac-to-dc voltage converter where total, fundamental, inphase, and quadrature components of the ac signal are converted to dc. The function of the A/D converter and readout section is to digitize and display dc voltage and to compute and display phase shift in degrees, using inphase and quadrature voltages.

The A/D converter board is a horizontal board located at the top front of the unit and contains analog voltage processing circuitry and part of the digitizing circuitry. The remaining digitizing circuitry is contained on the readout board along with the Beckman displays and the display bulbs. A single ribbon cable (J4) connects the main board to the A/D converter board. The readout board is connected to the A/D converter board by two ribbon cables (J1 and J2).

4.3.14 Absolute Value Amplifiers

The quadrature voltage is fed to an absolute value amplifier made up of Z37 and Z38. When this voltage is negative, diode CR25 is backbiased and the amplification is through Z38, yielding a positive voltage output. The nominal full range voltage input is 8.75 V dc and Z38 stage gain is nominally 1.09, yielding +9.5 V dc at the output. With a positive input voltage, diode CR25 is forward-biased and the negative output of Z37 is applied to Z38 through R154. Since R154 is one-half the value of R158, the gain to the negative input is twice that from the positive input. This results again in a positive output, producing the action of an absolute value amplifier. The total, fundamental, or inphase voltage is fed from the main board to the A/D converter board, depending on the mode of operation. The absolute value amplifier, made up of Z35 and Z36, operates the same as the quadrature channel.

4.3.15 Octant Detector

In the angle modes, during a portion of the digitizing cycle, the counters are loaded with either 0.0°, 90.0°, 180.0°, 270.0°, or 360.0° and are commanded to count either up or down. Each of the eight octants in the circle has a different command and is identified by the inphase polarity, quadrature polarity, and the voltage from octant detector Z34. This stage simply determines whether the inphase voltage exceeds the quadrature voltage or vice versa (Q28 provides hysteresis). The logic output, at Z26 pin 6, is designated OD and is at a logic 1 level when the inphase voltage is greater than the quadrature voltage.

4.3.16 Segment Detectors

The $\frac{\sin \theta}{\theta}$ voltage used in angle computations is generated by Z27 and Z28. The effect of Z28 on the $\frac{\sin \theta}{\theta}$ voltage is controlled by relays K3 and K4, which are controlled by segment detectors Z30 and Z31. For an input phase angle in the first octant, for example, relays K1 and K2 will be in the positions shown and the quadrature voltage ($\sin \theta$) will be applied to Z28 and Z25. The resistor dividers in front of Z30 and Z31 are such as to cause relays K3 and K4 to be de-energized if the phase angle is less than 23°. If the phase angle is between 23° and 35°, relay K3 is energized and K4 is de-energized. If it is between 35° and 45°, both K3 and K4 are energized.

4.3.17 DC Reference Voltage

The dc voltage standard is a temperature-compensated voltage regulator Z41 buffered by the noninverting amplifier Z29. The nominal voltage output is -9.5 V dc and is adjustable by trimpot R68. The dc voltages at Z29, Z27, and K1 are fed to the digitizer through switches Q11, Q9, and Q10 repectively.

4.3.18 Phase Angle Digitizing

The conversion of the inphase and quadrature dc voltages to degrees phase angle in digital form is accomplished by a combination of analog-to-digital signal processing. The technique for this A/D conversion uses a time-interval ratio measuring scheme with its attendant simplicity and accuracy, but in a new and unique way. It is essentially a dc resolver-to-digital converter, the resolver data being the inphase and quadrature components of the signal input. The analog-to-digital conversion is accomplished by the system shown on the block diagram. Typical waveforms are shown in figure 4-4. During a fixed time t_o, the input is switched to +V1 (K1), which is proportional in this mode to the quadrature voltage, sin θ. Thus, the ramp voltage at t_o is proportional to t_o sin θ. At t_o, the input is switched to -V2, which is proportional in this mode to a synthesized $\frac{\sin\theta}{\theta}$ (Z27) which ramps V1 (t) back to 0.0 V dc. Time periods t_o and t_m are quantized in the form of pulses from the clock. The known time t_o is generated by accumulating 10,000 pulses in the four-stage counter, starting from a zero reset state. When the 10,000th pulse is sensed, the input is switched from +V1 to -V2, which ramps V1 (t) back to zero volts. Z13, pins 3 and 6, is a set/reset flip-flop controlling the switching of +V1 and -V2. Zero crossover detector Z23 senses 0.0 V dc and does the following:

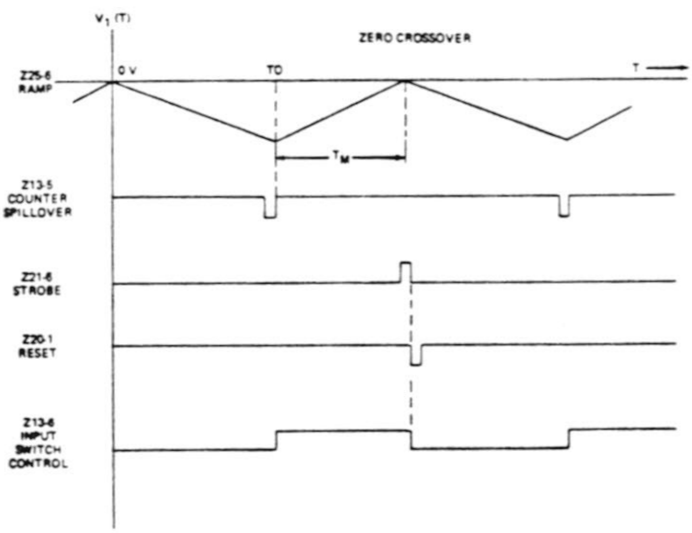


Figure 4-4. Digitizer Waveforms

- Strobes (Z21-6) the accumulated pulses (t_m) into the latch memory for display.
- Generates a reset pulse (Z20-1) delayed from the strobe pulse, which resets the counter to zero.
- Switches the input back to +V1 and the cycle repeats.

Since the voltage $\frac{\sin\theta}{\theta}$ is not available in an exact form, an approximation is synthesized, using the sin θ and cos θ dc voltages. At small angles, the cos θ approaches $\frac{\sin\theta}{\theta}$ and as θ increases, cos θ becomes smaller than $\frac{\sin\theta}{\theta}$. To compensate for this, a portion of the sin θ voltage is added to the cos θ voltage to bring it towards sin θ/θ. Thus,

$$\frac{\sin\theta}{\theta} = a \sin\theta + b \cos\theta, \text{ approximately}$$

As θ increases, the values of the coefficients a and b, of the above formula, must change to maintain accuracy. The final design covers a total range of 45° broken into three segments; that is, there are three different values for a and b, depending on the particular segment within the 45°. The first segment covers 0° to 23°, the second 23° to 35°, and the third 35° to 45°. The segment detectors shown in figure 4-2 determine which segment the input angle is in and make appropriate changes in the $\frac{\sin\theta}{\theta}$ generator. Since the approximation of $\frac{\sin\theta}{\theta}$ is used only over a 45° interval (excessive errors beyond 45°), in the second octant (45° to 90°), the following applies:

- Inphase and quadrature voltages are interchanged to implement the complementary function.
- At the end of the fixed period of ramping (t_o) 90.0° is loaded into the counters.
- The counters are placed in a count-down mode.

For example, if the input angle is 80°, the true inphase is 0.1737 and the true quadrature is 0.9848. These are reversed into the $\frac{\sin\theta}{\theta}$ generator and the A/D converter board which processes the equivalent of 10°. However, due to the 90.0° counter preset and the count-down command, the readout will be 80.0°, the correct value. Table 4-1 gives the configuration for each octant.

Table 4-1. Angle Mode Counter Control

Octant	Counter load	Count	Function
0-45°	0.0°	Up	Normal
45-90°	90.0°	Down	Complement
90-135°	90.0°	Up	Normal
135-180°	180.0°	Down	Complement
180-225°	180.0°	Up	Normal
225-270°	270.0°	Down	Complement
270-315°	270.0°	Up	Normal
315-360°	360.0°	Down	Complement

4.3.19 Voltage Digitizing

The digitizing of the dc voltages is accomplished by using the same techniques described above. During fixed time, t_o, the input is switched to +V1 (K1), which is proportional in this mode to the unknown dc voltage V_a (total, fundamental, inphase, or quadrature). At the end of the t_o interval, the input is switched to a precision reference voltage $-V_{ref}$ (Z29), which ramps V1 (t) voltage back to zero where the data is strobed out at zero crossover and the cycle repeats.

4.3.20 Readout Board

The readout board contains the display devices and digital circuitry used in the digitizer. The clock pulses (up and down) are applied to first BCD counter Z12 representing the least significant digit. Z8 is a 4-bit latch which stores the digital word in Z13 counter at strobe time. This 4-bit BCD number is fed to Z4 decoder-driver of the gas discharge displays. The count from Z12 spills to Z11, S10 and finally to the most significant digit (MSD) Z9. The latches, decoder-drivers, and associated displays operate in a fashion identical to that described for Z12. At the 10,000th pulse, Z9 pin 7 goes from logic 1 to 0 and is fed out to J1 pin 10 as a spillover to signal the end of the fixed time t_o, or to enable the over-range ½ digit through Z12 and Z11 on the A/D converter board.

4.3.21 Null Meter Circuit

In all four voltage modes, the dc analog voltages applied to the A/D converter board from the main board are also applied to the null meter. For measuring null voltage, the null meter is preferable to the digital readout because of its greater stability and sensitivity.

SECTION 5

MAINTENANCE

5.1 GENERAL

This section contains periodic maintenance, disassembly/assembly procedures, checkout calibration, and troubleshooting procedures for the DPAV.

CAUTION

A potential shock hazard exists when the unit is operated with ungrounded power source or case. Operators of this instrument should be aware of and take precautions against this condition.

5.2 REMOVAL AND REPLACEMENT

5.2.1 Replacement of Fuse

The power line fuse is located on the right side of the rear panel. It can be replaced by removing the fuse holder cap. For 115 V ac line operation, the fuse is a 1 A, Slo-Blo, Type 3 AG; for 230 V ac, it is 0.5 A, Slo-Blo, Type 3 AG.

NOTE

Throughout the following removal and replacement procedure the key numbers in parenthesis refer to figure 5-1.

5.2.2 Gaining Access to DPAV Interior

a. Remove five screws (1A) that secure top cover assembly (1) and remove top cover assembly.

b. Remove two screws (7A) and flip up A/D converter bracket (7) along with A/D converter (3) to gain access to main board (74) and rear of the A/D converter.

c. Loosen four screws and shift two printed card retainers to the outside in order to gain access to frequency boards for removal. This allows for removal of one frequency board to provide access to test points on other frequency boards during calibration.

d. Remove four screws (10A) and four screws (10B) that secure one side cover (10). Remove side cover. Repeat procedure for opposite side cover.

NOTE

At this point, entire unit is exposed for maintenance and calibration.

5.2.3 Removing A/D Converter

NOTE

Removal of A/D converter is only necessary when A/D converter bracket (7) structures obscure solder points to be accessed.

a. Using Scotchflex tool 3438, disconnect three cable assemblies J1 (green), J4 (red), and J2 (yellow) (46, 47, and 48) from wiring side of A/D converter board (3).

b. Remove two screws (7A) and two screws (8B) that secure A/D converter bracket (7) and remove two pivot spacers (8). Remove A/D converter bracket (7) with A/D converter (3).

c. Remove 10 screws (3A), 10 washers (3B), and 10 washers (3C) and remove A/D converter board (3) from A/D board bracket (7).

5.2.4 Accessing Main Board, Wiring Side

a. Remove four screws (12A) and four bumpers (12).

b. Remove screw (11A) and remove bottom cover (11).

NOTE

To remove readout board, null meter must be removed first.

5.2.5 Removing Null Meter

a. Using Augat tool T114-1, disconnect cable assembly W1 from main board (74).

INDEX NO.	PART
1 - 50	1
51 - 56	2
60 - 83	3
84 - 100	4
101 - 109	5

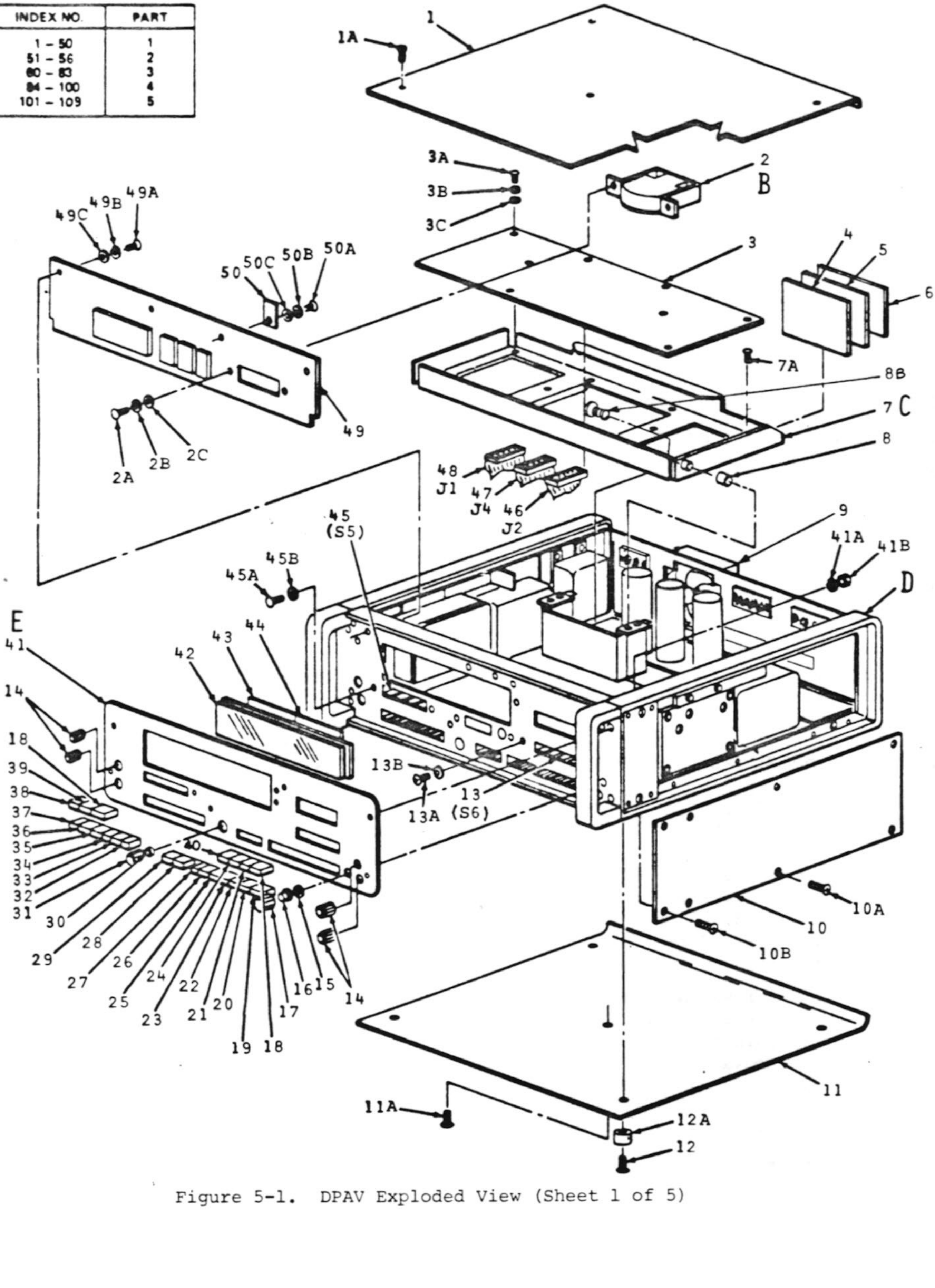
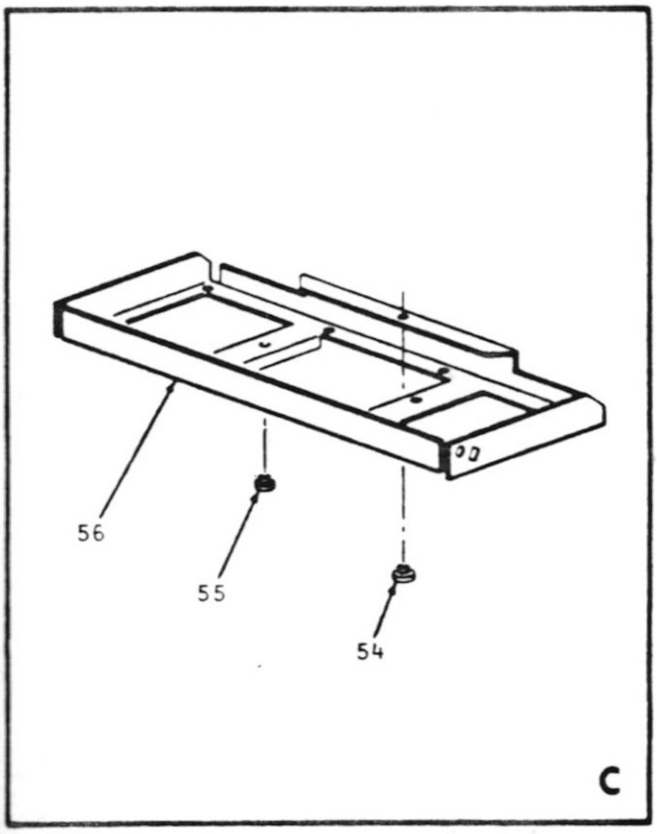
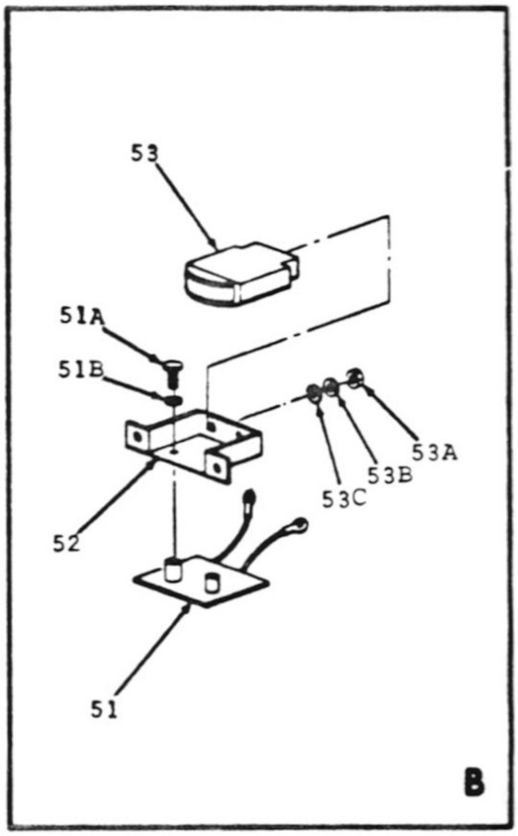


Figure 5-1. DPAV Exploded View (Sheet 1 of 5)





LEGEND

1. COVER, TOP
2. NULL METER
3. A/D CONVERTER
4. FREQUENCY BOARD
5. FREQUENCY BOARD
6. FREQUENCY BOARD
7. BRACKET, A/D CONVERTER
8. SPACER, PIVOT
9. FAN ASSEMBLY
10. COVER, SIDE
11. COVER, BOTTOM
13. SWITCH, 3 FREQUENCY
17. BINDING POST
18. BUTTON, F4
19. BUTTON, AUTO
20. BUTTON, 500 V
21. BUTTON, F3
22. BUTTON, 100 V
23. BUTTON, 10 V
24. BUTTON, F2
25. BUTTON, 1000 MV
26. BUTTON, 100 MV
27. BUTTON, 10 MV
28. BUTTON, OUT
29. BUTTON, IN
30. FERRULE, INNER
31. KNOB
32. BUTTON, REF PHASE
33. BUTTON, PHASE ANGLE
34. BUTTON, QUAD
35. BUTTON, IN PHASE
36. BUTTON, FUND
37. BUTTON, TOTAL
38. BUTTON, OFF
39. BUTTON, ON
40. BUTTON, F1
41. MARKING, PANEL
42. WINDOW, DISPLAY
43. DIFFUSER, LIGHT
44. DIFFUSER, LIGHT
45. SWITCH, PUSHBUTTON
46. GREEN CABLE
47. RED CABLE
48. YELLOW CABLE
49. READOUT BOARD
50. BUMPER, READOUT BOARD
51. NULL METER PC BOARD
52. BRACKET, NULL METER
53. METER, NULL
56. BRACKET, A/D CONVERTER
57. SUPPORT, LH
58. REFERENCE ISOLATION BOARD
59. SIGNAL BROADBAND ISOLATION BD.
60. SUPPORT, RH
63. FUSE
64. FUSEHOLDER
65. NAMEPLATE
66. NAMEPLATE
68. BRACKET, RH SIDE
69. BRACKET, RH PANEL
70. REFERENCE ISOLATION TRANSFORME
71. SUPPORT, RH SIDE
72. STIFFENER, PRINTED
73. SUPPORT, FRONT
74. MAIN BOARD
75. SIGNAL ISOLATION TRANSFORMER
76. TRIM, BOTTOM
77. HANDLE
78. SUB-PANEL
79. BRACKET, LH PANEL
80. SUPPORT, LH SIDE
81. BRACKET, LH SIDE
82. PLATE, TRANSFORMER
83. TRANSFORMER, POWER
84. TRIM, TOP
85. PANEL, FRONT
87. SUPPORT, RH & LH
92. BRACKET, RH & LH
95. CASE
96. TORROID
99. COVER
100. BRACKET, MOUNTING
102. BRACKET
103. SUPPORT, RH & LH

Figure 5-1. DPAV Exploded View (Sheet 2 of 5)

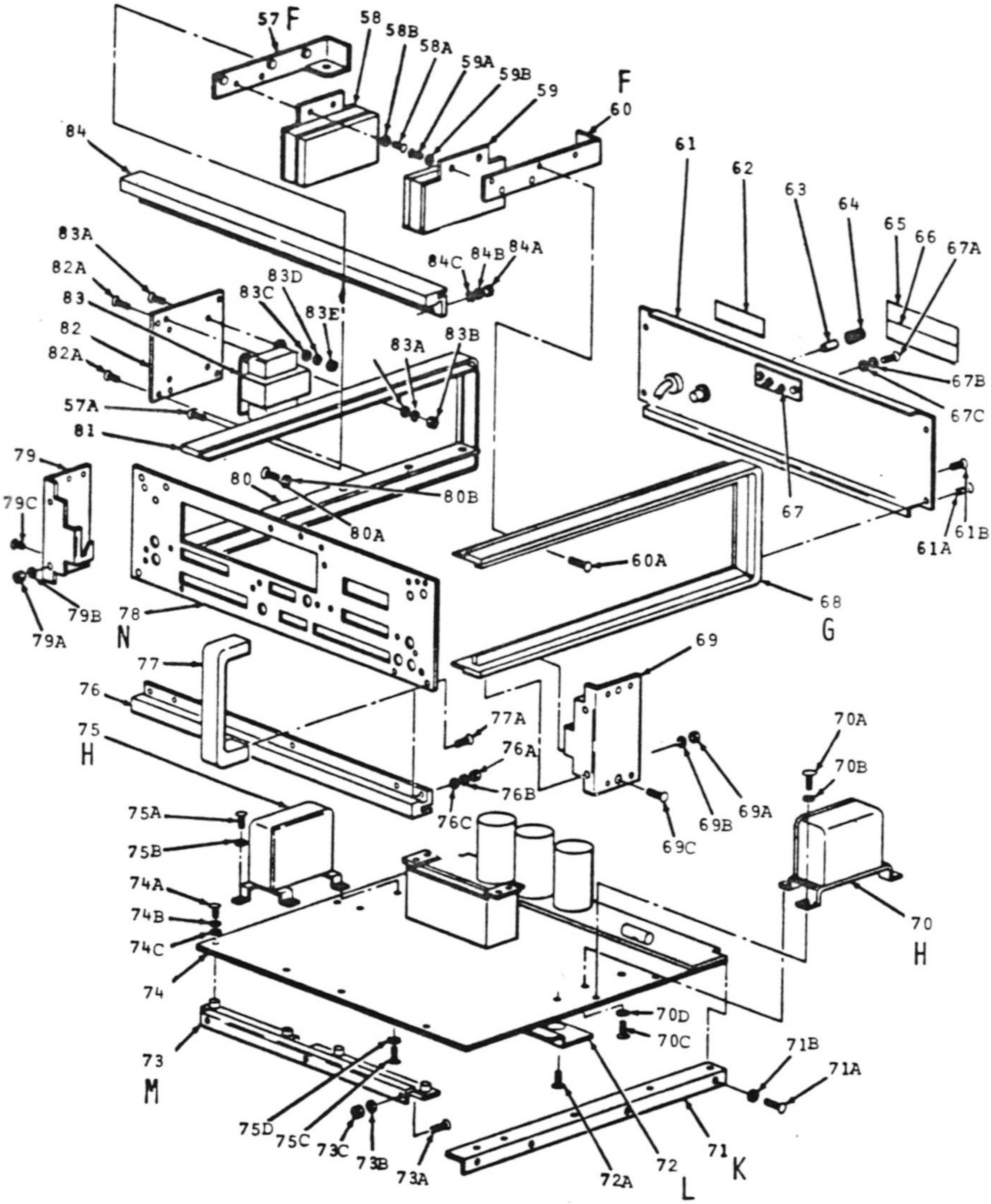


Figure 5-1. DPAV Exploded View (Sheet 3 of 5)

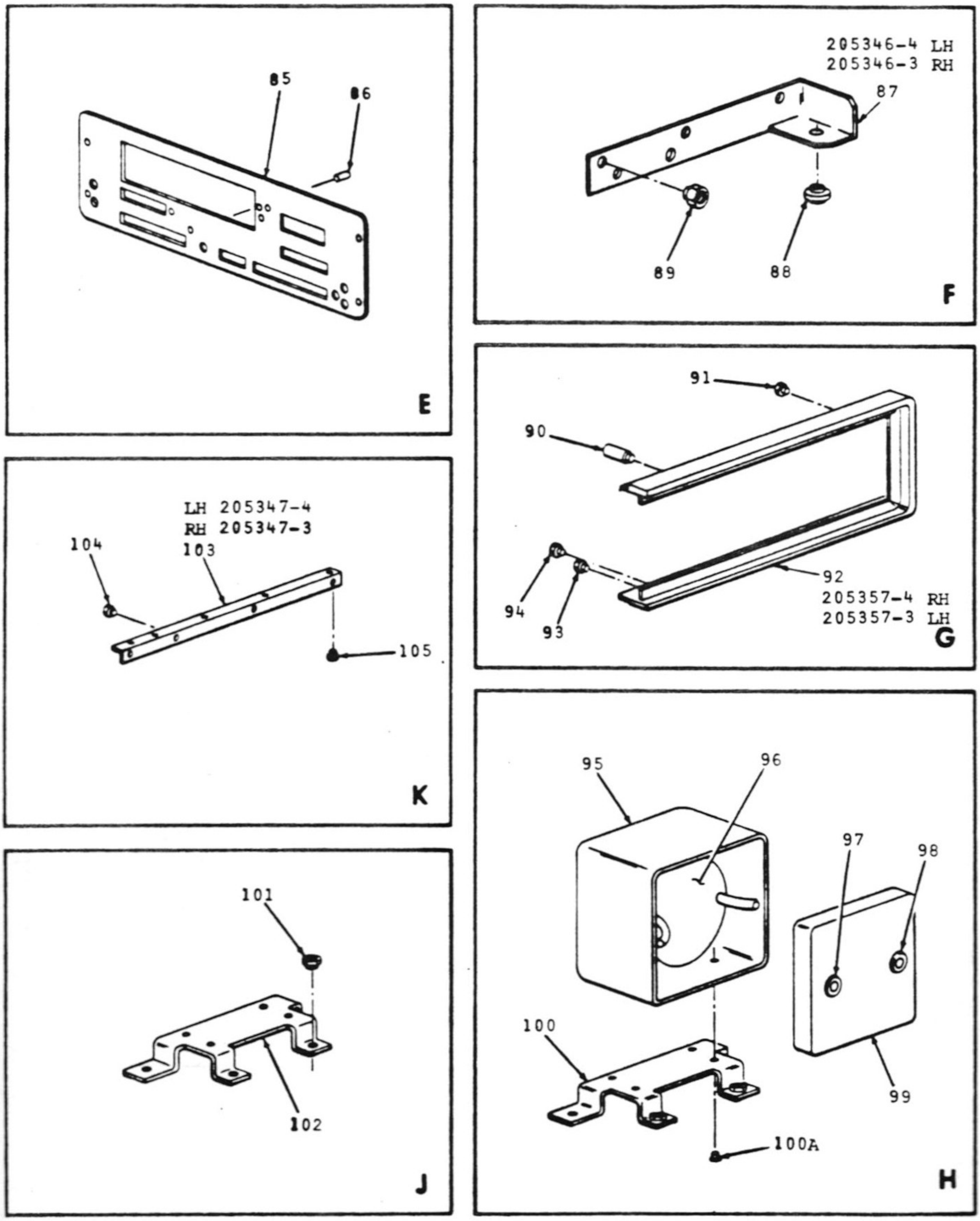


Figure 5-1. DPAV Exploded View (Sheet 4 of 5)

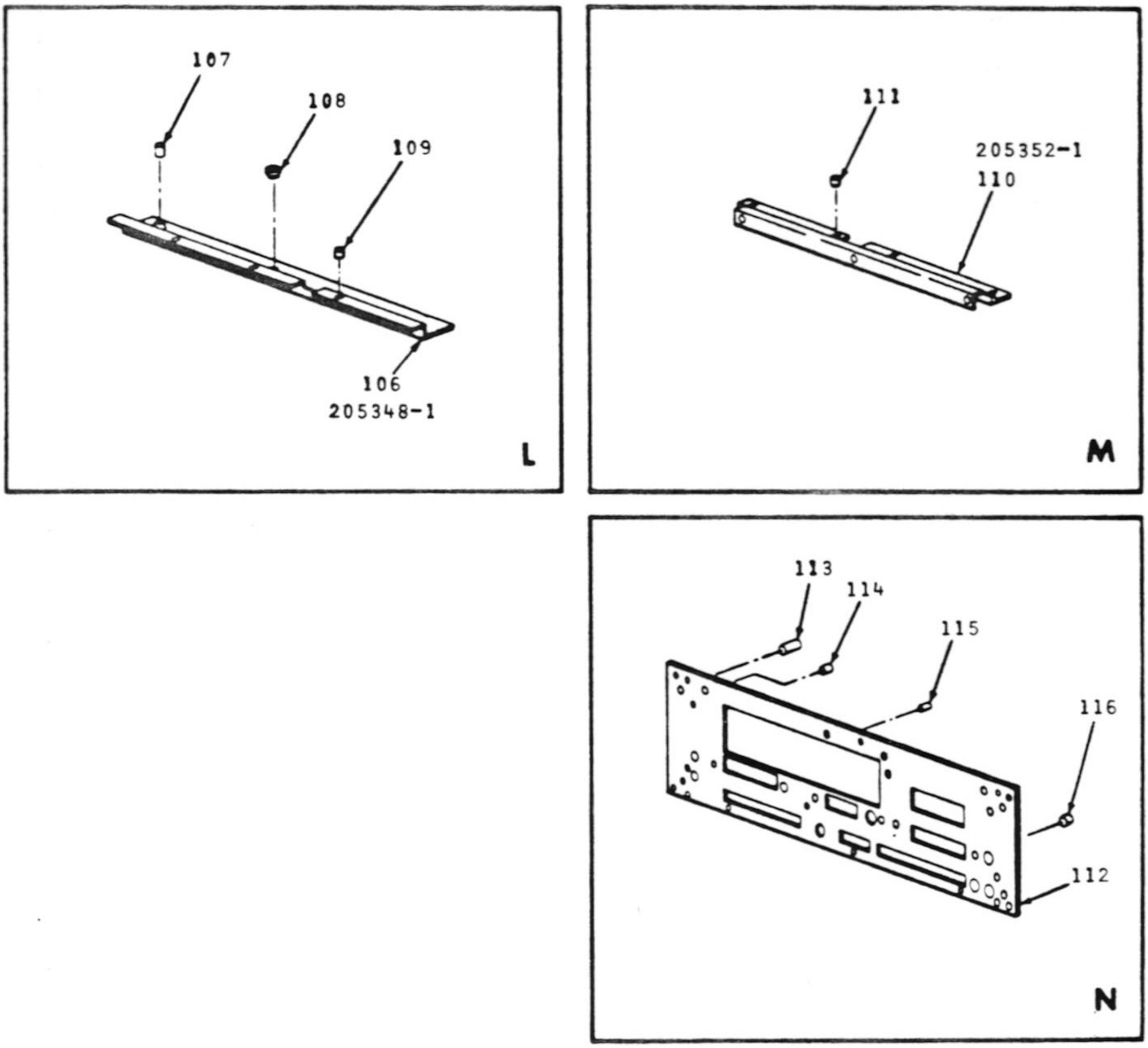


Figure 5-1. DPAV Exploded View (Sheet 5 of 5)

b. Remove two screws (2A), two washers (2B), and two washers (2C) that secure null meter (2) to readout board (49). Remove null meter (2).

c. Remove two screws (51A) and two washers (51B) and separate printed circuit board (51) from null meter (53).

d. Remove two nuts (53A), two washers (53B), and two insulated washers (53C). Remove printed circuit board (51) lugs from terminals of null meter (53).

5.2.6 Removing Readout Board

NOTE

If not already disconnected, use Scotchflex tool 3438 to disconnect cable assemblies J1 (green) and J2 (yellow) from A/D converter (3).

a. Remove two screws (50A) with two split lock washers (50B) and two washers (50C) that secure two bumpers (50) to readout board (49).

b. At ends of readout board, remove two screws (49A), with two split lock washers (49B) and two washers (49C) and remove readout board (49).

5.2.7 Removing Signal Broadband Isolation Board

a. Remove two screws (59A) and two washers (59B) that secure signal broadband isolation board (59). Unplug signal broadband isolation board.

b. Remove four screws and remove bottom cover that secures signal broadband isolation board. Remove signal broadband isolation board.

5.2.8 Removing Reference Isolation and Signal Isolation Transformers

a. Remove bottom cover two screws (112, 135, 73A, 72A), two screws (75A), and two washers (75B) that secure signal isolation transformer (75) to main board (74).

b. At main board (74), tag and unsolder wires from signal isolation transformer (75). Remove signal isolation transformer (75).

c. Repeat procedure for reference isolation transformer (70).

5.2.9 Removing Reference Isolation Board

a. Remove two screws (58A) and two washers (58B) that secure reference isolation board (58). Unplug reference isolation board.

b. Remove four screws and remove bottom cover (7) that secures board. Remove board.

5.2.10 Removing Power Transformer

a. At main board (74), unsolder color coded wiring coming from power transformer (83).

b. With DPAV rightside up, remove top two outer screws (82A), two split lock washers (83A), and two nuts (83B) that secure transformer mounting plate (82) to LH side bracket (68).

c. Turn DPAV upside down and remove remaining two outer screws (82A) that secure transformer mounting plate (82) to LH side bracket (68). Remove power transformer (83) with transformer mounting plate (82).

d. Remove four screws (82B), four split lock washers (83D), four washers (83C), and nuts (83E) that secure power transformer (83) to transformer mounting plate (82). Remove power transformer (83).

5.2.11 Removing Local Control Switch S5

a. Tag and unsolder two wires at local control switch (45).

b. Remove attaching hardware and remove local control switch.

5.2.12 Removing Frequency Switch S6

a. At main board (74), tag and unsolder wiring from frequency switch (13).

b. Remove attaching hardware and remove frequency switch (13).

5.2.13 Removing Fan

a. Remove connector from the fan (9) to the power transformer (83).

b. Remove four screws, four nuts, and four washers.

c. Remove fan guard.

d. Slide connector through rear panel and remove fan (9).

5.3 CLEANING

WARNING

Cleaning compound is toxic. Keep away from heat and open flame; the products of decomposition are toxic and extremely irritating. Use in a well ventilated area. Avoid inhalation and prolonged or repeated contact with skin.

a. Clean all machined metal parts by brushing briskly with MIL-C-81302, type I cleaning compound.

b. Wipe all metal parts with cleaning compound and wipe disconnected solder joints. Remove all traces of sealer from electrical contacts and contact surfaces of movable parts.

c. Air dry all cleaned components with filtered air not exceeding 10 psi pressure.

5.4 INSPECTION

Visually inspect the DPAV as indicated in table 5-1. Replace any components found defective. Refer to Section 7 (Parts List) for replaceable parts.

Table 5-1. Inspection Routine

Assembly	Check
Line power cable	Check input power cable for cracks, nicks, fraying, and loose connectors.
Chassis	a. Check for dirt and dust. b. Check all interconnecting wiring for cracks, nicks, fraying, and loose connectors.
Front panel	a. Check panel for general cleaniness. b. Check that all panel markings are legible. c. Check all push buttons for smooth and positive action. d. Check meters for broken or chipped plastic. e. Check all connectors for tightness.
Printed circuit and wiring boards	a. Check all boards for cracks and chips. b. Check printed circuit boards for damaged tracks. Check wiring boards for loose, and worn wires. c. Check components on boards for loose connections, improper seating, and signs of overheating and deterioration.
Cables	Check cables for signs of wear or damage.

5.5 ASSEMBLY

5.5.1 Replacing Frequency Switch S6

a. Solder wiring to frequency switch (13) and tag in accordance with paragraph 5.2.12 procedures for previously removed switch.

b. Install frequency switch (13) with attaching hardware.

c. Solder wiring from frequency switch (13) to main board (74) in accordance with tagged data.

5.5.2 Replacing Local Control Switch S5

a. Install local control switch (45) with attaching hardware.

b. Solder wiring from main board (74) to local control switch (45) in accordance with tagged data.

5.5.3 Replacing Power Transformer

a. Install power transformer (83) on transformer mounting plate (82) using four screws (82B), four split lock washers (83D), four washers (83C), and four nuts (83E).

b. Turn DPAV upside down and attach transformer mounting plate (82)(with power transformer (83) attached) to LH side bracket (68) using two bottom outer screws (82A).

c. Turn DPAV rightside up and finish securing transformer mounting plate (82) to LH side bracket (68) using two top outer screws (82A), two split lock washers (83A), and two nuts (83B).

d. Solder color coded wiring coming from power transformer (83) to matching points at main board (74).

5.5.4 Replacing Reference Isolation Board

a. Assemble reference isolation board (58) by replacing bottom cover assembly on board using four screws.

b. Plug in reference isolation board (58) and secure using two screws (58A) and two washers (58B).

5.5.5 Replacing Reference Isolation and Signal Isolation Transformers

a. Solder wiring to signal isolation transformer (70) and tag in accordance with paragraph 5.2.8 procedures for previously removed transformer.

b. Solder wires from signal isolation transformer (70) to main board (74) in accordance with tagged data.

c. Secure signal isolation transformer (70) to main board (74) using two screws (70A) and two washers (70B), one screw (70C), washer (70D), and rail (72).

d. Repeat procedure for reference isolation transformer (75).

5.5.6 Replacing Signal Broadband Isolation Board

a. Assemble signal broadband isolation board (59) by replacing bottom cover assembly on board using screws.

b. Plug in signal broadband isolation board (59) and secure using two screws (59A) and two washers (59B).

5.5.7 Replacing Readout Board

a. Install readout board (49) by securing with two screws (49A), two split lock washers (49B), and two washers (49C).

b. Install two bumpers (50) to readout board assembly (49) using two screws (50A) two split lock washers (50B), and two washers (50C).

c. Connect cable assemblies J1 (green) and J2 {yellow) between readout board (49) and A/D converter (3).

5.5.8 Replacing Null Meter

a. Attach printed circuit board assembly (51) lugs to terminals of null meter (53) and secure with two nuts (53A), two washers (53B), and two insulated washers (53C).

b. Attach printed circuit board assembly (51) to null meter (53) using two screws (51A) and two washers (51B).

c. Attach null meter (2) to readout board (49) securing with two screws (2A), two washers (2B), and two washers (2C).

d. Connect cable assembly W1 between main board (74) and null meter (2).

5.5.9 Replacing A/D Converter

a. Attach A/D converter (3) to A/D converter bracket (7) securing with 10 screws (3A), 10 washers (3B), and 10 washers (3C).

b. Attach A/D converter bracket (7) (with A/D converter (3)) to DPAV using two pivot spacers (8) and secure with two screws (8B).

c. Connect three cable assemblies J1 (green), J4 (red), and J2 (yellow) (46, 47, and 48) to wiring side of A/D converter (3).

5.5.10 Replacing DPAV Access Covers

a. Turn DPAV upside down, set bottom cover (11) in place and install screw (11A).

b. Attach four bumpers (12) securing with four screws (12A).

c. Turn DPAV rightside up and install one side cover (10) securing with four screws (10A) and four screws (10B). Repeat procedure for opposite side cover.

d. Plug in frequency cards as required and shift two printed card retainers to inside in order to hold frequency cards in place. Secure two retainters with four screws.

e. Flip down A/D converter bracket (7) along with A/D converter and secure with two screws (7A).

f. Set top cover assembly (1) in place and secure with five screws (11A).

5.6 PERFORMANCE CHECK

Perform the procedures of table 5-3 quarterly to verify proper operation of the DPAV. If a reading cannot be obtained, refer to paragraph 5.8 (alignment) and/or Section 6 (troubleshooting).

NOTE

The performance checks should be made after one-half hour warm-up time at room temperature with covers on.

5.6.1 Test Equipment

Table 5-2 lists the test equipment required for the performance checks. If the listed test equipment is not available, equivalents can be substituted.

During the check it may become necessary to remove a component from its socket or a ribbon cable from its connector. Use extraction tools to minimize the possibility of damage. For dual-in-line IC packages, Augat tool T114-1 is recommended. For the ribbon cable, 3M tool 3438 is recommended. No other special tools are required.

Table 5-2. Manufacturer Suggested Test Equipment

Name	Model number	Manufacturer
Variable, Low-Distortion Oscillator, 10 Hz to 100 kHz	Model 446R	Krohn-Hite
Variable Oscillator	Model 4000AR	Hewlett-Packard
Power Amplifier	Model DCA-10R	Krohn-Hite
Ac Calibrator	Model 5200A or 510A	John Fluke
Oscilloscope	Model 422	Tektronix
Phase Meter	Model 6500	Krohn-Hite

Table 5-2. Manufacturer Suggested Test Equipment (Continued)

Name	Model number	Manufacturer
DC Meter	Model 895A	John Fluke
Ratio Box (2)	Model RB504	North Atlantic Industries
High Frequency Ratio Box (two frequencies above 5 kHz)	Model RT-501	Dytronics
Phase Angle Generator	Model 311/RT-1/717S (Freq Range 30Hz-10KHz) Model 312/RT-1/717S (Freq Range 4KHz-500KHz)	Dytronics
VOM	Model 260	Simpson
Ribbon Cable Extraction Tool (Supplied with DPAV)	Model 3438	3M
DIP Extraction Tool	Model T114-1	Augat

Table 5-3. Performance Checks

Step	Procedure / Indication
1	GROUND ISOLATION CONTINUITY CHECK
a.	Remove line cord from power source. Disconnect rear-panel link and measure the resistance between the two points. Reading should be greater than 10 MΩ.
b.	Measure resistance between front panel REF LO and GND terminals. Reading should be greater than 100 MΩ.
c.	Measure resistance between rear panel terminal chassis ground and any convenient place on the chassis (screw, etc.). Reading should be less than 0.1 Ω.
d.	Replace rear panel link.
2	PRELIMINARY CHECKS
a.	Depress front panel 10 V, and appropriate main board Frequency Range push buttons. Connect ac calibrator to front panel REF HI and LO connectors. Place short between SIG HI and LO connectors. Adjust ac calibrator for 10 V rms output at corresponding main board frequency.
b.	Depress, in turn, the Function Selector push buttons (TOTAL through REF PHASE). At each position the corresponding indicator lights.
c.	Depress IN PHASE and REFERENCE OFFSET IN push buttons. REF OFFSET indicator is on.
d.	Depress REFERENCE OFFSET OUT push button. REF OFFSET indicator goes out.
e.	Depress, in turn, Voltage Scale push buttons (from 10 MV through 500 MV). The corresponding decimal point and Voltage Range indicator are on.
f.	Depress IN PHASE push button. Vary frequency output of ac calibrator by ±5% (between 380 and 420 Hz). NO SYNC indicator remains off.

Table 5-3. Performance Checks (Continued)

Step	Procedure / Indication
g.	Adjust ac calibrator output by ±10% (between 360 and 440 Hz). NO SYNC indicator goes on.
h.	Repeat steps a through g, above, for the remaining front panel Frequency Range push buttons.
3	AUTORANGE CHECK Depress desired Frequency Range push button. Adjust ac calibrator for output of 100 V rms at corresponding main board frequency. Depress AUTO push button. Remove short from SIG HI and LO connectors. Without removing ac calibrator from REF HI and LO connectors, connect ratio box between ac calibrator and SIG HI and LO connectors. Increase ratio box output from 0 mV to 100 V and back to 0 V. Unit up-ranges at 120% ±3% of full scale and down-ranges at 10% ±0.3% of full scale.
4	VOLTAGE ACCURACY CHECKS NOTE Allow a one-half hour warm-up period at room temperature prior to performing the voltage accuracy checks.
a.	Offset and Noise Check (1) With ac calibrator still connected to REF HI and LO connectors, reduce the output of ac calibrator to 10 volts rms at main board frequency. Disconnect and remove the ratio box from SIG HI and LO connectors. Short these connectors. (2) Depress front panel TOTAL, 1000 MV, and desired Frequency Range push buttons. DPAV displays 1 mV or less. (3) In turn, depress front panel IN PHASE and QUAD push buttons. For each frequency range, DPAV reads as shown below. Frequency Range — Reading 26 Hz to 5 kHz — 0.4 mV 5 kHz to 20 kHz — 0.8 mV 20 kHz to 32 kHz — 1.2 mV 32 kHz to 54 kHz — 2.4 mV (4) Depress the front panel TOTAL and 10 MV push buttons. DPAV displays 0.035 mV or less. (5) In turn, depress front panel IN PHASE and QUAD push buttons. For each frequency range, DPAV reads as shown below. Frequency Range — Reading 26 Hz to 5 kHz — 0.004 mV 5 kHz to 20 kHz — 0.008 mV 20 kHz to 32 kHz — 0.012 mV 32 kHz to 54 kHz — 0.024 mV (6) Adjust ac calibrator for an output of 10 V rms at desired main board frequency. Adjust ratio box for 10 mV rms output when 10 volts rms is applied to input. Remove short from SIG HI and LO terminals. Depress front panel FUND and 1000 MV push buttons. Connect input of ratio box to output of ac calibrator (in parallel with DPAV REF HI and LO connectors) and output of ratio box to

Table 5-3. Performance Checks (Continued)

Step	Procedure / Indication
	SIG HI and LO connectors. Adjust ac calibrator to increase frequency output to 500 Hz for a few seconds. NO SYNC indicator is on.
	(7) Reduce frequency to 400 Hz and wait a few seconds. NO SYNC indicator goes off.
b.	Accuracy and Linearity Check
	(1) Connect two ratio boxes in series between the ac calibrator and SIG HI and LO connectors. (Using two ratio boxes minimizes attenuation errors.) With differential voltmeter monitor the output of the ac calibrator. Connect phase angle generator between the ac calibrator and REF HI and LO connectors. Adjust the ac calibrator for 10 V rms at desired main board frequency and adjust the ratio boxes for an output of 10 mV rms ±0.02%. Adjust phase angle generator for 0.0° phase shift. Depress front panel 10 MV push button.
	(2) In turn, depress FUND and IN PHASE, push buttons. For each switch setting, DPAV readings are within the following specifications: Frequency Range — Specification 26 Hz to 60 Hz — 0.05% FS +0.1%, reading 60 Hz to 1.5 kHz — 0.05% FS +0.07%, reading 1.5 kHz to 20 kHz — 0.1% FS +0.15%, reading 20 kHz to 32 kHz — 0.15% FS +0.2%, reading 32 kHz to 54 kHz — 0.30% FS +0.6%, reading
	(3) Repeat steps (1) and (2), above, for each Voltage Scale, up to 10 V, changing signal ratio box for appropriate full scale reading.
	(4) Depress the 1000 MV push button and apply 100 mV rms to the SIG HI and LO connectors. Depress the REF PHASE and REFERENCE OFFSET IN push buttons. Adjust REFERENCE OFFSET ±45° control for a display of +45°.
	(5) Depress the FUND push button. DPAV reads 1000 mV ± accuracy from step (2).
	(6) Depress REFERENCE OFFSET OUT push button.
	(7) Apply 10 V rms, at main board frequency to the front panel REF HI and LO terminals. Apply 1 V rms ±0.02% to the SIG HI and LO temrinals, through a ratio box. Reduce the input in 0.2 V steps to 0 V. DPAV readings match ratio box settings within the accuracy specified for that frequency (e.g., for 400 Hz, accuracy is 0.05% FS +0.07% of reading).
	(8) Connect ac calibrator, phase angle generator, ratio box, and DPAV as shown in figure 5-2. Adjust ac calibrator for output of 10 V rms at desired main board frequency. Adjust phase angle generator for 90° phase shift and set ratio box for 1000 mV rms output to DPAV. Depress front panel 1000 MV and QUAD switches. DPAV reads within specifications given in step (2), above, and with a negative polarity.

Table 5-3. Performance Checks (Continued)

Step	Procedure	Indication

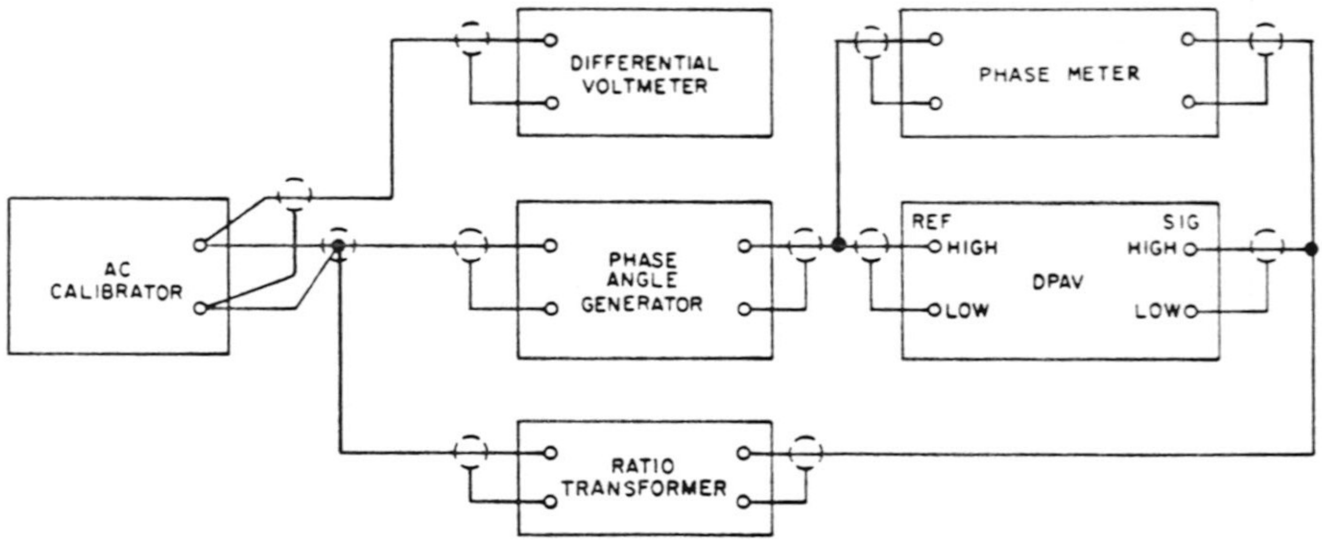


Figure 5-2. Accuracy Linearity Check

(9) Adjust phase angle generator for 270° phase shift.
DPAV reads the same as in step (8), above, except with a positive polarity.

c. Frequency Card Checks

Repeat steps a and b, above, for each DPAV Frequency Range.

d. Total Mode Frequency Response Check

(1) Depress front panel TOTAL and 1000 MV push buttons. Disconnect test setup and reconnect ac calibrator to SIG HI and LO connectors. Adjust ac calibrator for 1000 mV rms.

CAUTION

To avoid serious damage to the DPAV, do not apply a frequency below 26 Hz.

(2) While observing DPAV display, vary frequency output of ac calibrator from 30 Hz to 100 kHz.
DPAV display is between 997.5 and 1002.5 mV for all frequencies between 26 Hz and 10 kHz, between 995 and 1005 mV for all frequencies between 10.1 kHz and 30 kHz, between 990 and 1010 mV for all frequencies between 30.1 MHz and 100 kHz.

NOTE

If the above test is performed at a temperature of less than 18°C or more than 28°C, allow an extra tolerance of 0.2 millivolt for every degree by which the ambient differs from the normal range.

Table 5-3. Performance Checks (Continued)

Step	Procedure / Indication
	(3) Depress front panel 10 V push button. Adjust ac calibrator for 10 volt rms output to DPAV and repeat steps (1) and (2) above.
5	PHASE CHECKS

NOTE

Allow the DPAV to warm up one-half hour at room temperature.

a. Phase Match Check

NOTE

The Phase Angle and Reference Phase modes require accurate phase shifted signals. Refer to Appendix A for several common approaches.

Restore the set-up shown in figure 5-2. Adjust the ac calibrator for 10 V rms at desired main board frequency and the ratio box for 1000 mV rms. Adjust the phase angle generator for 0.0° phase shift. Depress the front panel 1000 MV, QUAD, and corresponding Frequency Range push buttons. Record value displayed by DPAV. Depress 10 V push button. Set ratio box for 10 volt output to DPAV. Record value displayed by DPAV.

DPAV reading at 1000 MV and 10 V is less than or equal to that given below.

Frequency Range	1000 MV Reading	10 V Reading
26 Hz to 60 Hz	±2.4 mV	±0.024 V
60 Hz to 5 kHz	±1.4 mV	±0.014 V
5 kHz to 20 kHz	±2.8 mV	±0.028 V
20 kHz to 32 kHz	±4.0 mV	±0.040 V
32 kHz to 54 kHz	±6.0 mV	±0.060 V

b. Quadrature and Reference Amplitude Check

(1) Depress the QUAD, 1000 MV, and Frequency Range (corresponding to main board frequency) push buttons.

(2) Apply 1000 mV at 0° to the SIG HI and LO terminals.

(3) Apply 10 V rms to REF HI and LO terminals and note the reading on the DPAV diaplay.

(4) In turn, adjust the input to the REF HI and LO terminals to 0.2 V, 3 V, 5.5 V, 7 V, and 100 V (maintaining a constant 1000 mV to SIG HI and LO terminals).

Maximum variation from recorded value of step (3) above, is as shown below.

Frequency Range	Variation
26 Hz to 60 Hz	±1.5 mV
60 Hz to 5 kHz	±1.0 mV
5 kHz to 20 kHz	±1.5 mV
20 kHz to 32 kHz	±2.0 mV
32 kHz to 54 kHz	±4.0 mV

c. Phase Angle Mode Accuracy Checks

(1) Adjust the ac calibrator for 0.0 V rms. Set-up the DPAV and test equipment

Table 5-3. Performance Checks (Continued)

Step	Procedure / Indication
	as shown in figure 5-3, but without the ratio box. Depress the front panel 10 V, PHASE ANGLE, and desired Frequency Range push buttons. Increase the output of the ac calibrator to 10 V rms at corresponding main board frequency.
	(2) Phase shift the phase angle generator in 5° steps to 360°.
	Indication: Accuracy is as shown below. (Be sure to allow for phase generator accuracy.)

Frequency Range	Phase Accuracy
26 Hz to 60 Hz	0.25° + ½ LSB
60 Hz to 5 kHz	0.2° + ½ LSB
5 kHz to 20 kHz	0.25° + ½ LSB
20 kHz to 32 kHz	0.35° + ½ LSB
32 kHz to 54 kHz	0.75° + ½ LSB

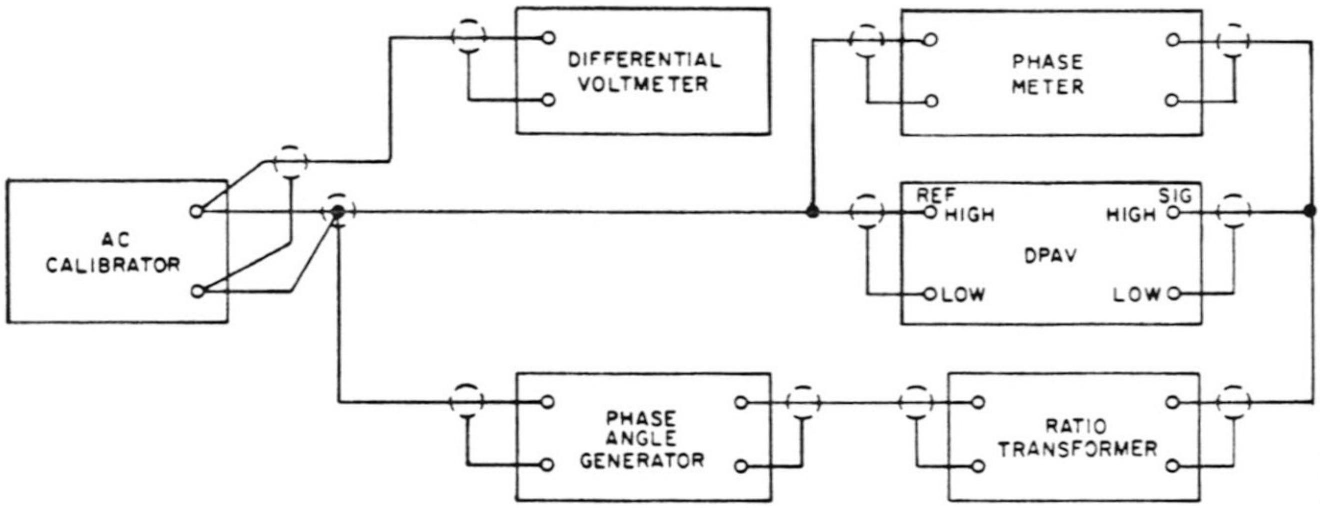


Figure 5-3. Phase Angle Mode Accuracy-Test Set-Up

d. Reference Phase Mode Accuracy Checks

(1) With the same test set-up as used in step c, above, but without the ratio box, and with the ac calibrator still set for 10 V rms, depress the front panel REF PHASE and REFERENCE OFFSET IN push buttons. Adjust the phase angle generator for a 0.0° phase shift. Adjust the front panel REFERENCE OFFSET ±45° control for the DPAV display of 45 degrees. Adjust the phase angle generator for a 45° phase shift.

(2) Depress front panel PHASE ANGLE push button.

Indication: DPAV reads 0.0° to within accuracy given in step c (2) above.

(3) Depress front panel REF PHASE push button. Adjust phase angle generator for 0.0° phase shift. Adjust front panel REFERENCE OFFSET ±45° control for DPAV display of 315.0°. Adjust phase angle generator for 315.0° phase shift. Depress front panel PHASE ANGLE push button.

Indication: Indication is the same as in step (2) above.

Table 5-3. Performance Checks (Continued)

Step	Procedure / Indication
e.	Frequency Card Checks NOTE In the following procedure, when main board frequency is specified, substitute the new operating frequency. Repeat steps a through d, above, for each DPAV operating frequency.

5.7 ABBREVIATED CALIBRATION PROCEDURE

Perform the calibration of table 5-4 quarterly or when the performance check indicates an out-of-tolerance condition. If proper indications cannot be obtained, perform the appropriate calibration procedure of paragraph 5.8.

NOTE

Unless otherwise specified, all checks are performed at main board frequency with 1 V signal and reference input. Use 931B AC Fluke, or equivalent to monitor signal input to within 0.02% at all times. Refer to figure 5-2 for test set up.

Table 5-4. Abbreviated Calibration Procedure

Step	Procedure / Indication / Corrective action
1	Initial Set-Up Set DPAV front panel controls as follows: Function Selector - TOTAL Voltage Scale - 1000 MV IN-OUT - OUT Frequency Range - Main board Power - OFF
2	Calibration Procedure
a.	Apply 1000 mV at main board frequency, to REF HI and LO terminals and short the SIG HI and LO terminals. Set Power switch to ON.
b.	Main Board DC Offsets

Table 5-4. Abbreviated Calibration Procedure (Continued)

Step	Procedure / Indication / Corrective action
	(1) Depress TOTAL push button. Monitor, with dvm, E41 (HI) and E40 (LO) on main board by isolation module, for 0 V dc ±0.2 mV. Adjust R14 on signal broadband isolation board. Monitor, with dvm, TP13 on A/D converter for 0 V dc ±0.2 mV. Adjust R116 on main board.
	(2) Depress IN PHASE push button. Monitor, with a dvm, TP13 on A/D converter for 0 V dc ±0.2 mV. Adjust R93 on main board.
	(3) Depress QUAD push button. Monitor, with a dvm, TP12 on A/D converter for 0 V dc ±0.2 mV. Adjust R104 on main board.
	(4) Repeat steps (1) through (3) monitoring the DPAV Digital Readout display. If readings are not 0±0.3 mV, continue with the following procedure. If readings are 0±0.3 mV, proceed to step d.
c.	A/D Dc Offsets
	(1) Depress IN PHASE push button. Monitor, with dvm, TP11 on the A/D converter for 0 V dc ±0.2 mV. Adjust R168 on the A/D converter. Monitor, with dvm, Z37-6 on A/D converter for -170 ±20 mV. Adjust R147 on the A/D converter.
	(2) Repeat both adjustments of step (1) for optimum zero.
	(3) Press QUAD push button. Monitor, with dvm, TP10 on the A/D converter for 0 V dc ±0.2 mV. Adjust R143 on A/D converter. Monitor, with dvm, Z35-6 on A/D converter for -170 ±20 mV. Adjust R126 on the A/D converter.
	(4) Repeat both adjustments of step (3) for optimum zero.
	(5) Repeat steps (1) thru (4) monitoring the DPAV Digital Readout display. If readings are not 0.0 ±0.4 mV, refer to the A/D converter alignment procedures of paragraph 5.8.7.
d.	Preliminary Main Board Gain Adjustment
	(1) Remove short from SIG HI and LO terminals. Apply 1000 mV ±0.02% to SIG HI and LO terminals and press the 1000 MV push button.
	(2) Depress the IN PHASE push button. Monitor, with dvm, TP13 on A/D converter for 8.75 ±0.02 Vdc. Adjust R88 on main board.
	(3) Apply 1000 mV at 270° to the REF HI and LO terminals
	(4) Depress the QUAD push button. Monitor, with dvm, TP12 on A/D converter for 8.75 ±0.02 V dc. Adjust R99 on main board.
	(5) Repeat steps (1) thru (4), monitoring the DPAV Digital Readout display. If readings are not 1000 ±0.4 mV, continue with the following procedure. If readings are 1000 ±0.4 mV proceed to step f.

Table 5-4. Abbreviated Calibration Procedure (Continued)

Step	Procedure / Indication / Corrective action
e.	Final Main Board Gain Adjustment (1) Apply 1000 mV at 0° to the REF HI and LO terminals. (2) Depress the IN PHASE push button. Monitor, on DPAV Digital Readout display, for a reading of 1000 ±0.4 mV. Adjust R153 on A/D converter (3) Depress the QUAD push button. Monitor, on DPAV Digital Readout display, for a reading of 0.0 ±0.2 mV. Adjust R129 on main board. (4) Depress the IN PHASE push button and apply 1000 mV at 180° to the REF HI and LO terminals. Monitor, on DPAV Digital Readout display, for a reading of -1000 ±0.4 mV. Adjust R161 on A/D converter. (5) Depress the QUAD push button and apply 1000 mV at 270° to the REF HI and LO terminals. Monitor, on DPAV Digital Readout display, for a reading of +1000 ±0.4 mV. Adjust R128 on A/D converter. (6) Apply 1000 mV at 90° to the REF HI and LO terminals. Monitor, on DPAV Digital Readout display, for a reading of -1000 ±0.4 mV. Adjust R132 on A/D converter.
f.	Frequency Board Alignment (1) Depress desired Frequency Range push button. (2) Apply 1000 ±10 mV, at the corresponding frequency, to the REF HI and LO terminals. Remove the signal from the SIG HI and LO terminals and short these terminals. (3) Depress the IN PHASE push button. Monitor, with dvm, at TP13 of A/D converter for a reading of 0 V dc ±0.2 mV. Adjust R8 on the frequency board. (4) Depress the QUAD push button. Monitor, with dvm, at TP12 of the A/D converter for a reading of 0 V dc ±0.2 mV. Adjust R18 on frequency board. (5) Remove short from the SIG HI and LO terminals and apply 1000 ±0.2 mV to these terminals. (6) Depress the IN PHASE push button. Monitor, on DPAV Digital Readout display, for a reading of 1000 ±0.4 mV. Adjust R2 on the frequency board.

Table 5-4. Abbreviated Calibration Procedure (Continued)

Step	Procedure / Indication / Corrective action
	(7) Depress the QUAD push button. Monitor, on DPAV Digital Readout display, for a reading of 0.0 ±0.3 mV. Adjust R10 on frequency board. If R10 does not produce desired result, adjust C36 (if available) on the frequency board.
	(8) Repeat steps (1) thru (7) for remaining frequencies.
	(9) Remove input from the REF HI and LO terminals and apply 1000 ±0.2 mV at 400 Hz to the SIG HI and LO terminals.
	(10) Depress the TOTAL push button. Monitor, on DPAV Digital Readout display, for a reading of 1001.0 ±0.2 mV. Adjust R120 on main board.
	(11) Repeat steps (9) and (10) with a 10 V input and obtain a reading of 10.010 mV. If correct reading cannot be obtained, refer to the Alignment procedure of paragraph 5.8.11.

5.8 ALIGNMENT AND CALIBRATION

The following procedure will assist a qualified technician to calibrate the DPAV. Familiarization with the operating instructions and theory of operation is desirable.

Perform these procedures at regular six-month intervals. They should also be used to correct any out-of-tolerance condition that might be detected, either during normal operation or during execution of the performance checks (para. 5.6). If the adjustments described in this paragraph fail to correct the out-of-tolerance condition, refer to the troubleshooting procedures.

Read each calibration procedure in its entirety before proceeding. If a problem is encountered during a specific procedure, proceed with the remaining procedures, and then repeat the entire procedure. If the problem is still encountered, refer to the troubleshooting procedure in Section 6.

NOTE

Do not attempt to operate the DPAV in Total mode when the input frequency is less than 26 Hz.

WARNING

High voltages exist at several points within the DPAV. Exercise caution in making measurements and adjustments. A potential shock hazard exists when the unit is operated with an ungrounded power source or case. Ensure that the rear panel link connects the CKT GND and CHAS GND terminals. Ensure that the chassis of the ac calibrator is grounded. If the ac calibrator is not used, ensure that the chassis of both the oscillator and the power amplifier are grounded.

5.8.1 Test Equipment Required

Manufacturer suggested test equipment is listed in table 5-2. If the listed test equipment is not available, equivalents may be substituted.

5.8.2 Preliminary Check

Remove line cord from the power souce. Disconnect rear panel link and measure the resistance between chassis ground and REF HI and SIG HI connectors. All resistance readings should be greater than 100 MΩ. Measure resistance between chassis ground and some convenient spot on the power supply heat sink. Resistance should be less than 0.1 Ω. Reconnect rear link.

5.8.3 Calibration of Power Supply

a. Connect DPAV to power source and turn it on. Be sure a reasonable warm-up time is allowed before calibration.

b. Using clip leads, short front panel SIG HI and SIG LO connectors and also short REF HI and REF LO connectors. Depress front panel ON push button.

c. Using dc meter and TP9 as ground, monitor +15 V (at +15 V jumper on rear of main board). Check for oscillation or excessive noise. Adjust potentiometer R177 for a reading of +15 V ±20 mV.

d. Using dc meter, monitor -15 V at a point nearest capacitor C92. Adjust potentiometer R175 for -15 V ±20%.

e. Using dc meter, monitor +5 V at a point on right side towards R182. Reading should be +5 V ±50 mV dc.

f. Using dc meter, measure voltage at collector of Q58. Reading should be between +181 and +199 V dc, and the display is lit.

g. Using oscilloscope, measure ac ripple for +15 V, -15 V, and +5 V. In each case, ripple should be less than 30 mV p-p. (DPAVs with IEEE option, the ripple of the +5 V supply will be less than 120 mV p-p and the ±15 V supply will remain the same.)

5.8.4 Reference Channel Adjustments

a. Short front panel REF HI and LO connectors. Using dc voltmeter, monitor voltage between E-51 (Lo) and E-50 (Hi) on main board and adjust R14 on reference isolation board for between -0.2 and +0.2 mV dc.

NOTE

Use ground near R157 for balance of reference channel testing.

b. Depress IN PHASE push button. Monitor Z47 output on pin 6 (anode of CR61) with oscilloscope and adjust potentiometer R275 so that voltage is just on positive side of 0 line (approximately +150 mV).

c. Remove short from REF HI and LO connectors and apply 0.99 to 1000 mV rms, at main board frequency to reference input and monitor TP12 with differential voltmeter. Adjust level potentiometer R232 for 230 millivolts (0.64 volt p-p) rms at TP12. Check for distortion or oscillation with oscilloscope.

d. Adjust potentiometer R221 fully counter clockwise. Monitor Z46 output at pin 6 (cathode of CR60) with oscilloscope. Waveform should be a full-wave rectified voltage (0.1 V p-p) riding on a dc voltage.

e. Set oscilloscope for 2 V dc input and use bottom graticule as zero and monitor Z46-6. Increase reference input voltage to 6.7 ± 0.2 V rms and adjust potentiometer R221 so that voltage climbs to about 9 volts, reaches a trip point, and drops to about 2.3 volts. This level change will be slow and should not trip before 6.7 V rms reference input. If 9-volt level cannot be reached at Z46-6, replace resistor R224 (selected value) in 10-ohm increments (up or down).

f. After adjustments of steps b through e have been made, apply 7 V rms, at main board frequency to reference input and monitor Z46 pin 6 (cathode of CR60). Lower input voltage slowly, observing oscilloscope voltage dropping toward zero. As oscilloscope voltage nears zero, lower input voltage very slowly until it snaps back in positive region. This should occur at a reference input of between 5.45 and 5.95 V rms.

5.8.5 Reference Phase Lock Loop and AC Filter

a. Adjust ac calibrator for a 10 V rms,

at main board frequency for reference voltage. Depress IN PHASE and REFERENCE OFFSET OUT push buttons.

b. Adjust potentiometer R161 to midrange and monitor TP19 (near Z7) with oscilloscope. Adjust R161 in VCO until the average value at TP19 (rectified ac riding on a dc level) is -0.5 to +0.5 V dc. If necessary, select capacitor C177 so that R161 will adjust to approximately center position.

c. Adjust input frequency between 372 and 428 Hz and observe TP19 voltage decreases approximately 12 volts dc and then increases approximately 12 volts dc.

d. With reference input shorted, use oscilloscope to monitor output of Z7 at TP19. Adjust offset potentiometer R157 until TP19 voltage is near zero volts and drifting has been reduced to a minimum. Use a more sensitive range (0.5 V/cm min.) on oscilloscope when voltage approaches zero.

5.8.6 Signal Channel Adjustments

5.8.6.1 Signal Broadband Isolation Module DC Offset

With SIG HI and LO connectors and REF HI and LO connectors shorted, depress TOTAL and 10 MV push buttons. On main board, near signal broadband isolation board, monitor voltage using dc meter connected between E-41 (Hi) and E-40 (Lo). Adjust potentiometer R14 on signal broadband isolation board for a reading between -0.2 and +0.2 mV dc.

5.8.6.2 Signal Filter Adjustments

a. Depress TOTAL and 1000 MV push buttons. Connect DPAV and test equipment as shown in figure 5-4, test circuit C. Set ratio box to 0.1. Adjust ac calibrator for 10.000 volts rms at main board frequency. If OVER LOAD indicator light goes on, remove operational amplifier Z36.

NOTE

Use TP9 as ground for all signal channel testing.

b. Using oscilloscope, monitor negative side of capacitor C11. Voltage should be an undistorted 4.7 volts peak-to-peak sine wave and free from oscillation or excessive noise.

c. Using oscilloscope, monitor TP1. Voltage should be an undistorted 690-millivolts peak-to-peak sine wave.

5.8.6.3 Total Mode Filter DC Offset

a. Depress TOTAL and 1000 MV push buttons. Disconnect ac calibrator. Using clip leads, short REF HI and LO connectors and also SIG HI and LO connectors.

b. Using oscilloscope, monitor anode of CR25. Adjust potentiometer R283 waveform for 0 V dc. No sign of oscillation should be present, but waveform will be noisy (approximately 400 mV p-p).

c. Monitor TP13 on the A/D converter (using TP14 as ground) with dc meter and adjust potentiometer R116 for between -0.2 and +0.2 mV dc.

5.8.6.4 Inphase and Quadrature Filter DC Offset

a. Short SIG HI and LO connectors. Connect ac calibrator to REF HI and LO connectors. Adjust ac calibrator for 10 volts rms at main board frequency. Depress 1000 MV push button.

b. Depress IN PHASE push button and monitor TP13 on A/D converter using dc meter. Adjust potentiometer R93 (near Z14) for voltage between -0.2 and +0.2 millivolt dc.

c. Depress QUAD push button and monitor TP12 (using TP14 as ground), on A/D converter, with dc meter. Adjust potentiometer R104 (near Z16 on main board) for -0.2 to +0.2 mV dc.

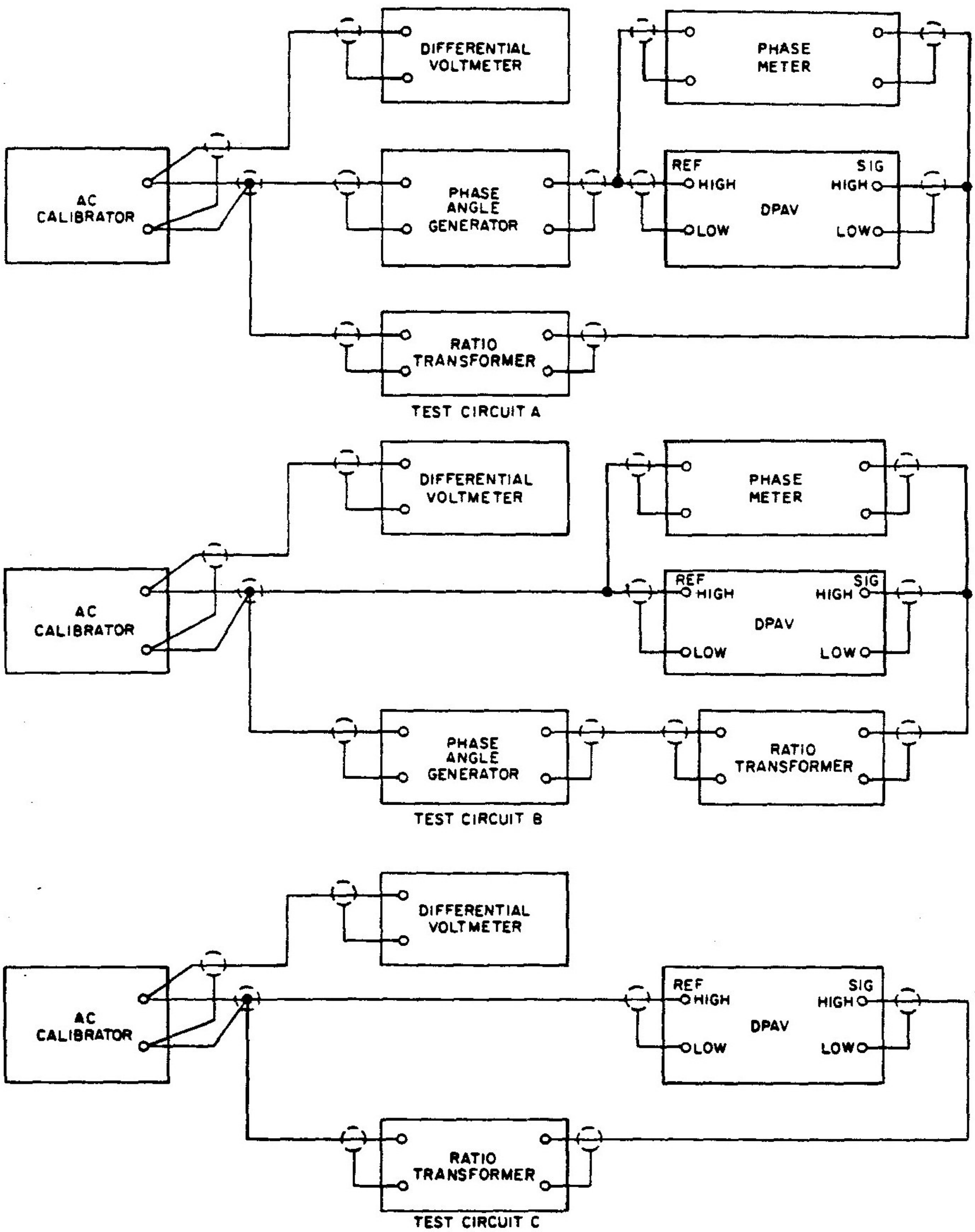


Figure 5-4. Calibration Set-Up

5.8.6.5 Inphase and Quadrature Gain Adjustments

a. Remove short from SIG HI and LO connectors. Connect DPAV as shown in figure 5-4 (test circuit A). Adjust ac calibrator for 10.000 V rms at main board frequency. Depress IN PHASE push button. Set ratio box to 0.1 and depress 1000 MV push button.

b. Using oscilloscope, monitor filter output at TP2. Voltage should be approximately 5.1 volts peak-to-peak sine wave, undistorted, free of oscillation and excessive noise, and have an average value between -0.1 and +0.1 V dc. Use differential voltmeter to monitor voltage at TP2 and adjust potentiometer R319 for reading between 1.7948 and 1.7952 V rms.

c. Monitoring TP13 on A/D converter, set input frequency at main board frequency and adjust potentiometer R88 for exactly +8.75 V dc.

d. Set phase angle generator for 90° phase shift and set ratio box to 0.1. Place unit in Quadrature input, 1000 mV range, and apply 10 V rms to reference input. Apply 1000.0 mV to signal input. Adjust R99 on main board for exactly -8.75 V dc at TP12 on A/D converter.

5.8.6.6 No SYNC Test

Adjust ac calibrator for a 10 V rms, at desired main board frequency reference input. Depress QUAD and appropriate Frequency Range push buttons. Change input frequency 20% and note NO SYNC indicator light goes on. Return input frequency to original setting and note indicator light goes off, after a 2-second delay. Remove reference input and note NO SYNC indicator light goes on.

5.8.7 A/D Converter Adjustments

5.8.7.1 Clock and DC Reference Adjustments

a. Connect the DPAV to test equipment as shown in figure 5-4, test circuit C. Set ratio box to 0.0. Adjust ac calibrator for 1000.0 millivolts at desired main board frequency. Depress 1000 MV and IN PHASE push buttons.

b. Using dc meter, monitor signal between TP14 (gnd) and TP7, both on A/D converter, and adjust potentiometer R68 for a reading of 9.50 V dc.

c. Monitor clock pulses at TP1 with oscilloscope. Note a negative pulse train having a period of roughly 25 microseconds and a pulse generation of about 0.75 microsecond.

d. Set ratio box for 1000 mV output. Monitor TP5 with oscilloscope and observe a symmetrical triangular waveform with -0.1 to +0.1 V positive peak and -9.5 V negative peak. If negative peak is not -9.5 V, adjust potentiometer R3 for proper value.

5.8.7.2 Voltage Mode Bias Adjustment

This paragraph describes the adjustments for voltage mode bias to eliminate offset errors in A/D converter circuitry.

a. With the same setup as for paragraph 5.8.7.1, turn power off, remove operational amplifier Z38, ground TP9 with jumper to TP14, and turn power on.

b. Using oscilloscope, measure and record period of clock pulse train on TP1.

c. Set potentiometer R34 fully counterclockwise.

d. Place oscilloscope probe on TP6 and

adjust oscilloscope to observe a 4 Hz negative-going pulse (0 to -9.5 V).

e. By varying potentiometer R34, adjust width of pulse to 1-1/2 times the length of clock period measured in step b, above.

f. Remove jumpers, turn power off, and replace Z38. Turn power on again.

5.8.7.3 Angle Mode Bias Adjustment

a. Set up equipment as in paragraph 5.8.7.1. Apply 10 V reference and 1 V signal at desired main board frequency. Depress REF PHASE and OFFSET IN push buttons. Adjust REFERENCE OFFSET control to 10°.

b. Place scope probe on TP1 and externally synchronize on TP6 (dc, negative edge). The sync pulse is about 3 Hz.

c. Adjust scope for negative-going clock pulses. Increase sweep speed to observe first two clock pulses. (Disregard any pulse seen at very beginning of sweep.) The time from the beginning of sweep to the first pulse is approximately 250 µs (fig. 5-5) and the time from the first to second pulse is about 500 µs. Measure and record the exact time between the first and second pulses.

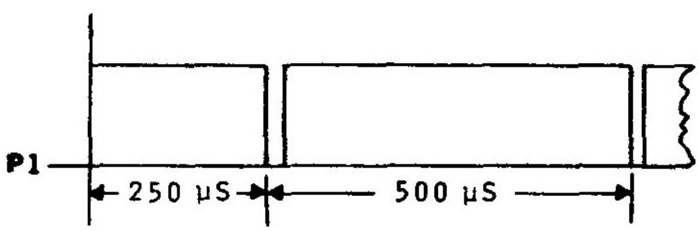


Figure 5-5. Angle Mode Clock Waveform

d. Turn power off and remove Z36. With jumper lead, ground TP9 to ground TP14. Turn power on.

e. Using oscilloscope, monitor TP6 and note negative going pulse (0 to about -8 V). Adjust potentiometer R48 until spacing between the beginning of the sweep to the positive leading edge equals to that recorded in step c, above. If negative-going pulses are approximately 2.7 V instead of -8 V, R48 cannot be adjusted. Adjust potentiometer R210 or 3.333 gain circuitry of Z61 on main board (para. 5.8.9.2).

f. Turn power off. Remove jumper and replace Z36. Turn power on.

5.8.7.4 Phase Mode Offset Adjustments

The following steps are necessary to adjust the dc offsets on the angle mode segment detectors and angle computer amplifier Z27.

a. With the same setup as for paragraph 5.8.7.1, set signal ratio box to 0.0. Turn power off. Remove operational amplifiers Z36 and Z38 on A/D converter. Turn power on and, with two jumpers, ground TP10 and TP11 to TP14.

b. Using oscilloscope, monitor octant detector Z34 output at TP19 and adjust potentiometer R115 so that voltage is just in transition between +13 and -13 V.

c. Monitor Z30 at TP18 with oscilloscope, and adjust potentiometer R86 so that voltage is just in transition between +13 and -13 V.

d. Monitor Z31 at TP17 with oscilloscope, and adjust potentiometer R95 so that voltage is just in transition between +13 and -13 V.

e. Using dc meter, monitor voltage at TP8 and adjust potentiometer R79 for -0.1 to +0.1 mV dc.

f. Remove jumpers, turn power off, and replace Z36 and Z38. Turn power on.

5.8.7.5 Inphase Channel Hysteresis Adjustment

a. Using clip leads, short SIG HI and LO connectors and REF HI and LO connectors. Depress IN PHASE push button.

b. Using dc meter, monitor TP11 and adjust potentiometer R168 for -0.2 to +0.2 mV dc.

c. Using dc meter, monitor voltage at cathode of CR25 and adjust potentiometer R147 for -105 to -200 mV dc (-170 mV dc is optimal). Repeat step b above, until no interaction occurs.

5.8.7.6 Quadrature Channel Hysteresis Adjustment

a. With the same setup as for paragraph 5.8.7.1 depress QUAD push button.

b. Using dc meter, monitor voltage at TP10 and adjust potentiometer R143 for -0.2 to +0.2 mV dc.

c. Using dc meter, monitor voltage at cathode of CR26 and adjust potentiometer R126 for -150 to -200 mV dc (-170 mV dc is optimal). Repeat step b above until no interaction occurs.

5.8.7.7 Inphase Gain

a. Connect DPAV to test equipment as shown in figure 5-4, test circuit A. Set ratio box for 1000 mV output. Depress 1000 MV, IN PHASE, and desired main board frequency push buttons. Adjust ac calibrator for 10.000 V rms at corresponding main board frequency.

b. Adjust phase angle generator for a 180° phase shift giving a negative reading on display, and adjust potentiometer R161 for exact full-scale reading of -1000.0 mV.

c. Invert signal by adjusting phase angle generator for a 0.0° phase shift, and adjust potentiometer R153 for exact full-scale positive reading.

5.8.7.8 Quadrature Gain

a. Use the same setup as for paragraph 5.8.7.1, but depress QUAD push button.

b. Adjust phase angle generator for a 90.0° phase shift and adjust potentiometer R132 for digital readout of -1000.0 mV.

c. Adjust phase angle generator for 270° phase shift and adjust potentiometer R128 for digital readout of +1000.0 mV.

5.8.8 Frequency Board Adjustment

The following tests and calibration procedures apply to all frequency boards.

NOTE

Unless otherwise specified, test points and components are located on the frequency board being calibrated.

5.8.8.1 Preliminary Checks

a. Set up equipment as shown in figure 5-4, test circuit C. Set ratio box to 0.1. Depress desired Frequency Range, IN PHASE, and 1000 MV push buttons. Adjust ac calibrator for 10.000 V rms at corresponding main board frequency.

NOTE

Pulse repetition rate at TP6 is 12 times input frequency.

b. Using oscilloscope, check signal filter output at TP5. It should be a sine wave approximately 5.1 V peak-to-peak, undistorted and free of oscillation and noise.

c. Using oscilloscope, check reference filter output at TP1. It should be a sine wave approximately 4.8 V peak-to-peak, undistorted and free of oscillation and noise.

d. Using oscilloscope, check integrator Z4 output at TP4. If loop is properly locked on, it should be a 0.7 V peak-to-peak rectified-type waveform with a -0.5 to +0.5 V dc average value. If average value is not -0.5 to +0.5 V dc, adjust VCO potentiometer R44.

e. Depress any other Frequency Range push button and check that signals at TP1 and TP5 have disappeared.

5.8.8.2 DC Offset Adjustments

a. Disconnect test equipment from REF HI and LO and from SIG HI and LO connectors. Using clip lead, short REF HI and LO connectors.

b. Using oscilloscope, monitor TP4 and adjust potentiometer R41 until TP4 voltage is relatively stable at 0.0 V dc. Reduce drift as much as possible.

c. Depress IN PHASE and 1000 MV push buttons. Reconnect ac calibrator to REF HI and LO connectors and short SIG HI and LO connectors. Adjust ac calibrator for 10 V rms at desired main board frequency.

d. Monitor readout and adjust potentiometer R8 on frequency board for -0.2 to +0.2 mV display.

e. Depress QUAD push button and repeat step d, adjusting potentiometer R18 on frequency board.

5.8.8.3 Gain Adjustment, Inphase Mode

a. Set up the equipment as shown in figure 5-4, test circuit C.

b. Depress 1000 MV, IN PHASE, and appropriate Frequency Range push buttons. Set ratio box to 0.1 and adjust ac calibrator for 10.000 V rms at corresponding test frequency.

c. Monitor readout and adjust frequency board gain potentiometer R2 for 1000.0 mV display.

5.8.9 Autoranging Adjustments

5.8.9.1 Voltage Mode

NOTE

Unless otherwise noted all potentiometers and components are located on the main board.

a. Connect ac calibrator to REF HI and LO connectors. Connect a ratio box between ac calibrator and SIG HI and LO connectors. Set ratio box to 0.1 and adjust ac calibrator for 10.000 V rms at highest phase sensitive frequency. Depress FUND, 1000 MV, and corresponding Frequency Range push buttons.

b. Increase signal input to 1200 mV rms and adjust potentiometer R204 until OVER LOAD indicator goes on at exactly 120% of full scale (1200 mV).

c. Depress AUTO push button and decrease signal input to 103 mV. Adjust potentiometer R209 until unit autoranges down to next range at exactly 10.3% of full scale (103 mV).

5.8.9.2 Signal FET Amplifier Bias Check

This adjustment sets the dc output of Z61 so that the dc bias voltage at Z61 does not change when K2 is energized. This prevents autorange oscillation in the Phase Angle mode.

a. Depress TOTAL and 1000 MV push buttons, and set ratio box to 0.0. Pull out integrated circuit Z34 and monitor positive side of C11 (between -15 and +15 millivolts approximately) with a differential voltmeter. With a clip lead, ground K2 relay coil (at anode of CR3). Change in monitored voltage should be less than 0.03 V dc when K2 is energized. Replace Z34 with power off and clip lead removed from K2.

b. Depress TOTAL and highest sensitive Frequency Range push buttons and apply a 10 V, at corresponding frequency, to reference input and a signal input of 0.333 V rms. Adjust potentiometer R210 to its maximum counterclockwise position, depress PHASE ANGLE push button, and then adjust R210 slowly clockwise until threshold is reached. At this time, the ac voltage level at TP1 increases by a factor of 3 compared to voltage just before threshold. Monitor TP1 using either differential voltmeter or oscilloscope.

5.8.10 Reference Channel Phase Matching

5.8.10.1 Reference Input Attenuator Adjustments

The adjustments on the reference attenuator should be made at the highest phase sensitive frequency. The adjustment matches the phase shift of the reference front end with the signal front end.

a. Using ratio box with low phase shift at frequency of measurement such as NAI RB503C, apply 10 V to reference and 1 V to signal inputs. Depress the 1000 MV and REF PHASE push buttons. Depress the appropriate Frequency Range push button.

b. With dc meter, monitor voltage between TP14 (gnd) and TP12 on A/D converter. Adjust potentiometer R10 on corresponding frequency board for 0 mV dc at TP12 or R129 on main board on units with no frequency cards.

c. Depress QUAD push button and adjust trimcap C11 on reference isolation board (on the front left side of main board) for 0 mV dc at TP12.

d. Apply 10 V to reference input and adjust capacitor C2 on reference isolation board for 0 mV dc at TP12.

e. Repeat steps c and d for no interaction.

5.8.10.2 Reference AGC Phase Adjustments

a. Connect the ratio box between the ac calibrator and REF HI and LO connectors. Connect ac calibrator to SIG HI and LO connectors. Set the ac calibrator for 1000.0 mV at the highest phase sensitive frequency. Set ratio box to 1.0.

b. Depress QUAD push button. Observe and record DPAV readout.

c. Lower ratio box setting to 0.2 (200 mV). Adjust capacitor C179 on main board for same quadrature readout with 200 mV reference level as with 1000 mV reference level (±0.1 mV). (If capacitor C179 cannot be adjusted, change capacitor C148 in 1 pf increments.

d. Check that adjustment of capacitor C179 did not affect adjustments of paragraph 5.8.10.1. Repeat if interaction has occurred.

5.8.10.3 Phase Matching

a. Connect ac calibrator to REF HI and LO connectors and connect a ratio box between ac calibrator and SIG HI and LO connectors. Depress QUAD, 1000 MV, and appropriate Frequency Range push buttons. Set ratio box at 0.1 and adjust ac calibrator for 10 V rms at corresponding main board frequency.

b. Monitor digital readout and ajust phase of reference ac filter Z18 on main board by adjusting potentiometer R129 for a 0.0 mV display. This aligns phase shift of signal and reference channels.

c. Place unit in 10 V range, adjust ratio box for a 10 V rms signal input, and monitor readout. If this voltage differs from that in step b, adjust R129 to balance phase between 1000 mV and 10 V ranges. If final readings are out of spec, refer to paragraph 5.8.11 and examine 1000:1 trim adjustment.

d. Repeat paragraphs 5.8.8 thru 5.8.10.3 for the remaining main board frequencies

5.8.10.4 Total Mode Frequency Trim Procedure

a. Disconnect REF HI and LO connectors and connect output of ac calibrator directly to SIG HI and LO connectors. Depress TOTAL push button. Adjust ac calibrator for 1000.00 mV at 200 Hz.

b. Adjust gain potentiometer R120 (near Z12) for 999.8 to 1000.2 mV on the front panel display.

c. Sweep input frequency from 30 Hz to 100 kHz and note peaking of readout.

Use adjustable capacitor C183 (near Z11) and install, if necessary, select-at-test capacitors C143 and C144 (near Z11) until frequency response is flat. Use figure 5-6, as reference, in trimming. This graph represents an average response of the total mode circuitry and should be used as a guide.

d. After C143 and C144 trimming adjustments have been made, take voltage readings at 60 Hz and 20 kHz. Readjust potentiometer R120 to balance the readings around 1000.0 mV.

e. Sweep input frequency from 26 Hz to 100 kHz. For all frequencies within each of the following ranges of frequencies, the DPAV display should remain within the limits listed below.

Frequency Range	DPAV Display
26 Hz to 60 Hz	995.0 to 1005.0 mV
60 Hz to 10 kHz	997.5 to 1002.5 mV
10 kHz to 30 kHz	995.0 to 1005.0 mV
30 kHz to 100 kHz	990.0 to 1010.0 mV

f. If retrim of capacitors C143 and C144 is required, the response of the 1000 mV scale has to be rechecked.

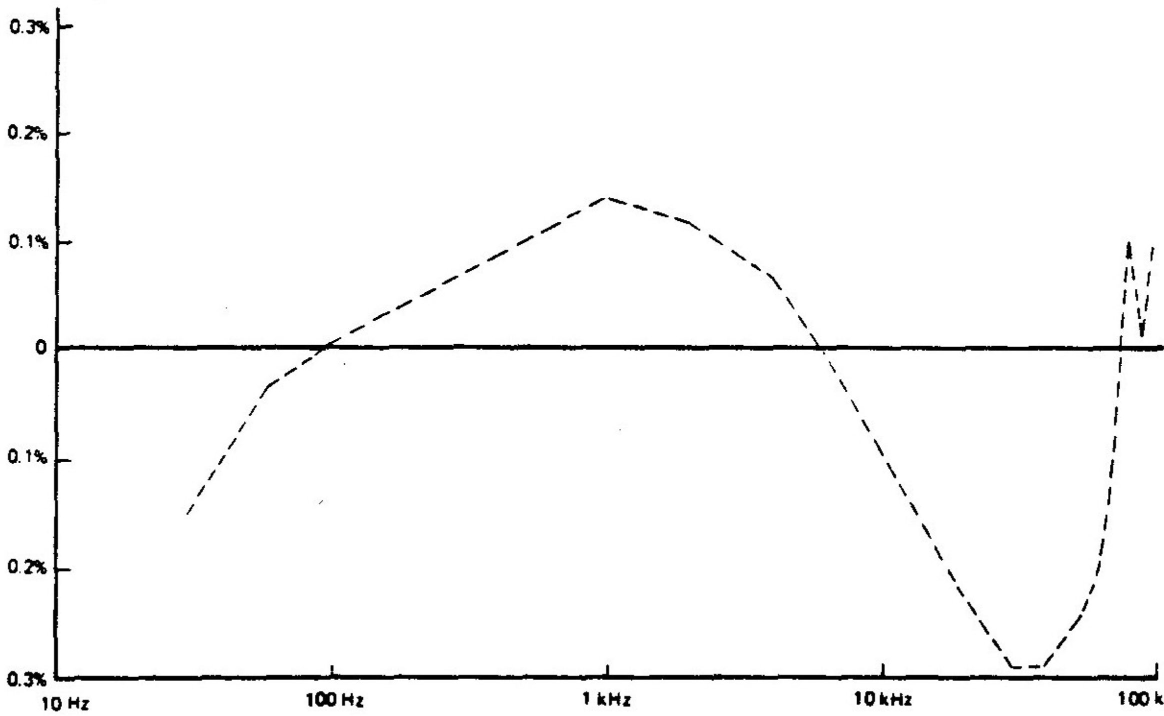


Figure 5-6. Average Total Mode Response (Broadband Isolation) 1000 mV Range

5.8.11 Signal Broadband Isolation Board 1000:1 Attenuator

This adjustment is made by matching the total mode response at high and low frequencies, specifically 90 Hz (adjust potentiometer R7) and 30 kHz (adjust capacitor C2).

a. Connect ac calibrator output to SIG HI and LO connectors.

b. Depress TOTAL and 1000 MV push buttons. Adjust ac calibrator for 1.0000 V rms at 90 Hz. DPAV should display approximately 1000.9 mV. Record exact reading.

c. Depress 10 V push button. Adjust ac calibrator for 10.0000 V rms at 90 Hz and adjust potentiometer R7, located on signal broadband isolation board, for exactly 10 times the reading recorded in step b.

d. Adjust ac calibrator for 1000.0 mV rms at 30 kHz. Depress 1000 MV push button. DPAV should display approximately 998.2 mV. Record exact reading.

e. Depress 10 V push button. Adjust ac

calibrator for 10.0000 V rms input to DPAV. Adjust capacitor C2, located on signal broadband isolation board, for exactly 10 times the reading recorded in step d.

5.8.12 ±45° Reference Offset Adjustment

a. Set ratio box to 0.1 and phase angle generator for a 0.0° phase shift. Adjust ac calibrator for an output of 1000 mV rms at appropriate main board frequency.

b. Depress REF PHASE, REFERENCE OFFSET IN, and corresponding Frequency Range push buttons. Adjust REFERENCE OFFSET ±45° control fully clockwise until display reads 48.0°. If reading cannot be obtained, adjust potentiometer R149 (near Z7 on main board) for DPAV display of +48.0° ±0.2°.

c. Observe DPAV display while rotating REFERENCE OFFSET ±45° control fully counterclockwise. Display angle should read at least 312.0° ±0.2° at the extreme ccw position. Set REFERENCE OFFSET ±45° control to 45°.

d. Using phase angle generator, apply a 45.0° phase shift to the REF HI and LO connectors. Depress the PHASE ANGLE push button. DPAV display reads 0° or 360° ±0.25°.

e. Repeat steps a thru d for each main board frequency and adjusting R35 on each corresponding frequency board for a reading of 48.0°.

5.8.13 Null Meter Adjustment

Use the DPAV at main board frequency mode with signal input connected to an inverting ratio box. The reference input should be held constant at 10 V rms, at main board frequency. Follow each step for proper null meter operation.

NOTE

With DPAV power off, adjust the zero adjust screw on the front of the null meter for exactly 0 reading.

a. Depress IN PHASE and 10 V push buttons. Set the ratio box output to 0 V rms, inphase. Adjust R1 on the null meter so that meter sits directly over the center line mark.

b. Set the ratio box for 10 V rms output and adjust R3 for full deflection to the right. Reverse the input polarity by means of the ratio box and check for full deflection to the left.

c. Repeat step b, above, with DPAV in Total and Fundamental modes for a full deflection to the right.

d. Depress REF PHASE and REFERENCE OFFSET IN push buttons. Turn the REFERENCE OFFSET ±45° control for a 45° reading. Press QUAD push button and observe the null meter reads to the left approximately 50% of full scale. Press IN PHASE push button and note null meter reads approximately the same to the right of its null position.

e. Repeat step d, above, for Phase Angle and Ref Phase modes. The null meter should stay in its center null position, regardless of input signal conditions.

f. The null meter is center-weighted to be more sensitive of its null position. To check this, depress IN PHASE and 10 V push buttons, and remove the reference offset. Set the ratio box for 0 mV output and observe that the meter reads a null. Increase the signal input voltage from the ratio box to 900 mV. Note meter moves to the right to about the end of the center (black) area. Reverse input polarity by means of the ratio box and check that the meter moves to the left about the same amount. Increase the input voltage, in 1 V steps to 5 V and check for less pronounced meter movement at each step. Reverse the input for an inphase signal and recheck the 1 V steps with the meter now moving to the right. This checks the meter sensitivity at null.

5.8.14 Shut Down Procedure

Shut down ac calibrator, depress DPAV OFF push button, and disconnect test setup.

SECTION 6

TROUBLESHOOTING

6.1 GENERAL

This section contains troubleshooting procedures for the DPAV.

CAUTION

During troubleshooting, it will become necessary to remove a component (DIP) from its socket or a cable assembly from its connector. To minimize the possibility of damage, an extraction tool should be used. For (DIP) dual-in-line IC packages, and cable assemblies, Augat tool No. T114-1 is recommended.

6.2 VISUAL INSPECTION

After removing the DPAV top and bottom covers, the unit should be thoroughly inspected. Some obvious causes of trouble could be:

- Cable connectors not properly seated
- IC's not properly seated in their sockets
- Broken wires or loose components
- Burnt components indicating thermal overload. The cause should be located and corrected.
- Metallic particles shorting adjacent lands on PC board. Both sides of boards should be inspected (where convenient) and all exposed boards completely brush cleaned to remove dust particles.

6.3 TROUBLESHOOTING PROCEDURES

Table 6-1 provides detailed troubleshooting procedures for the units of the DPAV.

Table 6-1. DPAV Troubleshooting Procedure

Step	Procedure	Indication		Remedy
		OK	Not OK	
1	POWER SUPPLY INOPERATIVE OR OUT OF SPECIFICATION			
a.	Remove and visually inspect Slo-Blo fuse F1.			Replace fuse if defective.
b.	Press DPAV Power switch to ON and measure with dmm voltage at emitter of transistor Q58 for a reading of 180 to 200 V dc.	X		Proceed to step d.
			X	Proceed to step c.
c.	Unsolder rectifier Z23 and measure with dmm between E10 terminals for a reading of 130 to 170 V rms.	X		Replace Q58, CR92, Z23, or C98.
			X	Replace T1 and reinstall Z23.
d.	Press DPAV Power switch to OFF.			
e.	Remove jumper connected between two points marked -15 V.			

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
f.	Press DPAV Power switch to ON and measure, with DMM, at -15 V point nearest capacitor C92 for a reading of -14.980 to -15.020 V dc.	X		Proceed to step i.
			X	Proceed to step g.
g.	Adjust potentiometer R175 for a DMM reading of -14.980 to -15.020 V dc.	X		Proceed to step i.
			X	Proceed to step h.
h.	Unsolder rectifier Z21 and monitor between E9 terminals for a DMM reading of 15 to 20 V rms.	X		Replace Z27 and reinstall Z21.
			X	Replace T1 and reinstall Z21.
i.	With oscilloscope at -15 V point nearest capacitor C92, monitor for an ac ripple voltage of less than 30 mV.	X		Proceed to step j.
			X	Replace C91.
j.	Press DPAV Power switch to OFF.			
k.	Remove jumper connected between two points marked +15 V.			
l.	Press DPAV Power switch to ON and monitor at +15 V point nearest capacitor C93 for a DMM reading of +14.980 to +15.020 V dc.	X		Proceed to step o.
			X	Proceed to step m.
m.	Adjust potentiometer R177 for DMM reading of +14.980 to +15.020 V dc.	X		Proceed to step o.
			X	Proceed to step n.
n.	Unsolder rectifier Z20 and measure voltage between E8 terminals for a DMM reading of 15 to 20 V rms.	X		Replace Z26 and connect Z20.
			X	Replace T1 and reinstall Z20.
o.	Connect oscilloscope at +15 V point nearest capacitor C93 and monitor an ac ripple voltage of less than 30 mV.	X		Proceed to step p.
			X	Replace C88.
p.	Press DPAV Power switch to OFF.			
q.	Remove jumper connected between two points marked +5 V.			
r.	Press DPAV Power switch to ON and measure voltage at +5 V point on right side toward resistor R182 for a reading of 4.950 to 5.050 V dc.	X		Proceed to step u.
			X	Proceed to step s.
s.	Unsolder rectifier Z22 and measure voltage between E11 terminals for a DMM reading of 8.5 to 11.5 V rms.	X		Replace Z28 and reinstall Z22.
			X	Replace T1 and reinstall Z22.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
t.	Connect oscilloscope at +5 V point on right side toward resistor R182 and monitor an ac ripple voltage of less than 30 mV.	X		Proceed to step u.
			X	Replace C94.
u.	Connect DMM between E26 (low) and E25 on main board. DMM reads 45.0 to 48.0 V dc.	X		Proceed to step x.
			X	Proceed to step v.
v.	Remove signal broadband isolation board and repeat measurement of step u.	X		Proceed to step 14.
			X	Replace signal broadband isolation board and proceed to step w.
w.	Unsolder rectifier Z24 on main board and measure voltage between E12 terminals for a DMM reading of 30 to 37 V dc.	X		Replace Z24.
			X	Replace T1 and reinstall Z24.
x.	Connect DMM between E29 (low) and E28 on main board. DMM reads 45.0 to 48.0 V dc.	X		Proceed to step 2.
			X	Proceed to step y.
y.	Remove reference isolation board and repeat voltage measurement of step x above	X		Proceed to step 13.
			X	Replace reference isolation board and proceed to step z.
z.	Unsolder rectifier Z25 on main board and measure voltage between E13 terminals. DMM reads 30 to 37 V dc.	X		Replace Z25.
			X	Replace T1 and reinstall Z25.
2	MAIN BOARD SIGNAL CHANNEL INOPERATIVE OR DOES NOT MEET SPECIFICATIONS			
a.	Set DPAV Function Selector switch to TOTAL and Voltage Scale switch to 1000 mV.			
b.	Connect ac calibrator to DPAV front panel SIG HI and LO connectors.			
c.	Connect ac differential voltmeter to output of ac calibrator.			
d.	Adjust ac calibrator for a reading of 983 and 1017 mV on DPAV display.	X		Proceed to step 3.
			X	Proceed to step e.
e.	Connect DMM between TP14 (ground) and TP13 on A/D converter, and monitor a reading of 8.600 to 8.900 V dc on DMM.	X		Proceed to step 6.
			X	Proceed to step f.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

·p	Procedure	Indication OK	Indication Not OK	Remedy
f.	Connect oscilloscope and DMM in parallel between TP9 (ground) and positive side of capacitor C11. Monitor the following:			
	(1) Oscilloscope displays a 4.55 to 5.00 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 V dc (fig. 6-1).	X		Proceed to step i.
			X	Proceed to step f(2).
	(2) Oscilloscope displays a 15.15 to 15.82 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 V dc.	X		Remove Z34 and proceed to step f(3).
			X	Proceed to step g.
	(3) Oscilloscope displays a 4.55 to 5.00 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 V dc.	X		Proceed to step i.
			X	Replace Z34 and proceed to step f(4).
	(4) Oscilloscope displays a 4.55 to 4.75 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 V dc.	X		Proceed to step g.
			X	Replace K2.
g.	Connect oscilloscope and DMM in parallel between TP9 (ground) and operational amplifier Z61-3 of main board. Oscilloscope displays a 2.5 to 3.0 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV dc.	X		Replace Z61.
			X	Proceed to step h.
h.	Connect oscilloscope and DMM in parallel between ISOL GND and TP1 on signal isolation board. Oscilloscope displays a 2.5 to 3.0 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV dc.	X		Replace T3.
			X	Proceed to step 15.
i.	Connect oscilloscope between TP9 (ground) and negative side of capacitor C17 on main board. Oscilloscope displays a 665 to 695 mV p-p sine wave, without distortion (fig. 6-1)	X		Proceed to step m.
			X	Proceed to step j.
j.	Remove integrated circuits Z31 and Z32 from main board.			
k.	Ground anode of CR6, energizing relay K5.			
l.	Replace Z31 and Z32. Oscilloscope displays a 665 to 695 mV p-p sine wave, without distortion.	X		Proceed to step 5.
			X	Z9, K3, K4, K5, R46, R47, or R48 defective. Replace defective component.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
m.	Connect oscilloscope in parallel with DMM between TP9 (ground) and positive side of capacitor C180 of main board. Oscilloscope displays a 7.5 to 8.5 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV dc.	X		Proceed to step n.
			X	Replace Z62.
n.	Connect DMM between TP9 (ground) and TP3. DMM reads -2.50 to -2.6 V dc.	X		Proceed to step s.
			X	Proceed to step o.
o.	Connect oscilloscope between TP9 (ground) and anode of diode CR25 on main board. Oscilloscope displays an 8.5 to 10.0 V p-p sine wave, without distortion but with a dead band around the zero crossover due to the diode switching (fig. 6-1). NOTE If either Z11 or Z12 is replaced, short input signal and adjust potentiometer R283 for 0.0 or adjust for 100.0 mV dc at anode of diode CR25. Disregard noise. Adjust potentiometer R116 for 0 V dc at TP8. Then adjust potentiometer R120 for -2.55 V dc at TP3. If this is beyond range of R120, set R120 at midrange and replace select-at-test resistor R310 with a resistor having a value that will produce specified output.	X		Proceed to step p.
			X	Replace Z11
p.	Disconnect ac calibrator and ac differential voltmeter from DPAV front panel and connect jumper wire between SIG HI and LO connectors.			
q.	Connect DMM between TP9 (ground) and TP3. DMM reads higher than 50 mV.	X		Proceed to step r.
			X	Replace Z12.
r.	Connect DMM between TP9 (ground) and anode of diode CR25. DMM reads higher than 100 mV.	X		Replace Z12.
			X	Replace Z11.
s.	Remove jumper wire from SIG HI and LO connectors.			
t.	Connect ac calibrator to SIG HI and LO connectors.			

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
u.	Connect ac differential voltmeter to output of ac calibrator.			
v.	Adjust ac calibrator for 1.0 V rms.			
w.	Connect DMM between TP9 (ground) and TP8. DMM reads 8.60 to 8.90 V dc.	X		Proceed to step 3.
			X	Replace Z15, Q17, Q16, or C47.
3	MAIN BOARD REFERENCE CHANNEL INOPERATIVE OR DOES NOT MEET SPECIFICATIONS			
a.	Connect ac calibrator to SIG HI and LO and REF HI and LO DPAV front panel connectors.			
b.	Connect differential voltmeter to ac calibrator.			
c.	Adjust ac calibrator for 1000.0 mV rms at 400.0 Hz or main board frequency.			
d.	Press front panel IN PHASE, 400 HZ, and 1000 MV switches. DPAV displays 983 to 1017 mV.	X		Proceed to step 4.
			X	Proceed to step e.
e.	Connect DMM between TP9 (ground) and TP8 on main board. DMM reads 8.60 to 8.90 V dc.	X		Proceed to step 6.
			X	Proceed to step f.
f.	Connect oscilloscope between GND and positive side of capacitor C146. Oscilloscope displays a 430 to 450 mV p-p sine wave without distortion.	X		Proceed to step g.
			X	Proceed to step k.
g.	Connect oscilloscope between TP9 (ground) and TP12. Oscilloscope displays a 620 to 660 mV p-p sine wave, without distortion (fig. 6-1).	X		Proceed to step h.
			X	Proceed to step m.
h.	Disconnect ac calibrator from SIG HI and LO connectors. Do not disturb connections to REF HI and LO connectors.			
i.	Adjust ac calibrator for 10.0 V rms at 400.0 Hz or main board frequency.			
j.	Connect oscilloscope between GND and positive side of capacitor C146. Oscilloscope displays a 140 to 160 mV p-p sine wave, without distortion.	X		Proceed to step w.
			X	Proceed to step k.
k.	Connect oscilloscope between GND and TP1 on reference isolation board.			
l.	Adjust ac calibrator for 1000 mV. Oscilloscope displays a 430 to 450 mV p-p sine wave, without distortion.	X		Replace T2.
			X	Refer to step 13.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
m.	Connect oscilloscope between GND and TP23. Oscilloscope displays a 635 to 665 mV p-p sine wave, with out distortion.	X		Proceed to step n.
			X	Replace Q41 or Q42.
n.	Remove operational amplifier Z47.			
o.	Connect oscilloscope and DMM in parallel between TP9 (ground) and microcircuit Z44-3. Oscilloscope displays a 510 mV p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV.	X		Proceed to step r.
			X	Replace Q45, Q46, or Z44 and proceed to step p.
p.	Connect DMM between GND and TP24. DMM reads 0.0 to 0.5 V dc.	X		Replace V1.
			X	Proceed to step q.
q.	Connect oscilloscope between TP9 (ground) and TP12. Oscilloscope displays a 3.5 V p-p sine wave, without distortion.	X		Proceed to step r.
			X	Replace Z44.
r.	Reinstall operational amplifier Z47.			
s.	Remove operational amplifier Z46.			
t.	Connect oscilloscope and DMM in parallel between GND and cathode of diode CR62. Oscilloscope displays a 12 to 15 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV dc. (There is a dead band about the zero crossover due to the diode switching.)	X		Proceed to step u.
			X	Replace Z47.
u.	Reinstall operational amplifier Z46.			
v.	Connect DMM between GND and negative side of diode CR60. DMM reads 2.0 to 3.0 V dc.	X		Replace Q47.
			X	Replace Z46.
w.	Set output of ac calibrator to 1.0 V rms at 400 Hz or main board frequency, and increase to 10.0 V rms. Lamp DS1 on reference isolation board goes on.	X		Replace K1 or Q1 or reference isolation board.
			X	Replace DS1, Q47, or Z45.
x.	Connect VOM between TP9 (ground) and TP26. VOM reads 4.5 to 5.5 V dc.	X		Proceed to step y.
			X	Proceed to step ab.
y.	Disconnect ac calibrator from REF HI and LO connectors.			
z.	Connect VOM between TP9 (ground) and TP26. VOM reads -0.5 to +0.5 V dc.	X		Proceed to step aa.
			X	Replace Q51, Q52, Z48, or Z50.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
aa.	DPAV front panel NO SYNC indicator goes on.	X		Proceed to step ab.
			X	Replace DS13 on readout board.
ab.	Connect ac calibrator to REF HI and LO connectors and adjust for 10.0 V rms at 400 Hz.			
ac.	Connect oscilloscope and DMM in parallel between GND and TP13. Oscilloscope displays a 4.5 to 4.7 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV dc (fig. 6-1).	X		Proceed to step ad.
			X	Replace C64, C65, Q25, or Z18.
ad.	Connect oscilloscope and DMM in parallel between GND and Z19-6 or TP30. Oscilloscope displays 4.5 to 4.7 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV dc.	X		Proceed to step ae.
			X	Replace Z19.
ae.	Remove integrated circuit Z51.			
af.	Connect oscilloscope between collector of transistor Q33 and GND. Oscilloscope displays waveform R of figure 6-1.	X		Reinstall Z51 and proceed to step ag.
			X	Replace C83, C177, Q31, Q32, or Q33 and reinstall Z51.
ag.	Remove integrated circuit Z6. Reinstall Z51			

NOTE

The timing in steps ah, ak, al, am, ao, ap, as, at, and au is based on 400 Hz only. It will be different for other frequencies.

Step	Procedure	Indication OK	Indication Not OK	Remedy
ah.	Connect oscilloscope between TP9 (ground) and socket pin XZ6-5. Oscilloscope displays a positive-going pulse 833 μs wide with period of 1700 μs.	X		Proceed to step ai.
			X	Replace Z54 or Z55 and reinstall Z6.
ai.	Set oscilloscope to external sync.			
aj.	Connect socket pin XZ6-5 to oscilloscope external sync connector.			
ak.	Connect oscilloscope between TP9 (ground) and socket pin Z6-1. Oscilloscope displays a positive-going pulse 833 μs wide with period of 1700 μs and 1250 μs delay.	X		Proceed to step al.
			X	Replace Z54, Z55, or Z57 and reinstall Z6.
al.	Connect oscilloscope, triggered as in step ai, between TP9 (ground) and socket pin XZ6-9. Oscilloscope	X		Proceed to step am.
			X	Replace Z56, Z57, or Z58 and reinstall Z6.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
	displays a positive-going pulse 833 μs wide with period of 1700 μs and 625 μs delay.			
am.	Connect oscilloscope, triggered as in step ai, between TP9 (ground) and socket pin XZ6-12. Oscilloscope displays positive-going pulse 833 μs wide with 1875 μs delay.	X		Proceed to step an.
			X	If responses to steps ag thru am are negative, integrated circuit Z51 or Z52 is defective Otherwise, integrated circuit Z56, Z57, or Z58 is defective. Replace defective component and reinstall Z6.
an.	Remove integrated circuit Z8.			
ao.	Connect oscilloscope, triggered as in step v, between GND and socket pin XZ8-5. Oscilloscope displays a positive-going pulse 833 μs wide with period of 1700 μs and 625 μs delay.	X		Proceed to step ap.
			X	Replace Z60.
ap.	Connect oscilloscope, triggered as in step ai, between GND and socket pin XZ8-2. Oscilloscope displays a positive-going pulse 833 μs wide with period of 1700 μs delay.	X		Reinstall Z8 and proceed to step aq.
			X	Replace Z60 and reinstall Z8.
aq.	Connect oscilloscope, triggered as in step ai, between GND and Z3-3. Oscilloscope displays a negative-going pulse 5 μs wide with period of 2500 μs delay.	X		Reinstall Z6 and proceed to step ar.
			X	Replace Z60 or Z3 and reinstall Z6.
ar.	Press REFERENCE OFFSET OUT switch.			
as.	Connect oscilloscope between GND and TP15. Oscilloscope displays waveform T of figure 6-1.	X		Proceed to step at.
			X	Replace CR32, Q27, or Z8 if defective.
at.	Connect oscilloscope between GND and TP16. Oscilloscope displays waveform T of figure 6-1.	X		Proceed to step au.
			X	Replace CR34, Q30, or Z8.
au.	Connect oscilloscope between GND and front panel and TP19. Oscilloscope displays waveform S of figure 6-1.	X		Proceed to step av.
			X	Replace Z7.
av.	Connect DMM between GND and TP19. DMM reads -1.0 to +1.0 mV.	X		Proceed to step bc.
			X	Proceed to step aw.
aw.	Disconnect ac calibrator from REF HI and LO connectors.			
ax.	Connect oscilloscope and DMM in parallel between GND and TP19.			

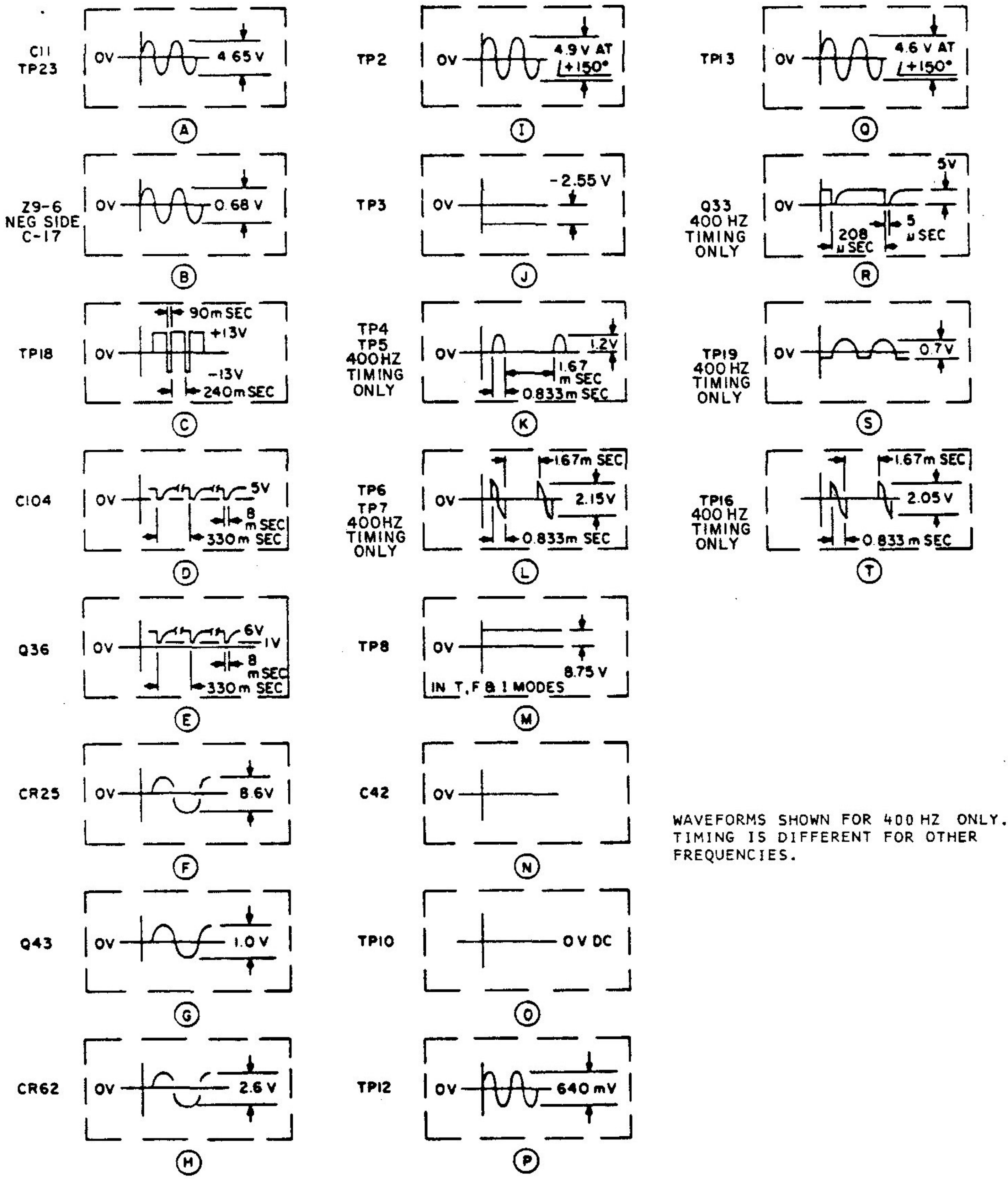


Figure 6-1. Main Board - Waveforms

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
ay.	Adjust potentiometer R157 for 0.0 V dc level. Precise adjustment will not be possible because of drift.			
az.	Reconnect ac calibrator to REF HI and LO connectors and adjust ac calibrator for 10.0 V rms at 400 Hz or main board frequency.			
ba.	Adjust potentiometer R161 for 0.0 V dc level. DMM reads -1.0 to +1.0 mV.	X		Proceed to step bc.
			X	Proceed to step bd.
bb.	Connect DMM between TP9 (ground) and TP11. DMM reads -1.0 to +1.0 mV.	X		Replace Z7.
			X	Replace Q23, Q53, or Z8.
bc.	Press front panel REFERENCE OFFSET IN switch			
bd.	Connect DMM between TP9 (ground) and TP11.			
be.	Vary setting of front panel REFERENCE OFFSET ±45° control while observing meter. DMM dc voltage reading changes as setting of REFERENCE OFFSET ±45° control is adjusted.	X		Proceed to step bf.
			X	Replace Q5, Q23, Q53, or Z5.
bf.	Press front panel REFERENCE OFFSET IN switch.			
bg.	Connect oscilloscope between GND and TP19.			
bh.	Vary setting of REFERENCE OFFSET ±45° control while observing oscilloscope.	X		Proceed to step bi.
			X	Replace Q29 or Q57.
	NOTE When REFERENCE OFFSET ±45° control is rotated fully counterclockwise, signal at TP19 should change from half-wave to full-wave rectified sine wave.			
bi.	Connect VOM between TP9 (ground) and TP26. VOM reads 4.5 to 5.5 V dc.	X		Proceed to step bj.
			X	Replace Q53.
bj.	Disconnect ac calibrator from REF HI and LO connectors.			
bk.	Connect VOM between TP9 (ground) and TP26. Observe the following readings:			

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
	(1) VOM reads -0.5 to +0.5 V dc.	X		Proceed to step bk(2)
			X	Replace either Q51, Q52, or Z4.
	(2) NO SYNC indicator goes on.	X		Refer to step 4.
			X	Replace DS13 on readout board.
	MAIN BOARD PHASE MODES INOPERATIVE OR OUT OF SPECIFICATIONS			
a.	Set up test equipment as shown in figure 6-2, without differential voltmeter.			
b.	Adjust phase angle generator for 0.0° phase shift.			
c.	Adjust ratio transformer for a 1000 mV output when input is 10 V rms.			
d.	Press front panel IN PHASE, 1000 MV, REFERENCE OFFSET OUT, and 400 HZ (or main board frequency) switches.			
e.	Adjust ac calibrator for 10.000 V rms at 400 Hz.			
f.	Connect DMM between TP14 (ground) and TP13 on A/D converter. DMM reads 8.600 to 8.900 V dc.	X		Refer to step 5.
			X	Proceed to step g.
g.	Connect oscilloscope between TP9 (ground) and TP1 on main board. Oscilloscope displays a 665 to 695 mV p-p sine wave, without distortion.	X		Proceed to step h.
			X	Replace C17 or K6.

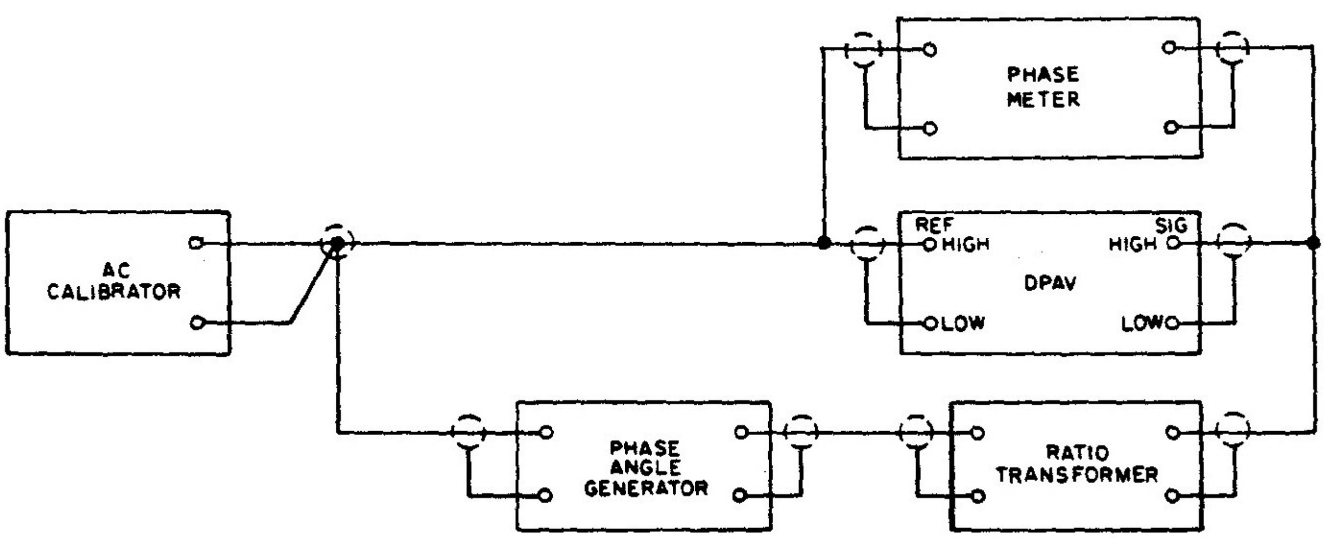


Figure 6-2. Phase Mode Troubleshooting, Test Set-Up

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
h.	Connect oscilloscope between TP9 (ground) and TP2. Oscilloscope displays 4.8 to 5.5 V p-p, without distortion.	X		Proceed to step i.
			X	Replace either C19, Q10, Q11 or Z10.
i.	Connect oscilloscope between TP9 (ground) and TP31. Oscilloscope displays 4.9 to 5.5 V p-p, without distortion.	X		Proceed to step j.
			X	Replace Z13.
	NOTE The timing in steps j thru r is based on 400 Hz only. It will differ for other frequencies.			
j.	Connect oscilloscope between TP9 (ground) and TP4. Oscilloscope displays waveform K of figure 6-1.	X		Proceed to step k.
			X	Replace either Z6, Q12, or CR13.
k.	Connect oscilloscope between TP9 (ground) and TP5. Oscilloscope displays waveform K of figure 6-1.	X		Proceed to step l.
			X	Replace either Z6, Q13, or CR15.
l.	Connect oscilloscope between TP9 (ground) and TP6. Oscilloscope displays waveform L of figure 6-1.	X		Proceed to step m.
			X	Replace either Z6, Q14, or CR17.
m.	Connect oscilloscope between TP9 (ground) and TP7. Oscilloscope displays waveform L of figure 6-1.	X		Proceed to step n.
			X	Replace either Z6, Q15, or CR20.
n.	Adjust phase angle generator for 90° phase shift.			
o.	Connect oscilloscope between TP9 (ground) and TP4. Oscilloscope displays waveform L of figure 6-1.	X		Proceed to step p.
			X	Replace either Z6, Q12, or CR13.
p.	Connect oscilloscope between TP9 (ground) and TP5. Oscilloscope displays waveform L of figure 6-1 with period of 2.500 ms.	X		Proceed to step q.
			X	Replace either Z6, Q13, or CR15.
q.	Connect oscilloscope between TP9 (ground) and TP6. Oscilloscope displays a 1.15- to 1.25-V half wave rectified sine wave, without distortion, 0.833 ms wide with period of 2.500 ms.	X		Proceed to step r.
			X	Replace either Z6, Q14, or CR17.
r.	Connect oscilloscope between TP9 (ground) and TP7. Oscilloscope displays 1.15- to 1.25-V half wave rectified sine wave, without distortion, 0.833 ms wide with period of 1.70 ms.	X		Proceed to step s.
			X	Replace either Z6, Q15, or CR20.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

tep	Procedure	Indication OK	Indication Not OK	Remedy
s.	Connect DMM between TP9 (ground) and operational amplifier Z16-6. DMM reads -2.5 to -2.6 V dc.	X		Proceed to step t.
			X	Replace Z16.
t.	Adjust phase angle generator for 0° phase shift.			
u.	Connect DMM between TP9 (ground) and operational amplifier Z14-6. DMM reads -2.5 to -2.6 V dc.	X		Proceed to step v.
			X	Replace Z14.
v.	Connect DMM between TP9 (ground) and TP8. DMM reads 8.60 to 8.90 V dc.	X		Proceed to step w.
			X	Replace either Z15, Q16, or C47.
w.	Adjust phase angle generator for 90° phase shift.			
x.	Connect DMM between TP9 (ground) and TP10. DMM reads 8.60 to 8.90 V dc.	X		Refer to step 5.
			X	Replace either Z17 or C51.
5	MAIN BOARD AUTORANGING CIRCUIT INOPERATIVE OR OUT OF SPECIFICATION			
	CAUTION Do not attempt to troubleshoot automatic function of autoranging circuit unless manual function is full operational.			
a.	Adjust phase angle generator for 0° phase shift.			
b.	Press IN PHASE and 1000 MV switches. Apply 1000 mV to SIG HI and LO connectors.			
c.	Connect oscilloscope between TP9 (ground) and TP18. Oscilloscope displays waveform A of figure 6-3.	X		Proceed to step d.
			X	Replace Z36.
d.	Connect oscilloscope between TP9 (ground) and anode of diode CR96. Oscilloscope displays waveform E of figure 6-1.	X		Proceed to step e.
			X	Replace Z35.
e.	Connect oscilloscope between TP9 (ground) and Z38, pin 8. Oscillopscope displays waveform B of figure 6-3.	X		Proceed to step f.
			X	Replace either Z38 or Z36.
f.	Connect oscilloscope between TP9 (ground) and TP17. Oscilloscope displays waveform D of figure 6-1.	X		Proceed to step g.
			X	Replace either Q38, Q37, or CR96.

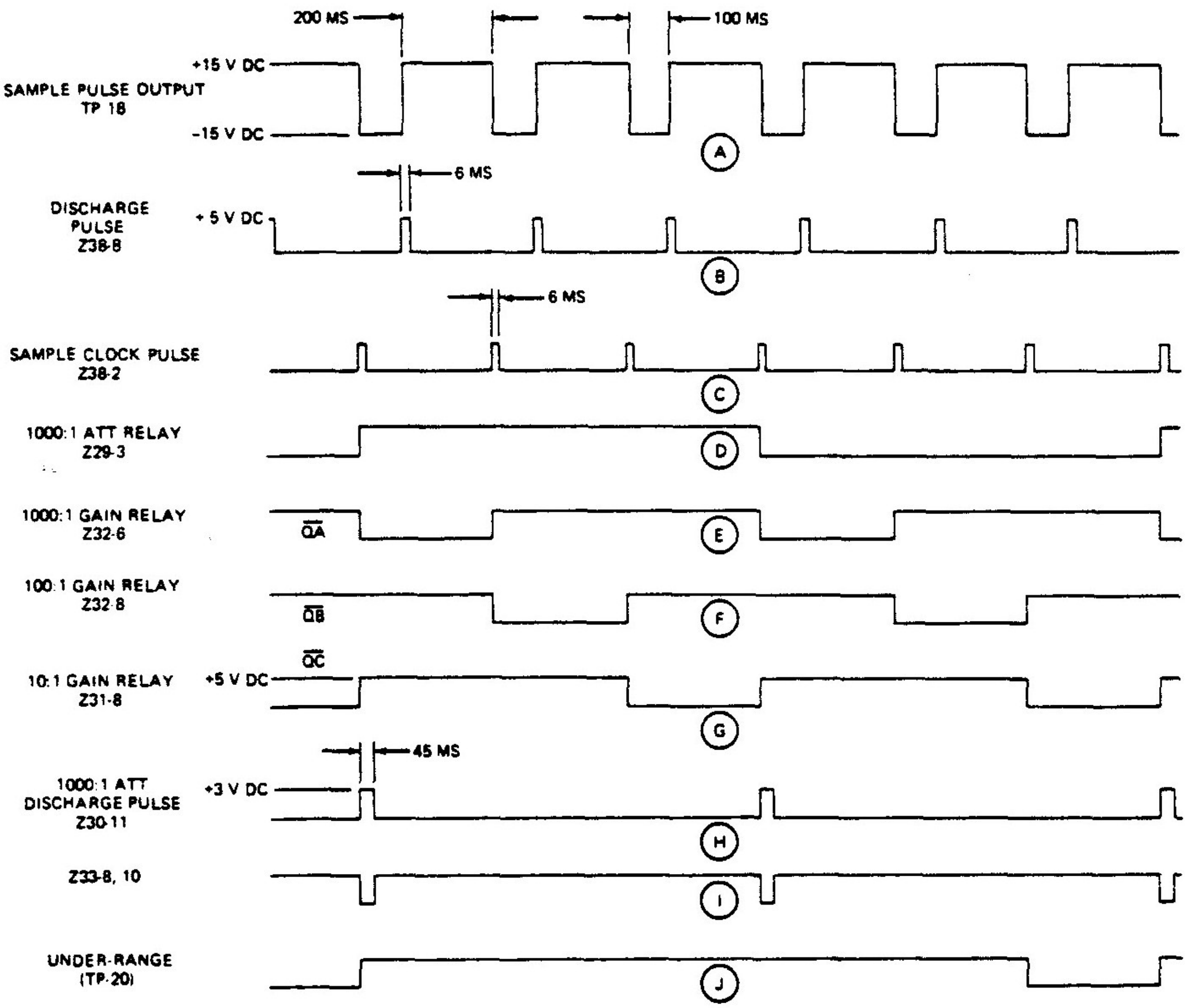


Figure 6-3. Autoranging Logic Waveform - Voltage Mode

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
g.	Press front panel PHASE ANGLE switch.			
h.	Connect VOM to TP28.			
i.	Adjust potentiometer R210 one turn clockwise and one turn counter-clockwise. VOM reads change in voltage as setting of potentiometer R210 is adjusted. NOTE Change in each direction from normal setting should be approximately 0.2 V dc.			
j.	Press front panel IN PHASE switch.			
k.	Connect VOM between TP9 (ground) and TP27. VOM reads 7 to 9 V dc.	X		Proceed to step n.
			X	Proceed to step l.
l.	Connect VOM between TP9 (ground) and TP27.			
m.	Adjust potentiometer R204 until VOM reads 8.7 V dc. VOM reads 7 to 9 V dc.	X		Proceed to step n.
			X	Replace R204.
n.	Connect VOM between TP9 (ground) and TP28. VOM reads 2 to 4 V dc.	X		Proceed to step q.
			X	Proceed to step o.
o.	Connect VOM between TP9 (ground) and TP28.			
p.	Adjust potentiometer R209 until VOM reads between 2 to 4 V dc.	X		Proceed to step q.
			X	Replace R209.
q.	Connect oscilloscope, and VOM in parallel between TP9 (ground) and TP21.			
r.	Turn power off and remove Z40. Turn power on and observe a 40 ms (5 V) pulse, with a 280 ms delay. Turn power off and reinstall Z40.	X		Proceed to step s.
			X	Replace Z41.
s.	Remove Z42. With a clip lead short TP20 to TP21. Turn power on and monitor clock pulses C thru J of figure 6-3.	X		Proceed to step u.
			X	Troubleshoot using figure 6-3 and associated schematic.
t.	Turn power off and reinstall Z42. Turn power on.			
u.	Connect oscilloscope between TP9 (ground) and TP20.			

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
v.	Decrease output of ac calibrator below 1 V rms. Oscilloscope displays change from positive 10 ms pulse to positive 200 ms pulse and back to positive 10 ms pulse when output of ac calibrator is decreased to 0.9 V rms.	X		Proceed to step x.
			X	Adjust ac calibrator for 10.0 V rms. Proceed to step w.
w.	Adjust potentiometer R209 until voltage at TP20 toggles from negative to positive value when output of ac calibrator is decreased to 1.0 V rms. Repeat steps u and v. Oscilloscope displays change from positive 200 ms pulse to 10 ms pulse when output of ac calibrator is varied between 0.9 and 1.1 V rms.	X		Proceed to step x.
			X	Replace Z42.
x.	Depress PHASE ANGLE push button and repeat step s. Monitor clock pulses of figure 6-4.	X		End of test. Disconnect test set up.
			X	Replace associated IC per figure 6-4.
6	A/D CONVERTER CLOCK AND SWITCHING INOPERATIVE OR OUT OF SPECIFICATION			
a.	Connect output of ac calibrator to phase angle generator and ratio transformer.			
b.	Connect output of phase angle generator to DPAV front panel REF HI and LO connectors.			
c.	Connect output of ratio transformer to DPAV front panel SIG HI and LO connectors.			
d.	Adjust phase angle generators for a 0.0° phase shift.			
e.	Adjust ratio transformer for a 1000 mV output when input is 10 V rms.			
f.	Press DPAV front panel IN PHASE, 1000 MV, and 400 HZ (or main board frequency) switches.			
g.	Adjust ac calibrator for 10.000 V rms at 400 Hz or main board frequency.			
h.	Connect DMM between TP14 (ground) and TP13. DMM reads 8.60 to 8.90 V dc.	X		Proceed to step i.
			X	Replace ribbon cable J4.
i.	Connect DMM between TP14 (ground) and TP12. DMM reads -0.15 to +0.15 V dc.	X		Proceed to step j.
			X	Replace ribbon cable J4.

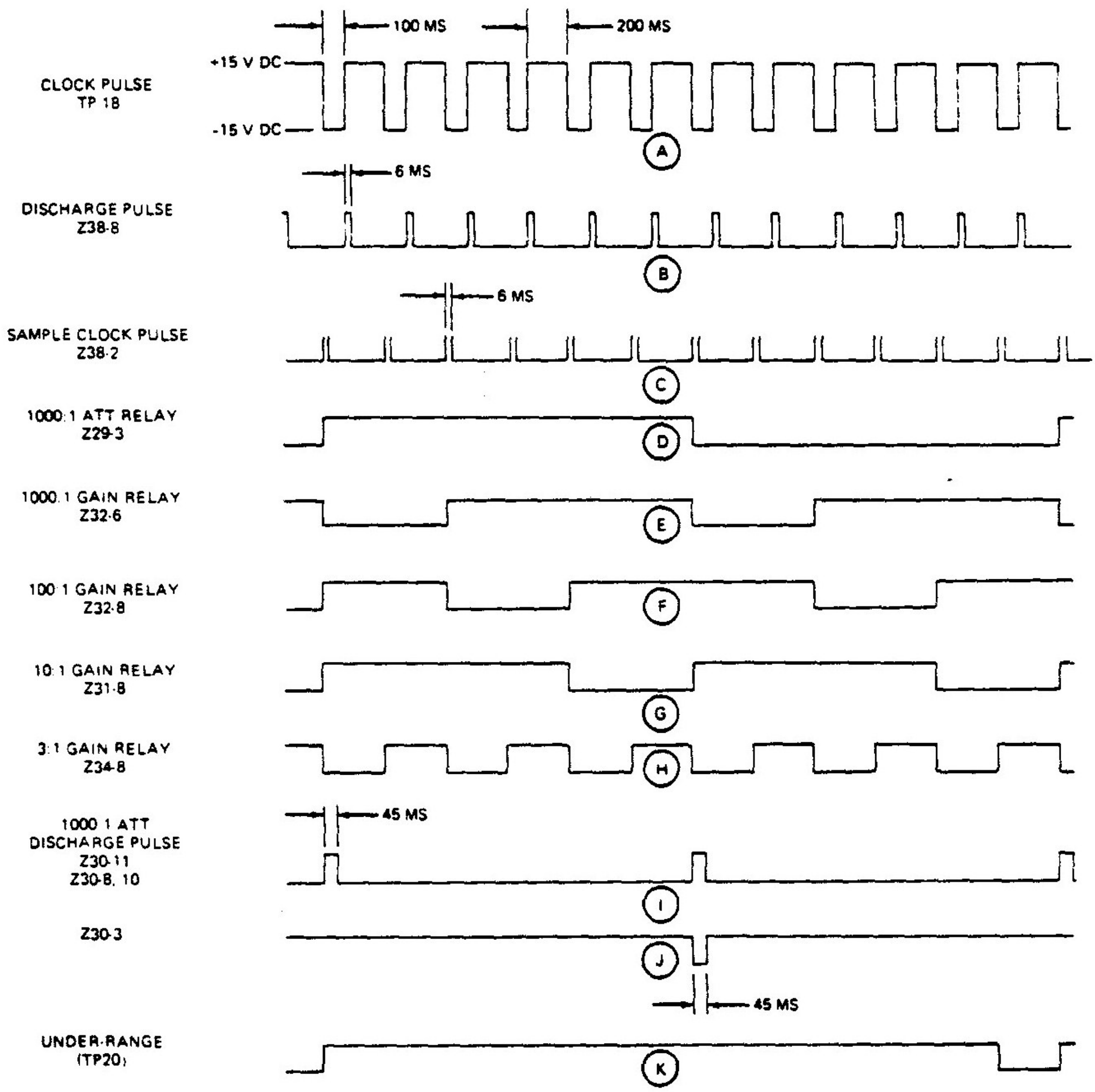


Figure 6-4. Autoranging Logic Waveform - Angle Mode

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
j.	Adjust phase angle generator for 270° phase shift.			
k.	Connect DMM between TP14 (ground) and TP12. DMM reads 8.60 to 8.90 V dc.	X		Proceed to step l.
			X	Replace ribbon cable J4.
l.	Connect DMM between TP14 (ground) and TP7. DMM reads -9.50 V dc.	X		Proceed to step n.
			X	Proceed to step m.
m.	Adjust potentiometer R68 for reading of -9.5 V dc.	X		Proceed to step n.
			X	Replace either Z29, Q20, or CR12.
n.	Connect oscilloscope between TP14 (ground) and TP1. Oscilloscope displays a chain of clock pulses with period of 21 to 25 μs and 5 V p-p.	X		Proceed to step p.
			X	Refer to alignment and adjustment procedures (Section 5). Perform clock pulse alignment procedures and proceed to step o.
o.	Connect oscilloscope between TP14 (ground) and TP1. Oscilloscope displays chain of clock pulses with period of 21 to 25 μs and 5 V p-p.	X		Record actual pulse width and proceed to step p.
			X	Replace either Q1, Q2, Z16, or Z15.
p.	Press front panel OFF switch.			
q.	Disconnect ratio transformer from SIG HI and LO connectors.			
r.	Connect jumper wire between SIG HI and LO connectors.			
s.	Connect clip lead between TP14 (ground) to TP9.			
t.	Remove operational amplifier Z38.			
u.	Press front panel ON switch.			
v.	Connect oscilloscope between TP14 (ground) and TP6. Oscilloscope displays chain of clock pulses with pulse width 1-1/2 times pulse width recorded for step o, period of 38 to 42 μs and 9.5 V p-p.	X		Proceed to step 7.
			X	Refer to paragraph 5.8.7.2. At completion, proceed to step w.
w.	Connect oscilloscope between TP14 (ground) and TP6. Oscilloscope displays chain of clock pulses with a pulse width 1-1/2 times pulse width recorded for step o, period of 38 to 42 μs, and 9 V p-p.	X		Proceed to step y.
			X	Proceed to step x.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
x.	Connect VOM to between source and drain of FETS Q9, Q12, and Q10 and between collector and emitter of transistors Q6, Q7, Q17, and Q18. VOM reads more than 50 ohms in any case.	X		Replace Z13, Z19, Z22, or Z25.
			X	Replace either Q6, Q7, Q9, Q10, Q12, Q17, or Q18. NOTE: If TP6 is still out of tolerance after completion of the above, proceed to step y.
y.	Press front panel OFF switch.			
z.	Remove jumper wire from TP14 (ground) and TP9.			
aa.	Reinstall operational amplifier Z38.			
ab.	Remove jumper wire from SIG HI and LO connectors.			
ac.	Connect output of ratio transformer to SIG HI and LO connectors.			
ad.	Set ratio transformer for 10:1 reduction.			
ae.	Adjust ac calibrator for 10.000 V rms at 400 Hz or main board frequency.			
af.	Press front panel IN PHASE, 1000 MV, 400 HZ (or main board frequency), and ON switches.			
ag.	Connect oscilloscope between TP14 (ground) and TP5. Oscilloscope displays dual slope ramp waveform and dimensions shown in figure 6-5.	X		End of troubleshooting. Disconnect all test equipment.
			X	Proceed to step 10.
7	A/D CONVERTER HYSTERESIS CIRCUITRY INOPERATIVE OR OUT OF SPECIFICATION			
a.	Connect ac calibrator to phase angle generator.			
b.	Connect phase angle generator to REF HI and LO connectors and set generator to 0°.			
c.	Connect jumper wire between SIG HI and LO connectors.			
d.	Apply 10.000 V rms at 400 Hz or main board frequency, to REF HI and LO connectors.			

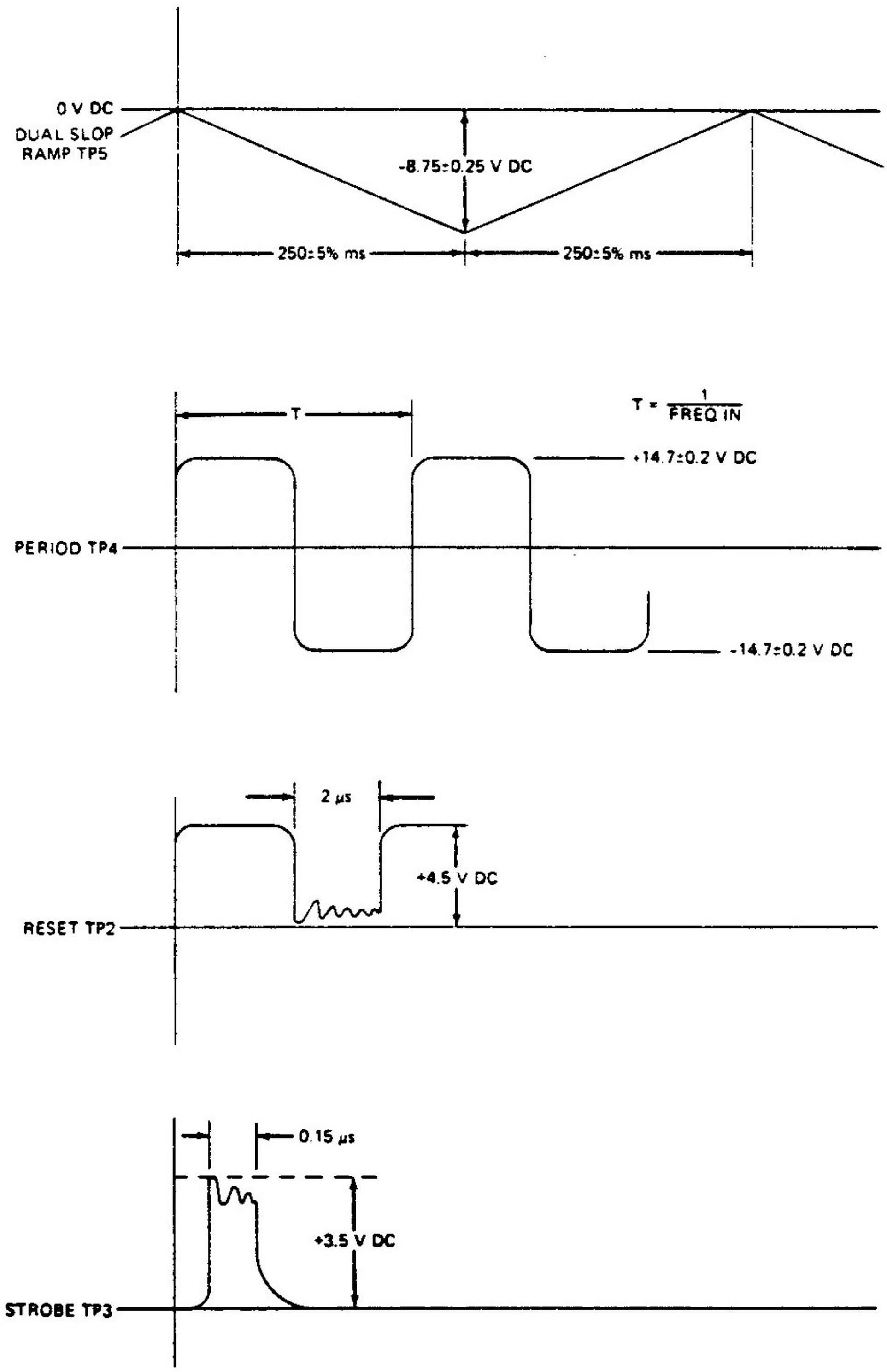


Figure 6-5. A/D Converter Waveforms

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
e.	Press front panel 400 HZ (or main board frequency) and 1000 MV switches.			
f.	Press front panel IN PHASE switch.			
g.	Connect DMM between TP14 (ground) and TP13 and observe a reading of 0.0 V dc on DMM	X		Proceed to step h.
			X	Refer to alignment and adjustment procedures (para. 5.8.6.4).
h.	Connect DMM between TP14 (ground) and TP11. DMM reads 0.0 V dc.	X		Proceed to step m.
			X	Proceed to step i.
i.	Tag and remove operational amplifier Z34 and integrated circuit Z26.			
j.	Connect DMM between TP14 (ground) and TP11.			
k.	Adjust potentiometer R168 for DMM reading of 0.0 V dc.	X		Proceed to step l.
			X	Replace Z38.
l.	Reinstall Z34 and Z26.			
m.	Connect DMM between TP14 (ground) and cathode of CR25 and observe a reading of -150 to -200 mV dc.	X		Proceed to step r.
			X	Proceed to step n.
n.	Tag and remove operational amplifier Z34 and integrated circuit Z26.			
o.	Connect DMM between TP14 (ground) and cathode of CR25.			
p.	Adjust potentiometer R147 for DMM reading of -150 mV. DMM reads -150 to -200 mV dc.	X		Proceed to step r.
			X	Replace either Z37 or Q23.
q.	Reinstall Z34 and Z26.			
r.	Press front panel QUAD switch.			
s.	Connect DMM between TP14 (ground) and TP12 and observe a DMM reading of 0.0 V dc.	X		Proceed to step t.
			X	Refer to alignment and adjustment procedures (para. 5.8.6.4).
t.	Connect DMM between TP14 (ground) and TP10 and observe a DMM reading of 0.0 V dc.	X		Proceed to step y.
			X	Proceed to step u.
u.	Tag and remove integrated circuits Z26 and Z40 and operational amplifier Z34.			
v.	Connect DMM between TP14 (ground) and TP10.			
w.	Adjust potentiometer R143 for DMM reading of 0.0 V.	X		Proceed to step y.
			X	Replace Z36.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
x.	Reinstall Z26, Z40, and Z34.			
y.	Connect DMM between TP14 (ground) and cathode of CR26 and observe a DMM reading of -150 to -200 mV dc.	X		Proceed to step ad.
			X	Proceed to step z.
z.	Tag and remove integrated circuits Z26 and Z40 and operational amplifier Z34.			
aa.	Connect DMM between TP14 (ground) and cathode of CR26.			
ab.	Adjust potentiometer R126 for DMM reading of -150 mV. DMM reads -150 to -200 mV dc.	X		Proceed to step ac.
			X	Replace either Z35 or Q26.
ac.	Reinstall Z26, Z40, and Z34.			
ad.	Press front panel IN PHASE switch and observe DPAV digital display of 0.0 mV.	X		Proceed to step ae.
			X	Replace Q29.
ae.	Press front panel QUAD switch and observe DPAV digital display of 0.0 mV.	X		End of troubleshooting. Disconnect all test equipment.
			X	Replace Q30.
8	A/D CONVERTER PHASE SENSITIVE VOLTAGE CIRCUITRY INOPERATIVE OR OUT OF SPECIFICATION			
a.	Set up test equipment shown in figure 6-6.			
b.	Adjust phase angle generator for 180° phase shift.			

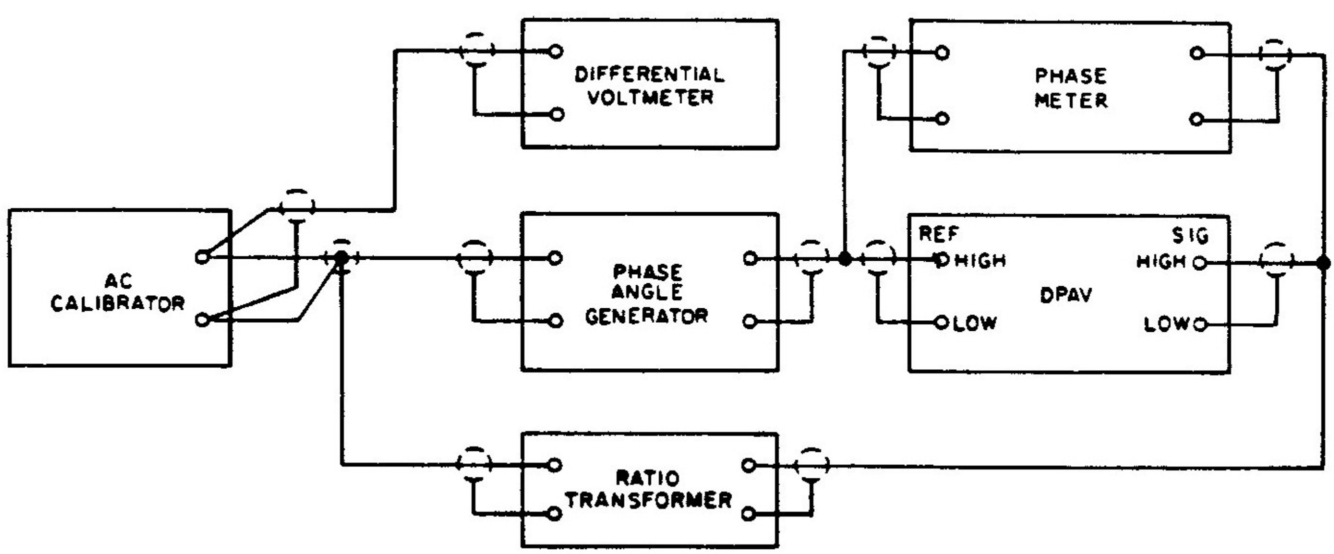


Figure 6-6. A/D Converter Phase Sensitive Voltage Test Set-Up

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication		Remedy
		OK	Not OK	
c.	Set ratio transformer to reduce voltage by a 10:1 ratio.			
d.	Adjust ac calibrator for 10.000 V rms at 400 Hz or main board frequency.			
e.	Press front panel IN PHASE, 400 HZ, and 1000 MV switches and observe DPAV digital display for -1000.0 mV.	X		Proceed to step k.
			X	Proceed to step f.
f.	Connect DMM between TP14 (ground) and TP11 and observe a DMM reading of 9.3 to 9.7 V dc.	X		Proceed to step l.
			X	Proceed to step g.
g.	Connect DMM between TP14 (ground) and TP11.			
h.	Adjust potentiometer R161 for DMM reading of -1000 mV on DPAV readout display and a DMM reading of 9.3 to 9.7 V dc.	X		Proceed to step k.
			X	Proceed to step i.
i.	Tag and remove operational amplifier Z34.			
j.	Connect DMM between TP14 (ground) and TP11 and observe a DMM reading of 9.3 to 9.7 V dc.	X		Replace Z34.
			X	Replace either Z38 or R161.
k.	Reinstall Z34.			
l.	Adjust phase angle generator for phase shift of 0.0° and observe DPAV digital display of +1000.0 mV.	X		Proceed to step p.
			X	Proceed to step m.
m.	Connect DMM between TP14 (ground) and TP11 and observe a DMM reading of 9.3 to 9.7 V dc.	X		Proceed to step p.
			X	Proceed to step n.
n.	Connect DMM between TP14 (ground) and TP11.			
o.	Adjust potentiometer R153 for DMM reading of +1000 mV on DPAV display. DMM reads 9.3 to 9.7 V dc.	X		Replace K1 or K2. If DPAV still does not display +1000.0 mV, refer to step 10.
			X	Replace R153 or Z37.
p.	Set up test equipment as shown in figure 6-6.			
q.	Adjust phase angle generator for 90° phase shift.			
r.	Press front panel QUAD switch.			
s.	Connect DMM between TP14 (ground) and TP10 and observe a DMM reading of 9.3 to 9.7 V dc.	X		Proceed to step y.
			X	Proceed to step t.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
t.	Connect DMM between TP14 (ground) and TP10.			
u.	Adjust potentiometer R132 for DMM reading of -1000 mV on DPAV display. DMM reads 9.3 to 9.7 V dc.	X		Proceed to step x.
			X	Proceed to step v.
v.	Tag and remove operational amplifier Z34.			
w.	Connect DMM between TP14 (ground) and TP10 and observe a DMM reading of 9.3 to 9.7 V dc.	X		Replace Z34.
			X	Replace Z36 or R132.
x.	Reinstall Z34.			
y.	Connect input of phase angle generator to ac calibrator and output to DPAV front panel REF HI and LO connectors.			
z.	Connect input of ratio transformer to ac calibrator.			
aa.	Adjust phase angle generator for 270° phase shift.			
ab.	Connect DMM between TP14 (ground) and TP10 and observe a DMM reading of 9.3 to 9.7 V dc.	X		End of troubleshooting. Disconnect all test equipment.
			X	Proceed to step ac.
ac.	Adjust potentiometer R128 for DMM reading of +1000 mV on DPAV display and observe the following:			
	(1) DMM reads 9.3 to 9.7 V dc.	X		Proceed to step ac(2).
			X	Replace Z35 or R128.
	(2) DPAV displays +1000.0 mV.	X		End of troubleshooting. Disconnect all test equipment.
			X	Replace K1 or K2.
9	A/D CONVERTER ANGLE SEGMENT DETECTORS INOPERATIVE OR OUT OF SPECIFICATION			
a.	Connect calibrator to front panel SIG HI and LO connectors and also to input of phase angle generator.			
b.	Connect output of phase angle generator to front panel REF HI and LO connectors and set generator to 0°.			
c.	Press front panel PHASE ANGLE and 400 HZ (or main board frequency) switches.			

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
d.	Adjust ac calibrator for 1000.0 mV at 400 Hz, or main board frequency, and observe DPAV digital display of +0.0°.	X		Proceed to step e.
			X	Proceed to step g.
e.	Adjust phase angle generator from 0 to 45° for phase shift in 1° increments and observe digital display for appropriate angle ±0.25°.	X		Proceed to step m.
			X	Proceed to step g.
f.	Press front panel OFF switch.			
g.	Tag and remove operational amplifiers Z36 and Z38.			
h.	Connect both TP10 and TP11 to TP14 (ground).			
i.	Disconnect ac calibrator from SIG HI and LO connectors.			
j.	Connect jumper wire between SIG HI and LO connectors.			
k.	Press front panel ON switch.			
l.	Connect VOM between TP14 (ground) and TP19. If VOM reads +15 V dc, adjust potentiometer R115 for transition to -15 V dc. If reading is -15 V dc, adjust R115 for transition to +15 V dc.	X		Proceed to step o.
			X	Proceed to step m.
m.	Tag and remove integrated circuit Z26 and repeat step l.	X		Replace Z26.
			X	Reinstall Z26 and proceed to step n.
n.	Tag and remove integrated circuit Z2 and repeat step l.	X		Replace Z2.
			X	Replace either Z34, Q27, or R115 and reinstall Z2.
o.	Connect VOM between TP14 (ground) and TP18.			
p.	Adjust potentiometer R86 for voltage transition at TP18.	X		Proceed to step q.
			X	Replace either Z30, R86, or Q24.
q.	Connect VOM between TP14 (ground) and TP17.			
r.	Adjust potentiometer R95 for a voltage transition at TP17.	X		Proceed to step s.
			X	Replace either Z31, R95, or Q25.
s.	Connect DMM between TP14 (ground) and TP8 and observe a DMM reading of 0.0 V dc.	X		Proceed to step x.
			X	Proceed to step t.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
t.	Connect DMM between TP14 (ground) and TP8.			
u.	Adjust potentiometer R79 for DMM reading of 0.0 V dc.	X		Proceed to step x.
			X	Replace Z27 or R79.
v.	Remove connections from TP14 (ground), TP11, and TP10.			
w.	Remove jumper wire from SIG HI and LO connectors and reconnect ac calibrator to SIG HI and LO connectors.			
x.	Repeat step e and observe a DPAV display for proper angle ±0.25°.	X		End of troubleshooting. Disconnect all test equipment.
			X	Replace Z28, K3 or K4.
10	A/D CONVERTER DIGITAL CHECKS CIRCUITRY INOPERATIVE OR OUT OF SPECIFICATION			
a.	Connect input of phase angle generator to ac calibrator and output to input of ratio transformer.			
b.	Connect output of ratio transformer to SIG HI and LO connectors.			
c.	Connect ac calibrator to REF HI and LO connectors.			
d.	Press front panel TOTAL, 1000 MV, and 400 HZ (or main board frequency) switches.			
e.	Adjust ac calibrator for 1000.0 mV rms at 400 Hz or main board frequency.			
f.	Connect oscilloscope between TP14 (ground) and TP5. Oscilloscope displays waveform and dimensions of figure 6-5.	X		Proceed to step t.
			X	Proceed to step g.
g.	Turn power off. Tag and remove integrated circuits Z14 and Z22.			
h.	Ground integrated circuit Z13-2.			
i.	Connect oscilloscope between GND and TP23. Signal jumps from logic 0 to logic 1 when probe is removed.	X		Remove ground from Z13-2 and proceed to step j.
			X	Replace either Z13 or Z19.
j.	Connect oscilloscope between TP14 (ground) and TP5.			
k.	Touch and hold grounding probe for approximately 3 to 5 seconds to integrated circuit Z13-1. Oscil-	X		Proceed to step r.
			X	Proceed to step l.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
	loscope traces sink slowly to approximately -15 V and then rises rapidly to 0 V when probe is removed.			
l.	Connect oscilloscope between TP14 (ground) and TP6.			
m.	Touch and hold grounding probe for approximately 3 to 5 seconds to integrated circuit Z13-1. Oscilloscope traces dip to -9.5 V dc, then jumps back to 1.0 V dc when probe is removed.	X		Replace Z25 or Z24.
			X	Replace either Q10, Q11, Q12, Q14, Q15, or Q16. Proceed to step n.
n.	Turn power off and reinstall Z14 and Z22.			
o.	Remove operational amplifier Z25.			
p.	Connect TP5 to SIG HI connector.			
q.	Turn power on. Connect oscilloscope between GND (TP14) and TP4 and observe a rounded square wave with dimensions shown in figure 6-5.	X		Proceed to step r.
			X	Replace Z23 or Z22.
r.	Turn power off. Remove connection to TP5 and reinstall Z25. Turn power on and monitor TP23 for a 5 V, 260 ms pulse.	X		Proceed to step s.
			X	Replace Z22. If still no good, proceed to step s.
s.	Connect oscilloscope between GND (TP14) and TP3. Set oscilloscope for display of 250- to 400- ns duration. Oscilloscope displays waveshape and dimensions shown in figure 6-5.	X		Proceed to step t.
			X	Replace Z21.
t.	Connect oscilloscope between GND and TP2 and observe a signal with waveshape and dimensions shown in figure 6-5.	X		Proceed to stpe u.
			X	Replace Z20.
u.	Connect phase cal output to DPAV SIG HI and LO connectors and also to the input of the phase generator. Connect the output of the phase generator to SIG HI and LO connectors. Set calibration to 1 V output at 400 Hz or main board frequency. Push IN PHASE, 1000 MV, and main board frequency push buttons. Adjust phase generator to angles in figure 6-7. Monitor the appropriate points for the proper logic levels.	X		Refer to step ll.
			X	Replace associated IC.

Set Phase Generator For Angle Between	Data To Be Loaded	Logic States of First NAND Gate Inputs			Logic States of First NAND Gate Outputs			
		S	C	OD	Z1-8	Z6-8	Z2-6	Z2-8
0°-45°	00.0	1	1	1	1	1	1	1
45°-90°	90.0	1	1	0	0	1	1	1
90°-135°	90.0	1	0	0	0	1	1	1
135°-180°	180.0	1	0	1	1	0	1	1
180°-225°	180.0	0	0	1	1	0	1	1
225°-270°	270.0	0	0	0	1	1	0	1
270°-315°	270.0	0	1	0	1	1	0	1
315°-360°	360.0	0	1	1	1	1	1	0

Octant	Data To Be Loaded	Logic States of Data Input Connectors			
		J2-7 (Z1-3)	J1-15 (Z1-6)	J2-5 (Z1-11)	J1-3 (Z6-6)
0°-45°	00.0	0	0	0	0
45°-90°	90.0	1	0	1	0
90°-135°	90.0	1	0	1	0
135°-180°	180.0	0	0	1	1
180°-225°	180.0	0	0	1	1
225°-270°	270.0	1	1	0	0
270°-315°	270.0	1	1	0	0
315°-360°	360.0	0	1	0	1

First NAND Gates	Inputs	Second NAND Gates	Inputs	Data Input Connectors
Z1-8	S, $\overline{OD}$	Z1-3	Z1-8, Z2-6	J2-7
Z6-8	$\overline{C}$, OD	Z1-6	Z2-6, Z2-8	J1-15
Z2-6	$\overline{S}$, $\overline{OD}$	Z1-11	Z1-8, Z6-8	J2-5
J2-8	$\overline{S}$, C, OD	Z6-6	Z6-8, Z2-8	J1-3

Figure 6-7. Data Loading Logic - A/D Converter

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
11	READOUT BOARD INOPERATIVE OR OUT OF SPECIFICATION NOTE Unless otherwise stated, all test points and components are on readout board.			
a.	Turn power off and remove integrated circuits Z15 and Z21 from A/D converter. Remove equipment from DPAV SIG HI and LO connectors. Place short across SIG HI and LO and REF HI and LO connectors. Depress TOTAL and 1000 MV push buttons. Turn power on.			
b.	Set ac calibrator for square wave output and adjust for 4.5 V peak at 2.5 Hz.			
c.	Connect output of ac calibrator to TP1 on A/D converter.			
d.	Observe least significant digit on right end of digital display. Digit changes from 0 through 9 and back to 0 in approximately 4 seconds.	X		Proceed to step e.
			X	Replace either DS2, Z12, Z8, or Z4.
e.	Increase frequency output of ac calibrator to 25 Hz.			
f.	Observe second least significant digit on digital display. Digit changes from 0 through 9 and back to 0 in approximately 4 seconds	X		Proceed to step g.
			X	Replace either DS2, Z11, Z7, or Z3.
g.	Increase frequency output of ac calibrator to 250 Hz.			
h.	Observe third least significant digit on digital display. Digit changes from 0 through 9 and back to 0 in approximately 4 seconds.	X		Proceed to step i.
			X	Replace either DS2, Z10, Z6, or Z2.
i.	Increase frequency output of ac calibrator to 2.5 kHz.			
j.	Observe fourth least significant digit on digital display. Digit changes from 0 through 9 and back to 0 in approximately 4 seconds. (Disregard OVERLOAD light.)	X		Proceed to step k.
			X	Replace either DS1, Z9, Z5, or Z1.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
k.	With 4.5 V peak, 2.5 kHz square wave signal still applied to TP1 on A/D converter, observe most significant 1/2 digit on digital display. 1 goes on and stays on. (Disregard OVERLOAD light.)	X		Proceed to step l.
			X	Replace DS1 or Q1.
l.	Disconnect ac calibrator.			
m.	Remove integrated circuit Z14 from A/D converter.			
n.	Ground Z4-6 for period of approximately 1 second and observe digital display. Each digit, except 1/2 digit, becomes and remains 0.	X		Proceed to step o.
			X	Replace either Z9, Z10, Z11, or Z12 corresponding to failing digit shown in figure 6-8.
o.	Ground integrated circuit Z14-6.			
p.	When each digit except 1/2 digit becomes 0, ground TP3 on A/C converter.			
q.	Remove ground from pin 6 of Z14.			
r.	Connect output of ac calibrator to TP1 on A/D converter.			
s.	Adjust ac calibrator for 4.5 V peak square wave output.			
t.	While observing digital display, vary frequency of ac calibrator from 2.5 Hz to 2.5 kHz and back to 2.5 Hz. All digits except 1/2 digit remain o.	X		Proceed to step u.
			X	Replace either Z5, Z6, Z7, or Z8 corresponding to failing digit in figure 6-8.
u.	Turn power off and replace Z14. Turn power on.			
v.	Remove ground from TP3 on A/D converter.			

	FAILING DIGIT				
	1/2 Digit	SIGNIFICANT 4th DIGIT	3rd	2nd	1st
Probably		Z9	Z10	Z11	Z12
Failing	Q1	Z5	Z6	Z7	Z8
Components		Z1	Z2	Z3	Z4

Figure 6-8. Probable Failure Groups

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
w.	Adjust ac calibrator for frequency output of 2 kHz.			
x.	Ground TP3 for three to five seconds on A/D converter and observe digital display. Each digit freezes when ground is applied and remains constant until ground is removed.	X		End of troubleshooting. Disconnect all test equipment. Turn power off and reinstall Z21 and Z15.
			X	Replace either Z5, Z6, Z7, or Z8 corresponding to failing digit in figure 6-8.
12	FREQUENCY BOARD INOPERATIVE OR OUT OF SPECIFICATION			
	NOTE The following procedure applies to all frequency boards. All test points are on the frequency card.			
a.	Remove the malfunctioned frequency board and insert extender cable for easy access to test points. Press appropriate Frequency Range, IN PHASE, REF OFFSET OUT, and 1000 MV push buttons. Connect ac calibrator to REF HI and LO and to SIG HI and LO connectors and adjust for 1 V rms at corresponding frequency.			
b.	Connect oscilloscope and DMM in parallel between GND and TP1. Oscilloscope displays a 4.5 to 4.7 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV.	X		Proceed to step c.
			X	Replace either Z2, Q6, C28, or C8.
c.	Connect oscilloscope and DMM in parallel between GND and Z3-6. Oscilloscope displays a 1.75 V p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV.	X		Proceed to step d.
			X	Replace Z3.
d.	Connect oscilloscope between GND and TP6 on frequency board. Oscilloscope displays rounded sawtooth pulse with repetition rate of 12 times input frequency and amplitude of 5 V.	X		Proceed to step e.
			X	Replace either Q9, Q10, Q11, C30, or C34.
e.	Connect oscilloscope between GND and TP2. Oscilloscope displays a chopped sine wave 2.05 V p-p with same repetition rate as input frequency.	X		Proceed to step f.
			X	Replace either CR5, Q7, or Z5.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
f.	Connect oscilloscope between GND and TP3. Oscilloscope displays a chopped sine wave 2.05 V p-p with same repetition rate as input frequency.	X		Proceed to step g.
			X	Replace either CR8, Q8, or Z5.
g.	Press front panel REFERENCE OFFSET OUT switch.			
h.	Connect oscilloscope and DMM in parallel between GND and TP4 and observe the following:			
	(1) Oscilloscope displays a 0.65 to 1.0 V p-p half-wave rectified sine wave, without distortion.	X		Proceed to step h(2).
			X	Replace Z4.
	(2) DMM reads -1.0 to +1.0 mV dc.	X		Proceed to step n.
			X	Proceed to step i.
i.	Remove REF HI and LO and apply short. Adjust potentiometer R41 for 0.0 V dc. Precise adjustment will not be possible because of drift. (Dc level will be at ±15 V level. Adjust for 0 or minimal drift.)			
j.	Remove short and connect ac calibrator to REF HI and LO connectors.			
k.	Adjust ac calibrator for 10.0 V rms at appropriate frequency.			
l.	Adjust potentiometer R44 for 0.0 V dc level. DMM reads -1.0 to +1.0 mV.	X		Proceed to step n.
			X	Proceed to step m.
m.	Connect DMM between TP9 (ground) and TP11 on main board. DMM reads -1.0 to +1.0 mV.	X		Replace Z4.
			X	Replace either Q53, Q23, or Z8 on main board.
n.	Press front panel REFERENCE OFFSET IN switch.			
o.	While observing oscilloscope, vary setting of REFERENCE OFFSET ±45° control. Oscilloscope displays dc voltage level change as setting of REFERENCE OFFSET ±45° control is adjusted.	X		Proceed to step p.
			X	Replace Q14.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
	NOTE When REFERENCE OFFSET ±45° control is adjusted fully counterclockwise, the appearance of the signal at TP4 will change from a half-wave rectified sine wave to a full-wave rectified sine wave.			
p.	Press REFERENCE OFFSET OUT switch.			
q.	Connect oscilloscope between TP9 (ground) and TP1 on main board. Oscilloscope displays a 665 to 695 mV p-p sine wave without distortion.	X		Proceed to step r.
			X	Refer to step 2.
r.	Connect oscilloscope between GND and TP5 on frequency board being tested. Oscilloscope displays a 4.8 to 5.0 V p-p sine wave, without distortion.	X		End of troubleshooting. Disconnect all test equipment.
			X	Replace either Z1, C27, Q1, or Q2.
13	REFERENCE ISOLATION BOARD INOPERATIVE OR OUT OF SPECIFICATION			
	NOTE Unless otherwise stated, all test points and components are on reference isolation board.			
a.	Connect VOM between REF LO and GND connectors on front panel and observe a VOM reading of more than 200 megohms.	X		Proceed to step b.
			X	Replace T2.
b.	Connect ac calibrator to REF HI and LO connectors.			
c.	Press front panel 10 V, IN PHASE, and 400 HZ (or main board frequency) switches.			
d.	Adjust ac calibrator for output of 1000.0 mV rms at 400 Hz or main board frequency.			
e.	Connect oscilloscope and DMM in parallel between GND and TP1. Oscilloscope displays a 430 to 450 mV p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 V dc.	X		Proceed to step j.
			X	Proceed to step f.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
f.	Connect DMM between GND and TP2 and observe a DMM reading of 13 to 15 V dc.	X		Proceed to step g.
			X	Replace either CR6, Q3, or C8.
g.	Connect DMM between GND and TP3 and observe a DMM reading of -13 to -15 V dc.	X		Proceed to step h.
			X	Replace either CR7, Q4, or C9.
h.	Connect oscilloscope between GND and anode of CR4. Oscilloscope displays a 430 to 450 mV p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 V dc.	X		Replace Z1.
			X	Proceed to step i.
i.	Increase output of ac calibrator to 10.0 V rms at 400 Hz while observing that indicator lamp DS1 on reference isolation board goes on.	X		Replace Q1 or K1
			X	Replace either DS1 on reference isolation board, or Q49 or Z45 on main board.
j.	Connect oscilloscope and DMM in parallel between GND or E81 and positive side of capacitor C146 or E42 on main board. Oscilloscope displays a 140 to 160 mV p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 V dc.	X		End of troubleshooting. Disconnect all test equipment.
			X	Replace T2.
14	SIGNAL BROADBAND ISOLATION BOARD INOPERATIVE OR OUT OF SPECIFICATION			
	NOTE Unless otherwise stated, all test points and components are on signal isolation broadband board.			
a.	Connect VOM between SIG LO and GND connectors on front panel and observe a VOM reading of more than 200 megohms.	X		Proceed to step b.
			X	Replace T3.
b.	Connect ac calibrator to SIG HI and LO connectors.			
c.	Press front panel 1000 MV, IN PHASE, and 400 HZ (or main board frequency) switches.			
d.	Adjust ac calibrator for output of 1000.0 mV rms at 400 Hz or main board frequency.			

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
e.	Connect oscilloscope and DMM in parallel between GND and TP1. Oscilloscope displays a 200 to 400 mV p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 mV dc.	X		Proceed to step k.
			X	Proceed to step f.
f.	Connect DMM between GND and TP2 and observe DMM reading of +13 to +15 V dc.	X		Proceed to step g.
			X	Replace either CR6, C8, or Q3.
g.	Connect DMM between GND and TP3 and observe DMM reading of -13 to -15 V dc.	X		Proceed to step h.
			X	Replace either CR7, C9, or Q4.
h.	Connect oscilloscope between GND and anode of CR4. Oscilloscope displays a 200 to 400 mV p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 V dc.	X		Replace Z1
			X	Proceed to step i.
i.	Press 10 V switch and increase output of ac calibrator to 10.0 V rms at 400 Hz and observe if indicator lamp DS1 on signal isolation board goes on.	X		Replace Q1 or K1.
			X	Replace either DS1 on signal isolation board or Q9 or Z29 on main board.
j.	Turn power off and, on main board, remove operational amplifier Z61. Turn power on.			
k.	Connect oscilloscope and DMM in parallel between GND or E79 and pin 3 of Z61 or E78. Oscilloscope displays a 20 to 40 mV p-p sine wave, without distortion, and DMM reads -1.0 to +1.0 V dc.	X		Proceed to step l.
			X	Replace T3.
l.	Turn power off and reinstall Z61. Turn power on.			
m.	Press 10 V switch and increase output of ac calibrator to 10.0 V rms at 400 Hz and observe that indicator lamp DS1 on signal isolation board goes on.	X		Replace Q1 or K1.
			X	Replace either DS1 on signal isolation board, or Q9 or Z29 on main board.
15	NULL METER INOPERATIVE OR OUT OF SPECIFICATION NOTE 1 Unless otherwise stated, all test points and components are on the null meter.			

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
	NOTE 2 With power off, adjust the zero adjust on the face of the null meter for exactly 0 reading.			
a.	Connect ac calibrator to REF HI and LO connectors and also to ratio transformer.			
b.	Connect output of ratio transformer to SIG HI and LO connectors.			
c.	Press IN PHASE, 1000 MV, and 400 HZ (or main board frequency) switches.			
d.	Set ratio transformer to 0.1 and adjust ac calibrator for 10.0 V rms at 400 Hz, or main board frequency. Null meter shows a positive deflection.	X		Proceed to step o.
			X	Proceed to step e.
e.	Connect DMM between TP9 (ground) and TP8 on main board. DMM reads 8.60 to 8.90 V dc.	X		Proceed to step f.
			X	Refer to step 2.
f.	Connect phase angle generator between ac calibrator and REF HI and LO connectors.			
g.	Set phase angle generator for 270° phase shift.			
h.	Press QUAD switch and observe that null meter shows a positive deflection.	X		Proceed to step j.
			X	Proceed to step i.
i.	Connect DMM between TP9 (ground) and TP10 on main board and observe a DMM reading of 8.60 to 8.90 V dc.	X		Replace either Q1, Z2, M1, or R3.
			X	Refer to step 2.
j.	Set phase angle generator for 0.0° phase shift.			
k.	Press IN PHASE switch.			
l.	Connect DMM to end of resistor R8 nearest transistor Q2 and observe a DMM reading of 8.60 to 8.90 V dc.	X		Proceed to step m.
			X	Replace ribbon cable J12.
m.	Connect DMM to end of resistor R7 nearest transistor Q1 and observe DMM reading of -0.1 to +0.1 V dc.	X		Proceed to step n.
			X	Refer to step 2.
n.	Connect DMM to anode of diode CR4 and observe a DMM reading of 13.0 to 15.0 V dc.	X		Replace Q2.
			X	Replace either Q4, CR4, Z1, or Z3.

Table 6-1. DPAV Troubleshooting Procedure (Continued)

Step	Procedure	Indication OK	Indication Not OK	Remedy
o.	Connect phase angle generator between ac calibrator and REF HI and LO connectors.			
p.	Set phase angle generator for 270° phase shift.			
q.	Press QUAD switch and observe that null meter shows a deflection.	X		Proceed to step v.
			X	Proceed to step r.
r.	Connect DMM between TP9 (ground) and TP10 on main board. DMM reads 8.60 to 8.90 V dc.	X		Proceed to step s.
			X	Refer to step 2.
s.	Connect DMM to end of resistor R7 nearest transistor Q1 and observe a DMM reading of 8.60 to 8.90 V dc.	X		Proceed to step t.
			X	Replace ribbon cable J12.
t.	Connect DMM to end of resistor R8 nearest transistor Q2 and observe a DMM reading of -0.1 to +0.1 V dc.	X		Proceed to step u.
			X	Refer to step 2.
u.	Connect DMM to anode of diode CR3 and observe a DMM reading of 13.0 to 15.0 V dc.	X		Replace Q1.
			X	Replace either Q3, CR3, Z1, or Z3.
v.	Disconnect ratio transformer from SIG HI and LO connectors.			
w.	Using clip lead, short SIG HI connector to SIG LO connector.			
x.	Adjust potentiometer R1 for a null meter indication of exactly zero.	X		Refer to alignment and adjustment procedures (para. 5.8.13). End of test. Disconnect all test equipment.
			X	Replace R1.

SECTION 7

PARTS LIST

This section contains a vendor codes list, parts list, and parts locator diagrams for the DPAV.

List of Manufacturers

Code	Name and Address
01121	Allen Bradley Co. 1201 South 2nd Street Milwaukee, Wisconsin 53204
01295	Texas Instrument Semiconductor Components Division 13500 North Central Expressway Dallas, Texas
02111	Spectrol Electronic Corporation 17070 East Gale Avenue City of Industry, California
03888	Pyrofilm Resistor Company 60 Wouth Jefferson Road Whippany, New Jersey 07981
04713	Motorola Semiconductor Products Inc. 5005 East McDowell Road Phoenix, Arizona 85008
06001	General Electric Company Electronic Capacitor & Battery Dept. P.O. Box 158 Irmo, South Carolina 29063
06665	Precision Monolithics 1500 Space Park Drive Santa Clara, California 95050
06751	Semcor Inc. 215 Royal Drive P.O. Box 78 Georgetown, Texas 78626
07187	Sperry Flight Systems Div. Sperry Rand Corp. P.O. Box 2529 21111 North 19th Avenue Phoenix, Arizona 85002
07263	Fairchild Semiconductor A 464 Ellis Street Mountain View, California 94040
08730	Vemaline Products Co. 487 Jefferson Blvd. Warwick, Rhode Island 02886
09182	Hewlett-Packard Company Harrison Labs Div. Berkeley Heights, New Jersey
09922	Burndy Corporation Richards Avenue Norwalk, Connecticut 06852
11880	Marstan Electronics Div. Balco Electronics 307 Washington Street Orange, New Jersey 07050
12040	National Semconductor Commerce Drive P.O. Box 443 Danbury, Connecticut 06810
12406	Elpac Inc. 3131 Standard Avenue Santa Ana, California 92704
14752	Electrocube Inc. 1710 South Del Mar Avenue San Gabriel, California 91776
16299	Corning Glass Works Electronic Components Division 3900 Electronics Drive Raleigh, North Carolina 27604
16512	National Connector Division Fabritek Inc. 9210 Science Center Drive Minneapolis, Minnesota 55428
18324	Signetics Corp. 811 East Argues Avenue Sunnyvale, California 94086
18612	Vishay Intertech, Inc. Resistor Products Division 63 Lincoln Highway Malvern, Pennsylvania 19355
20891	Cosar Corporation 3121 Benton Street Garland, Texas 75042

List of Manufacturers (Continued)

Code	Name and Address
24138	International Components Corp. 105 Maxess Road Melville, New York 11747
26625	Mial U S A Inc. 165 Franklin Avenue Nutley, New Jersey 07110
30857	Varo Inc. 900 North Shiloh Road Garland, Texas 75040
31918	I.E.E./Shadow 8081 Wallace Road Eden Prairie, Minnesota 55343
32997	Bourns Inc. 1200 Columbia Avenue Riverside, California 92507
37942	Mallory, P.R. Company 3029 East Washington Street Indianapolis, Indianna 46206
49956	Raytheon Company Lexington, Massachusetts 02173
56289	Sprague Electric Company 335 Marshall Street North Adams, Massachusetts 01247
59730	Thomas & Betts 36 Butler Street Elizabeth, New Jersey 07207
71590	Centralab Globeunion Inc. P.O. Box 591 Milwaukee, Wisconsin 53201
72136	Elmenco Electro Motive Mfg. Co. South Park & John Streets Willimantic, Connecticut 06226
72982	Erie Technological 644 West 12th Street Erie, Pennsylvania 16512
73138	Beckman Instruments Helipot Division 2500 Harbor Blvd. Fullerton, California 92634
74861	Industrial Condenser 3243-65 North California Avenue Chicago, Illinois 60618
74970	E.F. Johnson 299 10th Avenue, South West Waseca, Minnesota 56093
75042	IRC 401 North Broad Street Philadelphia, Pennsylvania 19108
75915	Littlefuse, Inc. 800 E.N.W. Highway Des Plaines, Illinois 60016
76381	Minnesota Mining & Mfg. 3M Center St. Paul, Minnesota 55101
76493	Miller J.W. Co. P.O. Box 5825 19070 Reyes Avenue Compton, California
79727	Continental Wirt Elect. 550 Davisville Road Warminster, Pennsylvania 19874
82110	Gudebrod Brothers Silk Co. 12 South 12th Street Philadelphia, Pennsylvania 19107
83125	Nytronics Inc. Orange Street Darlington, South Carolina 29532
83330	H.H. Smith 812 Snediker Avenue Brooklyn, New York 11207
84171	Arco Electronics Community Drive Great Neck, New York 10222
91637	Dale Electronics Inc. P.O. 609 Columbus, Nebraska 68601
95073	Douglas Randall Inc. 6 Pawcatuck Avenue Westerly, Rhode Island 02891
95750	Republic Electronic Ind. 575 Broad Hollow Road Melville, New York 11746

Replacement Parts List: Phase Angle Voltmeter, Model 225

NOTE

Call outs in the designation column refer to figure 5-1.

Des.	Description	Part No.	Mfr. Code	Mfr. Part No.	Qty
74	Main Board Assembly	500869			1
49	Readout Board Assembly	783590-1, -2			1
3	A/D Converter Assembly	783591			1
58	Reference Isolation Board Assembly	783601-2			1
70	Reference Isolation Transformer Assembly	783594-1			1
59	Signal Broadband Isolation Board Assembly	783602-2			1
75	Signal Isolation Transformer Assembly	783594-2			1
2	Null Meter Assembly	783672			1
51	Null Meter P.C. Board	500887			1
4,5,6	Frequency Board Assembly	783599-XXXX			
7	Bracket, A/D Converter	205343			1
8	Spacer, Pivot	205356			2
9	Fan Assembly	500957			1
10	Cover, Side	205395			2
1,11	Cover, Top/Bottom	205394			2
13	Switch, Push Button (4-pos)	807034	31918	6G15-2UGR	1
17	Binding Post	800120	83330	137	1
18	Button, Blank	806698	31918	FSB-Black	2
19	Button, AUTO	205298-15			1
20	Button, 500 V	205298-38			1
22	Button, 100 V	205298-27			1
23	Button, 10 V	205298-26			1
25	Button, 1000 MV	205298-25			1
26	Button, 100 MV	205298-24			1
27	Button, 10 MV	205298-23			1
28	Button, OUT	205298-7			1
29	Button, IN	205298-6			1
30	Ferrule, Inner	802413	59730	GSB.096	1
31	Knob	807041	08730	3022	1
32	Button, REF PHASE	205298-22			1
33	Button, PHASE ANGLE	205298-21			1
34	Button, QUAD	205298-10			1
35	Button, IN PHASE	205298-20			1
36	Button, FUND	205298-9			1
37	Button, TOTAL	205298-8			1
38	Button, OFF	205298-3			1
39	Button, ON	205298-33			1
41	Marking, Panel	205675			1
42	Window, Display	205257			1
43	Diffuser, Light	205516-2			1
44	Diffuser, Light	205516-1			1
45	Switch, Pushbutton	807031	31918	5G-15-2UGR	1
46	Cable Assembly, Green	500871-2			1
47	Cable Assembly, Red	500871-1			1

Replacement Parts List: Phase Angle Voltmeter, Model 225 (Continued)

Des.	Description	Part No.	Mfr. Code	Mfr. Part No.	Qty
48	Cable Assembly, Yellow	500871-3			1
50	Bumper, Readout Board	205690			2
53	Meter, Null (See item 2)	205666			1
52	Bracket, Null Meter	205680			1
56	Bracket, A/D Converter (See item 7)	205343-1			1
57	Support, LH	205346-2			1
60	Support, RH	205346-1			1
63	Fuse, 220 V, .5A	803877	75915	313.500	1
	Fuse, 115 V, 1A	803876	75915	313001.	1
64	Fuseholder	800137	75915	342004L	1
65	Nameplate	205571-1			1
66	Nameplate	205571-3			1
68	Bracket, RH Side	205357-2			1
69	Bracket, RH Panel	205345-2			1
71	Support, RH Side	205347-1			1
72	Stiffener, Printed	205348			1
73	Support, Front	205352-2			1
76	Trim, Bottom	205359			1
77	Handle	807042	08730	CA86	2
78	Sub-panel	205353			1
79	Bracket, LH Panel	205345-1			1
80	Support, LH Side	205347-2			1
81	Bracket, LH Side	205357-1			1
82	Plate, Transformer	205349			1
83	Transformer, Power	205502			1
84	Trim, Top	205359			1
85	Panel, Front	205673-1			1
87	Support, RH (See item 60)	205346-3			1
	Support, LH (See item 57)	205346-4			1
92	Bracket, RH Side (See item 68)	205357-4			1
	Bracket, LH Side (See item 81)	205357-3			1
95	Case, Modified	205391			1
96	Torroid	550463			1
99	Cover, Modified	205564			1
100	Bracket, Mounting	205370			1
102	Bracket (See item 100)	205370-1			1
103	Support, RH Side (See item 71)	205347-3			1
	Support, LH Side (See item 71)	205347-4			1
	Panel, Rear	206011			1
	Plate Cover	206013			1
	Plate Cover	206014			1
	Frequency Extender Card	783724			1

Replacement Parts List: Main Board - 500869

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C11	Capacitor, Elect. Tantalum 22μf, 20V, ±20%	801093	56289	150D226X0020R2	3
C13	Capacitor, Mica 39pf, 500V, ±10%	802338	72136	DM15-390K	5
C14	Capacitor, Film .1μf, 25V, +80-20%	806086	72982	5815-000Y5U0104Z	10
C16	Same as C14				
C17	Same as C11				
C21	Capacitor, Ceramic .01μf, 25V +80-20%	880034	72982	5835-000-Y5U0103Z	25
C22	Same as C21				
C24	Capacitor, Mica 5pf, 500V, 10%	802421	72136	DM15-050K	3
C25	Capacitor, Ceramic 150pf, 1000V, ±10%	806883	72982	831-000X5F0-151K	12
C26	Same as C21				
C27	Same as C21				
C28	Same as C25				
C29	Capacitor, Elect. Aluminum 10μf, 25V, +100-0%	806890	24138	PCD10PB25	15
C30	Same as C29				
C31	Same as C25				
C32	Same as C29				
C33	Same as C25				
C34	Same as C29				
C35	Same as C29				
C36	Same as C29				
C37	Same as C25				
C38	Capacitor, Film 1μf, 100V, ±10%	807569	74861	1LMZP100	4
C40	Same as C21				
C41	Same as C21				
C42	Same as C38				
C44	Same as C21				
C45	Same as C21				
C46	Capacitor, Polyester 1.5μf, 25V, ±10%	807554	74861	2.5LMZP150	2

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C47	Capacitor, Polyester Film .15µf, 80V, ±5%	806694	06001	AE22R154J	2
C48	Same as C13				
C51	Same as C47				
C52	Same as C46				
C53	Same as C13				
C56	Same as C25				
C57	Same as C21				
C58	Same as C21				
C59	Same as C38				
C63	Same as C38				
C66	Same as C21				
C68	Same as C21				
C70	Same as C21				
C71	Capacitor, Ceramic 200pf, 1000V, ±10%	805602	72982	831-000X5F-0201K	1
C72	Capacitor, Ceramic 5000pf, 1000V, ±10%	805620	72982	811-000X5R-0502K	1
C73	Same as C21				
C74	Same as C29				
C75	Same as C29				
C78	Same as C13				
C81	Same as C29				
C82	Same as C25				
C84	Same as C29				
C85	Capacitor, Elect. Tantalum 4.7µf, 20V, ±20%	807392	56289	196D-475X9050KA1	1
C86	Same as C25				
C87	Capacitor, Mica 2pf, 500V, ±20%	802420	72136	DM15DD022D0	2
C88	Capacitor, Elect. Aluminum 2700µf, 40V, +75-10%	806904	37942	CGS272U040R2C	2
C89	Same as C14				
C90	Same as C14				
C91	Same as C88				
C92	Same as C14				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C93	Same as C14				
C94	Capacitor, Elect. Aluminum 6800µf, 25V, +75-10%	806905	37942	CGS82U025R2L3PH	1
	Capacitor, Elect. Aluminum 8000µf, 30V (Alternate)	807218	06001	86F547L	
C95	Same as C14				
C96	Same as C14				
C97	Capacitor, Elect. Aluminum 1µf, 50V, +150-0%	807169	24138	PCD1 PA 50	1
C98	Capacitor, Elect. Aluminum 40µf, 350V, +50-10%	807204	37942	TCG400T350G2L	1
C101	Capacitor, Mica 1pf, 500V, ±.5pf	802619	72136	DM15-010D	2
C104	Capacitor, Film .22µf, 80V, ±10%	802863	56289	192P2249R8	1
C105	Capacitor, Polyester Film .33µf, 250V, ±10%	807324	74861	2.5LMEP33	1
C107	Capacitor, Mica 75pf, 500V, ±5%	801686	72136	DM15-750J	2
C113	Same as C21				
C117	Same as C21				
C119	Capacitor, Elect. Aluminum 1000µf, 16V, -10+50%	807346	24318	PCD1000PN16	1
C122	Same as C21				
C123	Same as C21				
C125	Capacitor, Elect. Aluminum 100µf, 25V, +100-0%	806891	24138	PCD100PG25	7
C126	Same as C25				
C127	Capacitor, Elect. Tantalum 3.9µf, 20V, ±10%	804647	06751	TS2K-20-395	1
C128	Same as C24				
C129	Same as C13				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C130	Same as C21				
C131	Same as C21				
C132	Same as C25				
C133	Same as C29				
C134	Same as C25				
C135	Capacitor, Ceramic 1500pf, 100V, ±10%	805357	72982	B133-000-W5R0152K	1
C136	Capacitor, Elect. Tantalum 2.2μf, 20V, ±20%	800596	56289	150D225X0020A2	1
C137	Same as C25				
C142	Same as C87				
C143	Capacitor, Select at Test nominal 390pf				1
C144	Capacitor, Select at Test				1
C145	Capacitor, Mica 390pf, 50V, ±5%	801786	72136	DM15-F-391JP500WV4CR	1
C146	Capacitor, Select at Test				1
C148	Same as C101				
C149	Same as C14				
C150	Same as C21				
C151	Same as C21				
C156	Same as C125				
C157	Same as C125				
C158	Same as C125				
C159	Same as C125				
C161	Same as C29				
C162	Same as C14				
C163	Capacitor, Elect. Aluminum 22μf, 16V, -0+100%	807194	24138	PCD22PG16	2
C164	Same as C163				
C165	Same as C107				
C166	Capacitor, Mica 10pf, 500V, ±10%	802422	72136	DM15-D-100JP500WV-4CR	2
C169	Capacitor, Elect. Tantalum 4.7μf, 10V, ±20%	800594	56289	150D475X001A2	1
C170	Same as C29				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C172	Same as C166				
C173	Same as C125				
C174	Same as C125				
C177	Capacitor, Select at Test				
C179	Capacitor, Variable 1.5pf	806970	74970	273-0001-001	1
C180	Same as C11				
C181	Same as C21				
C182	Same as C21				
C183	Capacitor, Variable 7-40pf	807603	72982	518-000-G-7.0-40-0pf	1
C185	Same as C29				
C186	Same as C29				
C187	Capacitor, Mica 430pf, 500V, ±2%	807529	72136	DM15D431G4CR	1
C188	Same as C21				
C190	Same as C24				
C193	Capacitor, Mica 3pf, 500V, ±5%	807459	72136	DM10-030J	1
CR3	Diode	802924	07236	1N3600	42
CR4	Same as CR3				
CR5	Same as CR3				
CR6	Same as CR3				
CR9	Same as CR3				
CR10	Same as CR3				
CR12	Same as CR3				
CR13	Diode	807217	04713	1N5229	6
CR14	Same as CR3				
CR15	Same as CR13				
CR16	Same as CR3				
CR17	Same as CR13				
CR18	Diode	806951	04713	1N5231	1
CR19	Same as CR3				
CR20	Same as CR13				
CR21	Same as CR3				
CR22	Same as CR3				
CR25	Diode	806330	QPL	JAN 1N914	8
CR27	Same as CR3				
CR28	Same as CR3				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
CR29	Same as CR3				
CR30	Same as CR3				
CR31	Same as CR3				
CR32	Same as CR13				
CR33	Same as CR3				
CR34	Same as CR13				
CR35	Same as CR3				
CR38	Same as CR25				
CR41	Same as CR3				
CR42	Same as CR3				
CR43	Same as CR3				
CR46	Same as CR25				
CR49	Same as CR25				
CR50	Same as CR25				
CR51	Same as CR3				
CR52	Same as CR3				
CR53	Same as CR3				
CR54	Same as CR3				
CR55	Same as CR3				
CR56	Same as CR3				
CR57	Same as CR3				
CR58	Same as CR3				
CR59	Same as CR3				
CR60	Same as CR3				
CR61	Same as CR25				
CR62	Same as CR25				
CR64	Same as CR3				
CR65	Same as CR3				
CR66	Same as CR3				
CR67	Same as CR3				
CR69	Same as CR3				
CR70	Same as CR3				
CR71	Same as CR3				
CR72	Same as CR3				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
CR73	Same as CR25				
CR75	Same as CR3				
CR77	Same as CR3				
CR92	Diode	807689	04713	1N5279B	1
CR96	Diode	808852	09182	1N5712	1
J4	Header	807107	76381	3429-2002	1
J7	Connector	807212	16512	NC-200147	5
J8	Same as J7				
J9	Same as J7				
J10	Same as J7				
J11	Same as J7				
K2	Relay	806971	20891	530-4-1A	4
K3	Same as K2				
K4	Same as K2				
K5	Same as K2				
K6	Relay, SPDT	806959	20891	530-4-1C	1
L1	Choke, 33uh	804836	76493	9230-56	7
L2	Same as L1				
L3	Same as L1				
L4	Same as L1				
L6	Same as L1				
L7	Same as L1				
L8	Same as L1				
Q1	Transistor	805059	04713	2N2906	8
Q2	Same as Q1				
Q3	Same as Q1				
Q4	Same as Q1				
Q5	Same as Q1				
Q6	Same as Q1				
Q9	Transistor	808190	06001	GES 6002	17
Q10	Transistor	804583	01295	TIS73	2
Q11	Same as Q10				
Q12	Same as Q9				
Q13	Same as Q9				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
Q14	Same as Q9				
Q15	Same as Q9				
Q16	Transistor	805808	01295	TIS75	2
Q17	Transistor	804360	07263	2N4360	3
Q19	Same as Q9				
Q23	Same as Q1				
Q25	Same as Q16				
Q26	Same as Q9				
Q27	Same as Q9				
Q29	Transistor	803662	01295	2N3819	3
Q30	Same as Q9				
Q31	Same as Q1				
Q32	Transistor	804318	04713	2N4851	1
Q33	Same as Q9				
Q34	Transistor	882779	04713	2N5116	1
Q37	Same as Q9				
Q38	Transistor	806213	01295	2N5246	2
Q39	Same as Q9				
Q40	Same as Q9				
Q43	Same as Q29				
Q45	Same as Q17				
Q46	Same as Q17				
Q47	Same as Q9				
Q49	Same as Q9				
Q51	Same as Q9				
Q52	Same as Q9				
Q53	Same as Q29				
Q56	Transistor	800872	01295	2N1381	1
Q57	Same as Q38				
Q58	Transistor	807690	04713	MPSA43	1
R1	Resistor, Composition 51kΩ, 1/4W, ±5%	801985	01121	CB5135	32
R2	Same as R1				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R3	Same as R1				
R4	Same as R1				
R8	Same as R1				
R9	Same as R1				
R10	Same as R1				
R11	Same as R1				
R12	Same as R1				
R13	Same as R1				
R14	Same as R1				
R15	Same as R1				
R16	Same as R1				
R17	Same as R1				
R18	Same as R1				
R19	Same as R1				
R20	Same as R1				
R21	Same as R1				
R22	Same as R1				
R23	Resistor, Composition 10kΩ, 1/4W, ±5%	801006	01121	CB1035	10
R24	Same as R23				
R25	Same as R1				
R26	Same as R1				
R27	Resistor, Composition 150kΩ, 1/4W, ±5%	802757	01121	CB1545	5
R28	Same as R1				
R29	Same as R1				
R30	Same as R27				
R31	Same as R1				
R45	Resistor, Composition 4.3kΩ, 1/4W, ±5%	802188	01121	CB4325	2
R46	Resistor, Metal Film 9kΩ, .3W, ±.02%	806921	75042	MAR 5 T16 9K, .02%	1
R47	Resistor, Metal Film 900Ω, .3W, ±.02%	806922	75042	MAR 5 T16 900Ω, .02%	1
R48	Resistor, Metal Film 100Ω, .3W, ±.02%	806924	75042	MAR 5 T16 100Ω, .02%	1

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R51	Resistor, Metal Film 735Ω, .3W, ±.1%	807175	75042	MAR 5 T16 735Ω, .1%	1
R52	Resistor, Metal Film 10kΩ, .3W, ±.1%	807176	75042	MAR 5 T16 10K, .1%	1
R53	Resistor, Composition 2kΩ, 1/4W, ±5%	801094	01121	CB2025	11
R56	Same as R53				
R65	Resistor, Metal Film 20kΩ, .3W, ±.1%	806919	75042	MAR 5 T16 20K, .1%	10
R66	Resistor, Composition 12kΩ, 1/4W, ±5%	801721	01121	CB1235	7
R67	Resistor, Variable 500Ω,±20%	806909	32997	3386P-1-501	2
R68	Same as R65				
R69	Same as R65				
R70	Resistor, Composition 15kΩ, 1/4W, ±5%	801988	01121	CB1535	11
R71	Same as R53				
R72	Resistor, Metal Film 240Ω, 1/4W, ±2%	807184	16299	C4 240Ω, 1/4W, 2%	2
R73	Same as R65				
R74	Same as R65				
R75	Same as R53				
R76	Same as R70				
R77	Same as R67				
R78	Same as R65				
R79	Same as R65				
R80	Same as R53				
R81	Same as R70				
R82	Resistor, Composition 560Ω, 1/4W, ±5%	802258	01121	CB5615	1
R83	Same as R53				
R84	Same as R72				
R85	Same as R65				
R86	Same as R65				
R87	Same as R70				
R88	Resistor, Variable 1KΩ	807227	32997	3299W-1-102	2

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R89	Resistor, Metal Film 75kΩ, .3W, ±.1%	806920	75042	MAR 5 T16 75K, .1%	4
	Resistor, Metal Film 75kΩ, .3W, ±.1%	807546	11880	MPC1B	
R90	Same as R66				
R91	Resistor, Composition 820Ω, 1/4W, ±5%	801402	01121	CB8211	2
R92	Resistor, Composition 3MΩ, 1/4W, ±5%	804966	01121	CB3055	2
R93	Resistor, Variable, 50KΩ	806911	32997	3299W503	10
R94	Same as R89				
R95	Resistor, Wirewound 250kΩ ±.1%	807327	11880	MPC1A	2
R96	Resistor, Metal Film 75kΩ, 1/4W, ±2%	807183	16299	C4 75K, 1/4W, 2%	2
R97	Resistor, Composition 130kΩ, 1/4W, ±5%	801394	01121	CB1345	3
R98	Same as R53				
R99	Same as R88				
R100	Same as R89				
R101	Same as R66				
R102	Same as R91				
R103	Same as R92				
R104	Same as R93				
R105	Same as R89				
R106	Same as R95				
R107	Same as R96				
R108	Same as R97				
R109	Same as R53				
R110	Resistor, Metal Film 7.5kΩ, 1/8W, ±1%	807585	QPL	RN55E7501F	1
R111	Resistor, Metal Film 10kΩ, 1/8W, ±1%	807588	QPL	RN55E1002F	1
R112	Resistor, Composition 8.2kΩ, 1/4W, ±5%	802080	01121	CB8225	6
R113	Same as R23				
R115	Resistor, Metal Film 46.4kΩ, 1/8W, ±1%	807591	QPL	RN55E4642F	1

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R116	Same as R93				
R119	Resistor, Metal Film 93.1kΩ, 1/8W, ±1%	807587	QPL	RN55E9312F	3
R120	Resistor, Variable 2kΩ	807195	32997	3299W-1-202	1
R121	Same as R119				
R122	Same as R1				
R123	Resistor, Composition 10Ω, 1/4W, ±5%	803784	01121	CB1005	3
R124	Same as R123				
R125	Resistor, Composition 1kΩ, 1/4W, ±5%	801004	01121	CB1025	1
R126	Resistor, Composition 3.3kΩ, 1/4W, ±5%	803388	01121	CB3325	9
R130	Resistor, Select at Test				1
R131	Resistor, Composition 1.5kΩ, 1/4W, ±5%	802232	01121	CB1525	8
R132	Same as R123				
R134	Resistor, Variable 10kΩ	807729	02111	162-10K	1
R136	Same as R23				
R137	Same as R23				
R138	Same as R23				
R139	Resistor, Metal Film 20kΩ, 1/8W, ±1%	806544	16299	NC4 20K, 1/8W, 1%	6
R140	Same as R139				
R141	Same as R23				
R142	Same as R131				
R143	Same as R53				
R144	Same as R53				
R145	Same as R139				
R146	Same as R139				
R147	Same as R70				
R148	Resistor, Metal Film 22.1kΩ, 1/8W, ±1%	806936	16299	NC4 22.1K, 1/8W, 1%	2
R149	Same as R93				
R151	Same as R70				
R152	Same as R139				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R153	Same as R139				
R154	Same as R23				
R155	Resistor, Composition 36Ω, 1/4W, ±5%	807341	01121	CB3605	1
R156	Same as R97				
R157	Same as R93				
R158	Resistor, Composition 240kΩ, 1/4W, ±5%	802084	01121	CB2445	1
R159	Resistor, Composition 5.1kΩ, 1/4W, ±5%	801397	01121	CB5125	4
R160	Resistor, Composition 20kΩ, 1/4W, ±5%	801636	01121	CB2035	4
R161	Resistor, Variable 5k	807197	32997	3299W-1-502	1
R163	Resistor, Composition 200Ω, 1/4W, ±5%	802226	01121	CB2015	1
R164	Same as R53				
R166	Resistor, Composition 150Ω, 1/4W, ±5%	803672	01121	CB1515	1
R167	Same as R1				
R168	Same as R1				
R170	Same as R65				
R171	Same as R70				
R172	Sqme as R119				
R173	Same as R1				
R174	Resistor, Metal Film 390Ω, 1/4W, ±2%	807177	16299	C4 390Ω, 1/4W, 2%	2
R175	Resistor, Variable 200	806913	32997	3299W-201	2
R176	Same as R174				
R177	Same as R175				
R184	Resistor, Composition 150kΩ, 1/2W, ±5%	800856	01121	EB1545	1
R185	Resistor, Metal Film 5.6kΩ, 1/8W, ±1%	806718	16299	C4 5.6K, 1/8W, 1%	1
R186	Resistor, Metal Film 110kΩ, 1/8W, ±1%	807592	QPL	RN55D1103F	1
R187	Same as R160				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R188	Resistor, Composition 6.2kΩ, 1/4W, ±5%	801395	01121	CB6225	9
R189	Same as R160				
R190	Resistor, Composition 270kΩ, 1/4W, ±5%	804400	01121	CB2745	2
R191	Same as R27				
R192	Resistor, Composition 1MΩ, 1/4W, ±5%	802730	01121	CB1055	2
R193	Same as R27				
R194	Same as R23				
R195	Same as R126				
R198	Same as R188				
R199	Same as R188				
R200	Same as R131				
R201	Same as R159				
R202	Same as R126				
R203	Same as R131				
R204	Same as R93				
R205	Same as R126				
R206	Same as R131				
R207	Same as R188				
R208	Resistor, Metal Film 150kΩ, 1/4W, ±2%	806239	16299	C07 150K, 1/4W, 2%	1
R209	Same as R93				
R210	Same as R93				
R211	Same as R159				
R217	Same as R45				
R218	Same as R112				
R220	Resistor, Composition 39kΩ, 1/4W, ±5%	802081	01121	CB3935	2
R221	Resistor, Variable 2kΩ	806910	32997	3386F-1-202	2
R222	Resistor, Composition 2.7kΩ, 1/4W, ±5%	802191	01121	CB2725	1
R223	Same as R70				
R224	Resistor, Select at Test				1
R225	Same as R131				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R227	Same as R112				
R228	Resistor, Metal Film 3.9kΩ, 1/4W, ±2%	804311	16299	C07 3.9K, 1/4W, 2%	1
R229	Same as R148				
R230	Same as R70				
R231	Resistor, Metal Film 93.1kΩ, 1/8W, ±1%	806931	16299	NC4 93.1K, 1/8W	1
R232	Same as R221				
R233	Same as R220				
R234	Resistor, Metal Film 43kΩ, 1/4W, ±2%	807112	16299	C4 43K, 1/4W, 2%	1
R235	Resistor, Metal Film 15kΩ, 1/4W, ±2%	807181	16299	C4 15K, 1/4W, 2%	1
R236	Same as R159				
R237	Same as R70				
R238	Same as R190				
R239	Resistor, Composition 100kΩ, 1/4W, ±5%	801986	01121	CB1045	4
R240	Same as R239				
R241	Same as R239				
R244	Same as R70				
R245	Same as R23				
R246	Same as R188				
R247	Same as R126				
R248	Same as R188				
R249	Same as R188				
R250	Same as R192				
R251	Same as R112				
R254	Same as R126				
R255	Same as R112				
R257	Same as R112				
R258	Resistor, Composotion 91kΩ, 1/4W, ±5%	803240	01121	CB9135	1
R259	Resistor, Composition 22kΩ, 1/4W, ±5%	802182	01121	CB2235	1

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R261	Resistor, Metal Film 33kΩ, 1/8W, ±2%	806743	16299	NC4 33K, 1/8W, 2%	1
R263	Same as R1				
R264	Same as R1				
R265	Same as R1				
R266	Same as R1				
R268	Same as R66				
R269	Resistor, Composition 5.6kΩ, 1/4W, ±5%	805190	QPL	RCR07G562JP	1
R271	Resistor, Select at Test				1
R272	Resistor, Metal Film 2.61kΩ, 1/8W, ±1%	806930	16299	NC4 2.61K, 1/8W, 1%	1
R273	Resistor, Metal Film 39kΩ, 1/4W, ±2%	807205	16299	C4 39K, 1/4W, 2%	1
R274	Resistor, Composition 10MΩ, 1/4W, ±5%	803389	01121	CB1065	2
R275	Same as R93				
R276	Resistor, Composition 2.2MΩ, 1/4W, ±5%	804297	01121	CB2255	1
R277	Same as R126				
R279	Resistor, Composition 10Ω, 1/4W, ±5%	883106	01121	CB1005	1
R282	Resistor, Metal Film 2.49kΩ, 1/8W, ±1%	807590	QPL	RN55E2491F	1
R283	Same as R93				
R284	Same as R27				
R285	Resistor, Composition 100Ω, 1/4W, ±5%	801981	01121	CB1015	2
R286	Same as R131				
R287	Resistor, Composition 430Ω, 1/4W, ±5%	801399	01121	CB4315	1
R288	Same as R126				
R289	Same as R239				
R290	Same as R160				
R291	Same as R274				
R293	Same as R188				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R294	Same as R188				
R295	Same as R66				
R296	Resistor, Metal Film 470Ω, 1/4W, ±2%	807329	16299	C4 470Ω, 1/4W, 2%	2
R297	Same as R296				
R299	Resistor, Composition 270Ω, 1/4W, ±5%	802190	01121	CB2715	1
R300	Same as R285				
R301	Same as R66				
R302	Resistor, Metal Film 68.1Ω, ±1%	808176	01121	CC68N1F	1
R305	Same as R131				
R306	Resistor, Metal Film 2kΩ, 1/8W, ±1%	807584	QPL	RN55N2001F	1
R307	Resistor, Metal Film 22.1kΩ, 1/8W, ±1%	807586	QPL	RN60E2212F	1
R308	Resistor, Metal Film 51.1kΩ, 1/4W, ±1%	805911	QPL	RN65C5112F	1
R309	Resistor, Metal Film 91kΩ, 1/4W, ±2%	804301	16299	C07 91K, 1/4W, 2%	1
R311	Resistor, Metal Film 1.98kΩ, .3W, ±.1%	807791	75042	MAR 5 T16 1.98K, .1%	1
R312	Resistor, Metal Film 432Ω, 1/8W, ±.1%	808022	75042	MAR 5 T16 432Ω, .1%	1
R313	Resistor, Metal Film 2.509kΩ, 1/8W, ±.1%	808021	75042	MAR 5 T16 2.509K, .1%	1
R314	Resistor, Composition 120Ω, 1/4W, ±5%	802204	01121	CB1215	2
R315	Same as R314				
R316	Resistor, Composition 1.2kΩ, 1/4W, ±5%	801982	01121	CB1225	1
R320	Same as R66				
R321	Resistor, Composition 200kΩ, 1/4W, ±10%	803243	01121	CB2045	1
S1	Switch, Range, Mod. 7-pos.	808715	71590	PB15-7-2-1L	1
S2	Switch, Ref. (In-Out) 2-pos.	808717	71590	PB15-2-2-1L	1
S3	Switch, Function Mod. 6-pos.	808716	71590	PB15-6-2-1L	1
S4	Switch, 115V-230V	806675	79727	G-326	1

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
V1	Raysistor	806972	49956	CK2139	1
XZ1	Socket, 14-pin	807473	09922	DILB-14P-11	26
XZ2	Same as XZ1				
XZ3	Same as XZ1				
XZ4	Socket, 8-pin	808406	09922	DILB-8P-108	2
XZ5	Same as XZ1				
XZ6	Same as XZ1				
XZ7	Socket, 8-pin	805671	82110	A23-2052	24
XZ8	Same as XZ1				
XZ9	Same as XZ7				
XZ10	Same as XZ7				
XZ11	Same as XZ7				
XZ12	Socket, 16-pin	807474	09922	DILB-16P-11	2
XZ13	Same as XZ7				
XZ14	Same as XZ7				
XZ15	Same as XZ7				
XZ16	Same as XZ7				
XZ17	Same as XZ7				
XZ18	Same as XZ7				
XZ19	Same as XZ7				
XZ29	Same as XZ1				
XZ30	Same as XZ1				
XZ31	Same as XZ1				
XZ32	Same as XZ1				
XZ33	Same as XZ1				
XZ34	Same as XZ1				
XZ35	Same as XZ7				
XZ36	Same as XZ7				
XZ37	Same as XZ12				
XZ38	Same as XZ1				
XZ39	Same as XZ1				
XZ40	Same as XZ1				
XZ41	Same as XZ7				
XZ42	Same as XZ7				

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
XZ43	Same as XZ1				
XZ44	Same as XZ7				
XZ45	Same as XZ7				
XZ46	Same as XZ7				
XZ47	Same as XZ7				
XZ48	Same as XZ7				
XZ50	Same as XZ1				
XZ51	Same as XZ1				
XZ52	Same as XZ1				
XZ53	Same as XZ1				
XZ54	Same as XZ1				
XZ55	Same as XZ1				
XZ56	Same as XZ1				
XZ57	Same as XZ1				
XZ58	Same as XZ1				
XZ60	Same as XZ1				
XZ61	Same as XZ7				
XZ62	Same as XZ7				
XZ63	Same as XZ7				
XZ64	Same as XZ4				
Z1	Integrated Circuit	804344	04713	MC 836P	3
Z2	Integrated Circuit	806952	01295	SN7426N	4
Z3	Integrated Circuit	804458	04713	MC 849P	3
Z4	Integrated Circuit	808412	01295	SN75452BP	2
Z5	Same as Z2				
Z6	Same as Z5				
Z7	Integrated Circuit	807478	07342	Selected LM301AH	2
Z8	Same as Z5				
Z9	Integrated Circuit	808145	12040	LF357H	3
Z10	Integrated Circuit	807428	12040	LM138H	2
Z11	Same as Z7				
Z12	Integrated Circuit	808048	07342	Selected LM301AH	1
Z13	Integrated Circuit	806347	49956	LM301AH	5
Z14	Integrated Circuit	808172	06665	OP-02 CJ	2

Replacement Parts List: Main Board - 500869 (Continued)

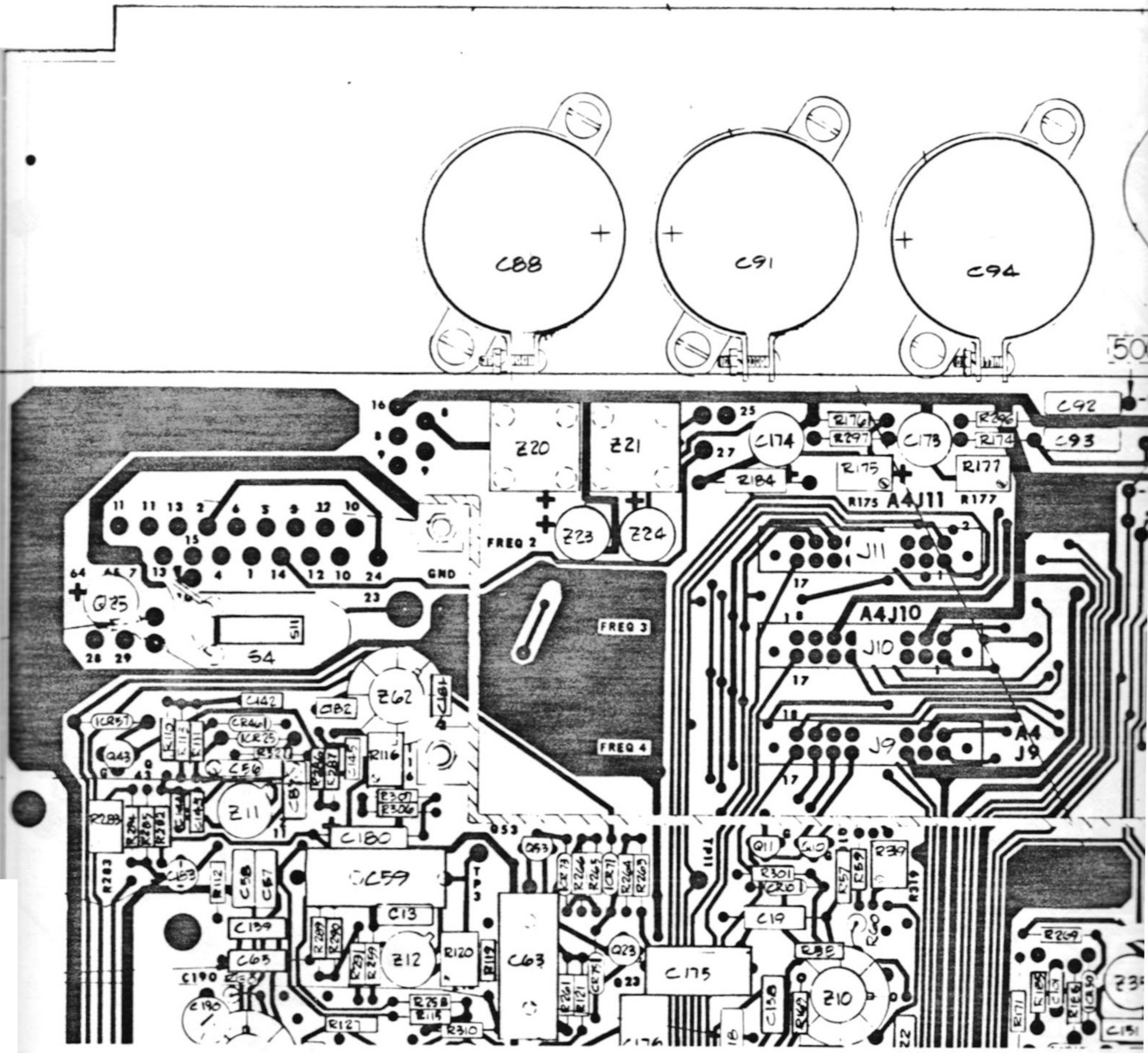
Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
Z15	Same as Z13				
Z16	Same as Z14				
Z17	Same as Z13				
Z18	Same as Z10				
Z19	Integrated Circuit	804069	04713	MC1709CG	1
Z20	Rectifier	806969	30857	VH-148	3
Z21	Same as Z20				
Z22	Same as Z20				
Z23	Rectifier	805744	30857	VE-48	3
Z24	Same as Z23				
Z25	Same as Z23				
Z26	Integrated Circuit	808271	QPL	LM7805KC	3
Z27	Same as Z26				
Z28	Same as Z26				
Z29	Same as Z3				
Z30	Same as Z3				
Z31	Integrated Circuit	805026	07263	946DC	4
Z32	Same as Z31				
Z33	Same as Z1				
Z34	Integrated Circuit	804807	07263	9000DC	1
Z35	Integrated Circuit	885122	01295	SN54H04J/883B	
Z36	Integrated Circuit	806051	49956	RC741T	5
Z37	Integrated Circuit	804833	12040	9300DC	1
Z38	Integrated Circuit	804939	07263	937DC	1
Z39	Same as Z31				
Z40	Same as Z1				
Z41	Same as Z36				
Z42	Same as Z36				
Z43	Same as Z31				
Z44	Same as Z9				
Z45	Same as Z36				
Z46	Same as Z36				
Z47	Same as Z13				
Z48	Integrated Circuit	808145	12040	LF357H	1

Replacement Parts List: Main Board - 500869 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
Z50	Integrated Circuit	805456	07263	9601DC	1
Z51	Integrated Circuit	806504	01295	SN7420N	2
Z52	Integrated Circuit	806505	01295	SN7404N	1
Z53	Integrated Circuit	806948	07263	7492APC	1
Z54	Integrated Circuit	806122	01295	SN7410N	2
Z55	Integrated Circuit	804883	01295	SN7400N	3
Z56	Same as Z51				
Z57	Same as Z54				
Z58	Same as Z55				
Z60	Same as Z55				
Z61	Op Amp	808430		OP-16	1
Z62	Integrated Circuit	885101	34371	HA2-5115-5	
Z63	Integrated Circuit	807797	12040	LF356AH	1
Z64	Same as Z4				

Replacement Parts List: Main Board Frequency - 400 Hz

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C18	Capacitor, Polystyrene .001µf, 100V, ±1%	808065	84171	1PG102F	2
C19	Capacitor, Polystyrene .022µf, 100V, ±1%	808073	84171	1PG223F	2
C64	Same as C19				
C65	Same as C18				
C76	Capacitor, Polycarbonate .022µf, 50V, ±10%	806897	14752	625B1A223K	
C77	Capacitor, Polycarbonate .047µf, 50V, ±10%	807185	14752	625B1A473K	1
C83	Capacitor, Polycarbonate 2500pf, 500V, ±2%	807404	72136	DM19-252G	1
C138	Capacitor, Mica 180pf, 500V, ±1%	807433	72136	DM15-181F	2
C139	Same as C138				
C175	Capacitor, Mica 50pf, 500V, ±1%	807436	72136	DM15-500F	2
C176	Same as C175				
R57	Resistor, Metal Film 10kΩ, .3W, ±.1%	807176	75042	MAR5 T16-10K,.3W,.1%	4
R58	Resistor, Metal Film 75kΩ, .3W, ±.1%	806920	75042	MAR5 T16-75K,.3W,.1%	2
R59	Resistor, Metal Film 240Ω, 1/4W, ±2%	807184	16299	C4-240Ω, 1/4W, 2%	1
R60	Same as R57				
R127	Same as R128				
R128	Same as R57				
R129	Resistor, Variable 1KΩ	807184	16299	C4-1K,1/2W	1
R130	Same as R57				
R133	Resistor, Composition 20kΩ, 1/4W, ±5%	801636	01121	CB2035	1
R150	Resistor, Composition 130kΩ, 1/4W, ±5%	801394	01121	CB1345	1
R162	Resistor, Metal Film 16.5kΩ, 1/4W, ±1%	807166	16299	C4-16.5K,1/4W, 1%	1
R169	Resistor, Composition 82kΩ, 1/4W, ±5%	802083	01121	CB8235	1
R319	Resistor, Variable 100Ω	807198	32997	3299W-1-101	1



- gain total - R120

Figure 7-1. Main Board, Parts Locator (Sheet 1 of 4)

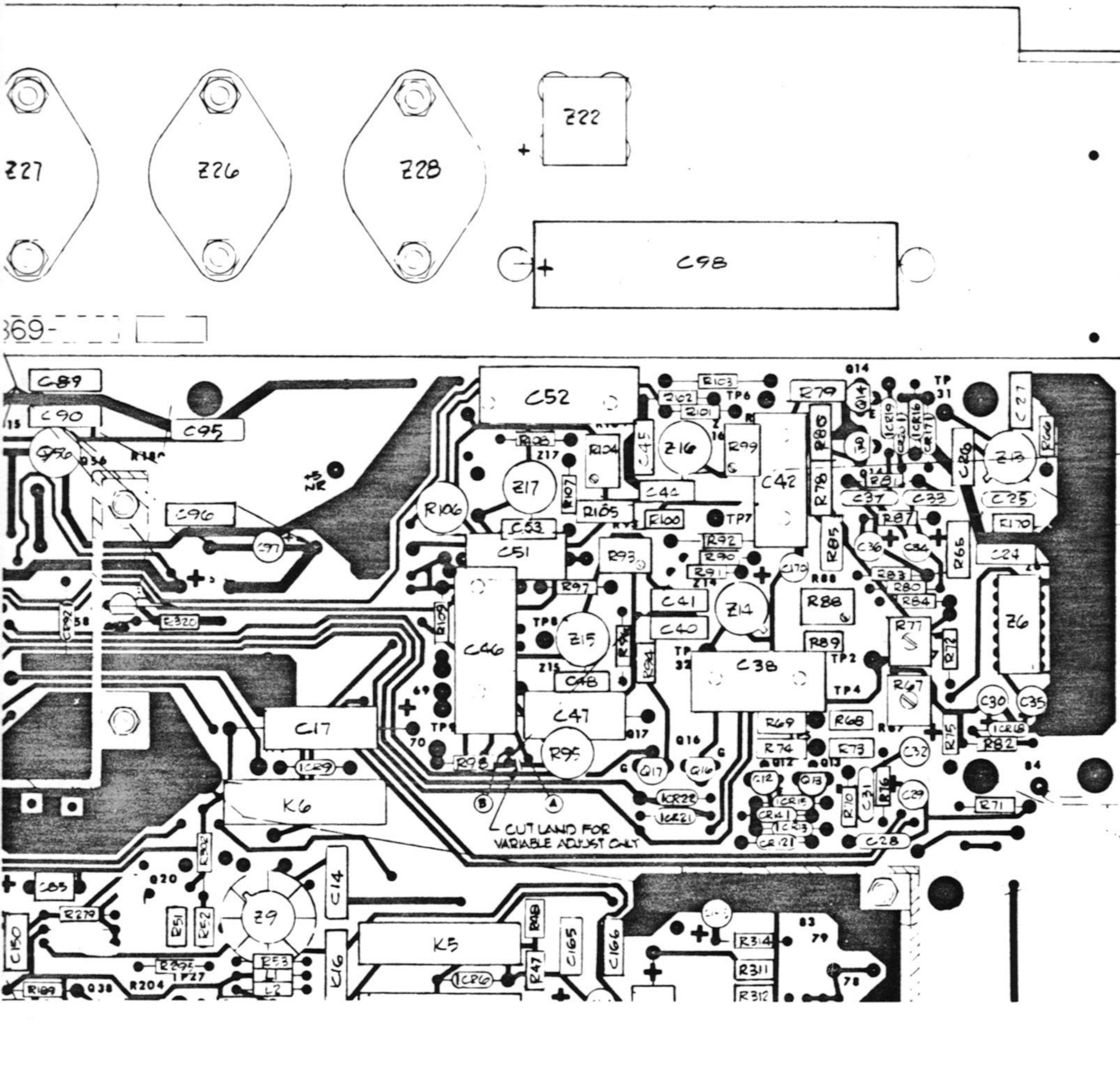


Figure 7-1. Main Board, Parts Locator (Sheet 2 of 4)

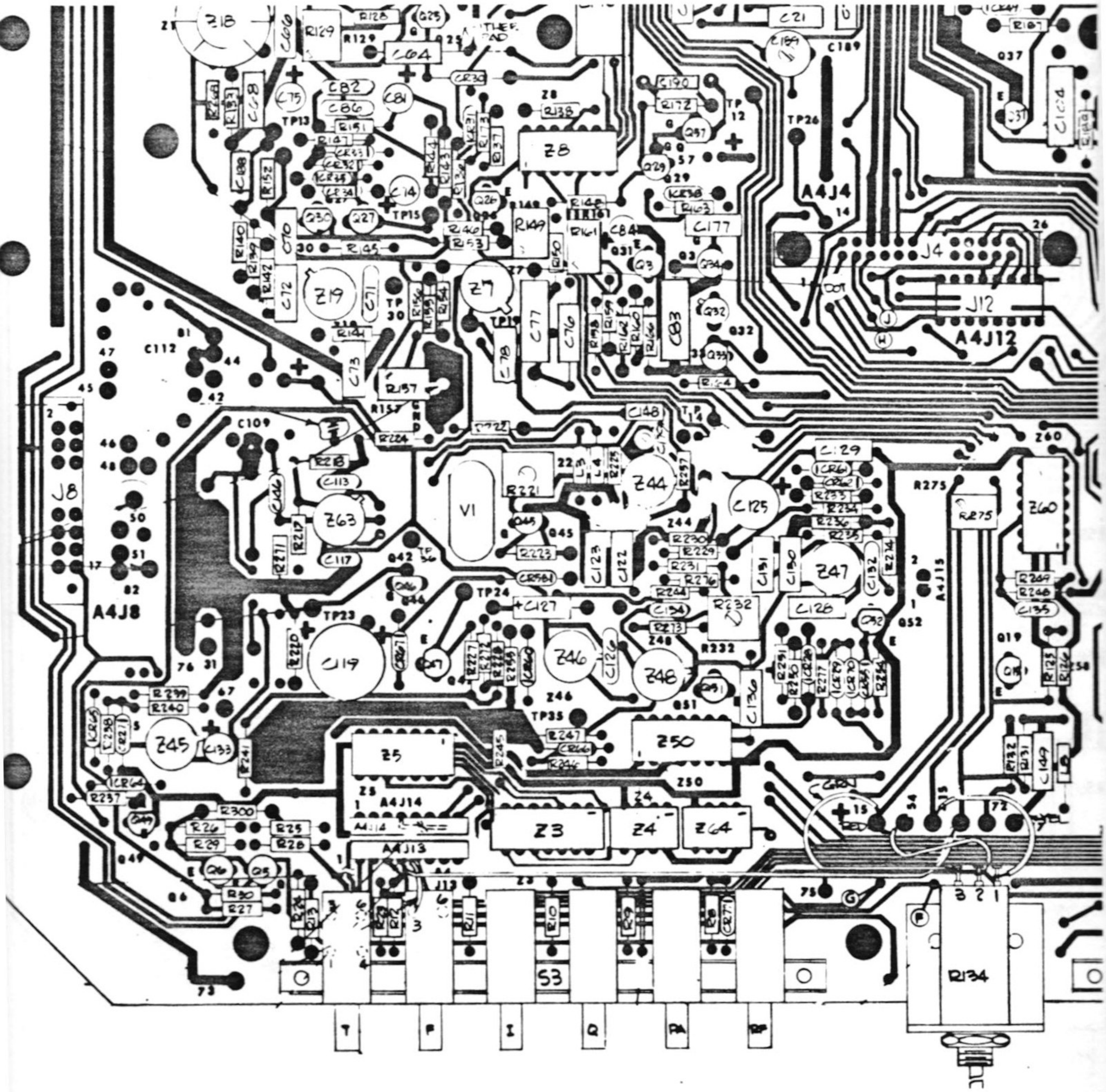


Figure 7-1. Main Board, Parts Locator (Sheet 3 of 4)

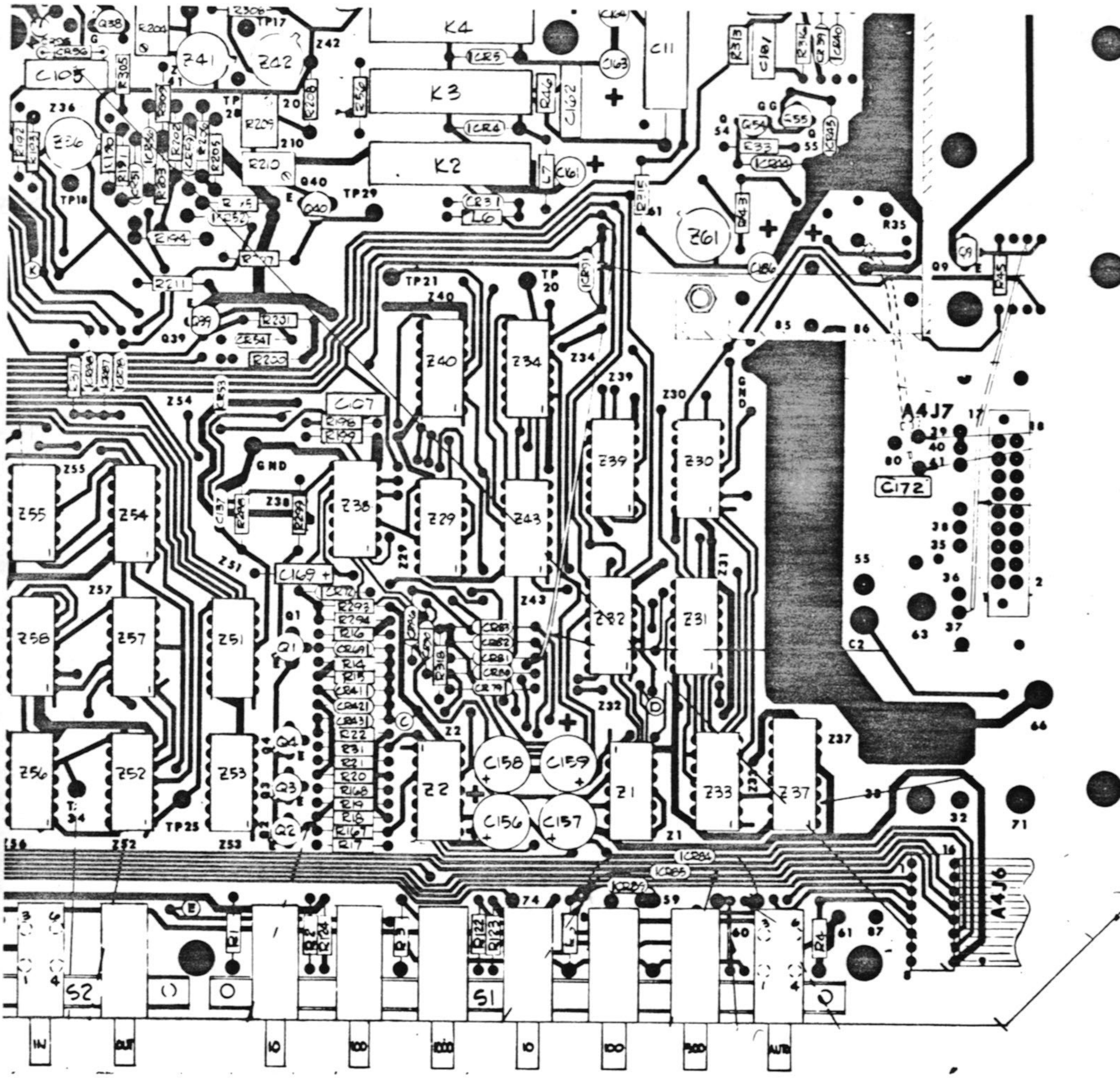


Figure 7-1. Main Board, Parts Locator (Sheet 4 of 4)

Replacement Parts List: Readout Board - 783590-1, -2

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Ceramic .1μf, 25V	880640	95750	CK06BX104K	4
C2	Same as C1				
C3	Same as C1				
C4	Same as C1				
C5	Capacitor, Mica 91pf, 500V, ±5%	807258	72136	DM15BD910J	1
DS1	Readout Diaplay	807669	73138	SP351	1
DS2	Readout Display	807670	73138	SP353	1
DS3	Lamp	806963	24138	2203-AS25	11
DS4	Same as DS3				
DS5	Same as DS3				
DS6	Same as DS3				
DS7	Same as DS3				
DS8	Same as DS3				
DS9	Same as DS3				
DS10	Same as DS3				
DS11	Same as DS3				
DS12	Same as DS3				
DS13	Same as DS3				
J1	Header	807107	76381	3429-2002	2
J2	Same as J1				
L1	Choke, 33μh	803823	76493	9310-52	4
L2	Same as L1				
L3	Same as L1				
L4	Same as L1				
Q1	Transistor	807406	04713	2N5550	4
Q2	Same as Q1				
Q3	Same as Q1				
Q4	Same as Q1				
R1	Resistor, Composition 47kΩ, 1/4W, ±5%	801638	01121	CB4735	4
R2	Resistor, Composition 330kΩ, 1/4W, ±5%	803553	01121	CB3345	11

Replacement Parts List: Readout Board - 783590-1, -2 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R3	Resistor, Composition 130kΩ, 1/4W, ±5%	801394	01121	CB1345	2
R4	Same as R2				
R5	Same as R2				
R6	Same as R2				
R7	Same as R2				
R8	Same as R1				
R9	Same as R1				
R10	Same as R2				
R11	Same as R2				
R12	Same as R2				
R13	Same as R2				
R14	Same as R1				
R15	Same as R2				
R16	Same as R2				
R17	Resistor, Composition 10kΩ, 1/4W, ±5%	801006	01121	CB1035	4
R18	Same as R17				
R19	Same as R17				
R20	Same as R17				
R21	Resistor, Composition 2.2kΩ, 1/2W, ±5%	800079	01121	EB2225	4
R22	Same as R21				
R23	Same as R21				
R24	Same as R21				
R26	Same as R3				
Z1	Integrated Circuit	806945	07187	DD-700	4
Z2	Same as Z1				
Z3	Same as Z1				
Z4	Same as Z1				
Z5	Integrated Circuit	806149	01295	SN7475N	4
Z6	Same as Z5				
Z7	Same as Z5				
Z8	Same as Z5				
Z9	Integrated Circuit	806798	01295	SN74192N	4

Replacement Parts List: Readout Board - 783590-1, -2 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr Code	Mfr. Part No.	Total Qty
Z10	Same as Z9				
Z11	Same as Z9				
Z12	Same as Z9				
Z13	Integrated Circuit	808412	01295	SN75452BP	2
Z14	Integrated Circuit	804344	07263	936DC	1
Z16	Same as Z13				
	Socket, Readout (For DS1)	807673	73138	CS352	1
	Socket, Readout (For DS2)	807672	73138	CS353	1
	Socket, Integrated Circuit (For Z1 thru Z12)	808197	00779	640358-3	12
	Socket, Integrated Circuit For Z13 & Z16)	808406	09922	DILB9P108	2
R25[1]	Resistor, Composition 200Ω, 1/4W, ±5%	802226	01121	CB2015	1
Z15[1]	Integrated Circuit	804344	07263	936DC	1
	Socket, I.C. 14-pin (For Z15[1])	807473	09922	DILB-14P-11	1

[1]Ratio Option Only (-2 units only, see Appendix D)

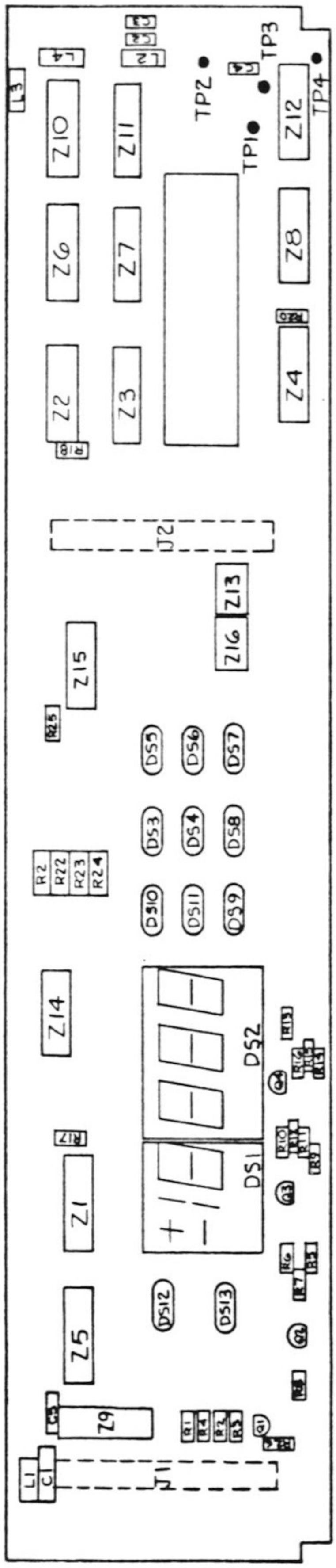


Figure 7-2. Readout Board, Parts Locator

Replacement Parts List: A/D Converter - 783591

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Ceramic 500pf, 1000V, ±10%	880710	72982	831-000X5F0501K	3
C2	Capacitor, Ceramic .1µf, 25V, +80-20%	806086	72982	5815-000Y5U00104Z	7
C3	Capacitor, Mica 470pf, 500V, ±5%	807257	72136	DM15BD471J	1
C4	Capacitor, Ceramic .01µf, 25V, +80-20%	880034	72982	5835-000-Y5U0103Z	13
C5	Capacitor, Ceramic 1000pf, 600V, ±10%	880038	72982	801-000-X5F0102K	3
C6	Capacitor, Ceramic 150pf, 1000V, ±10%	806883	72982	831-000-X5F0151K	5
C7	Capacitor, Mica 1500pf, 500V, ±10%	802425	72136	DM19-152K	1
C8	Capacitor, Elect. Aluminum 1uf, 50V, +75-10%	807169	24318	PDA1M50	3
C9	Same as C8				
C10	Same as C8				
C12	Same as C2				
C13	Same as C2				
C14	Same as C5				
C15	Same as C5				
C16	Same as C6				
C17	Same as C1				
C18	Same as C1				
C19	Same as C2				
C20	Same as C2				
C21	Same as C2				
C22	Same as C2				
C23	Same as C6				
C24	Same as C6				
C25	Same as C6				
C26	Capacitor, Ceramic .1µf, 100V, ±10%	880640		CK06BX104K	4
C27	Same as C26				
C28	Capacitor, Ceramic 33pf, 500V, ±5%	806719	72982	831-000-U2J0330J	3

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C29	Capacitor, Met. Polyester 1μf, 100V, ±10%	807569	74861	1LMEP100	1
C30	Capacitor, Ceramic 22pf, 1000V, ±5%	806885	72982	831-000-U2J0220J	3
C31	Same as C30				
C32	Same as C30				
C33	Same as C4				
C34	Same as C4				
C37	Same as C4				
C38	Same as C4				
C40	Same as C4				
C41	Same as C4				
C42	Same as C28				
C43	Same as C4				
C44	Same as C4				
C46	Same as C4				
C47	Same as C$				
C48	Same as C28				
C49	Same as C4				
C50	Same as C4				
C51	Same as C26				
C52	Same as C26				
CR1	Diode	802924	07263	1N3069	27
CR2	Same as CR1				
CR3	Same as CR1				
CR4	Same as CR1				
CR5	Same as CR1				
CR6	Same as CR1				
CR8	Same as CR1				
CR9	Same as CR1				
CR11	Same as CR1				
CR12	Diode	806957	04713	1N937	1
CR14	Same as CR1				
CR15	Same as CR1				

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
CR16	Same as CR1				
CR17	Same as CR1				
CR18	Same as CR1				
CR19	Same as CR1				
CR20	Same as CR1				
CR21	Same as CR1				
CR22	Same as CR1				
CR23	Same as CR1				
CR24	Same as CR1				
CR25	Same as CR1				
CR26	Same as CR1				
CR27	Same as CR1				
CR28	Same as CR1				
CR29	Same as CR1				
CR30	Same as CR1				
CR31	Same as CR1				
J1	Header	807107	76381	3429-2002	5
J2	Same as J1				
J3	Same as J1				
J4	Same as J1				
J5	Same as J1				
K1	Relay	806959	20891	530-4-1C	2
K2	Same as K1				
K3	Relay	806960	20891	360-4-2A	2
K4	Same as K3				
L1	Choke, 33µh	804836	76493	9230-56	8
L2	Same as L1				
L3	Same as L1				
L4	Same as L1				
L5	Same as L1				
L6	Same as L1				
L7	Same as L1				
L8	Same as L1				
Q1	Transistor	807535	04713	2N4852	1

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
Q2	Transistor	804088	04713	2N4123	8
Q4	Transistor	807406	04713	2N5550	2
Q5	Same as Q4				
Q6	Same as Q2				
Q7	Same as Q2				
Q8	Same as Q2				
Q9	Transistor	805808	01295	TIS75	3
Q10	Same as Q9				
Q11	Same as Q9				
Q12	Transistor	803662	01295	2N3819	5
Q14	Same as Q12				
Q15	Same as Q2				
Q16	Transistor	805059	QPL	JAN 2N2906	4
Q17	Same as Q16				
Q18	Same as Q16				
Q19	Same as Q16				
Q21	Same as Q2				
Q22	Same as Q2				
Q23	Same as Q12				
Q24	Transistor	804360	07263	2N4360	2
Q25	Same as Q24				
Q26	Same as Q12				
Q27	Same as Q2				
Q28	Same as Q12				
Q29	Transistor	808190	06001	GES6002	2
Q30	Same as Q29				
R1	Resistor, Composition 6.8kΩ, 1/4W, ±5%	802189	01121	CB6825	3
R2	Resistor, Composition 6.2kΩ, 1/4W, ±5%	801395	01121	CB6225	4
R3	Potentiometer, 50kΩ,±10%	808051	32997	3279W-1-503	1
R4	Resistor, Composition 22kΩ, 1/4W, ±5%	802182	01121	CB2235	1
R5	Resistor, Composition 100Ω, 1/4W, ±5%	801981	01121	CB1015	5

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R6	Resistor, Composition 5.1kΩ, 1/4W, ±5%	801397	01121	CB5125	2
R8	Resistor, Composition 200Ω, 1/4W, ±5%	802226	01121	CB2015	3
R11	Resistor, Composition 15kΩ, 1/4W, ±5%	801988	01121	CB1535	2
R12	Same as R11				
R13	Resistor, Composition 2Ω, 1/2W, ±5%	806793	01121	EB20G5	1
R14	Resistor, Composition 1MΩ, 1/4W, ±5%	802730	01121	CB1055	10
R15	Resistor, Composition 47kΩ, 1/4W, ±5%	801638	01121	CB4735	2
R16	Resistor, Composition 150kΩ, 1/4W, ±5%	802757	01121	CB1545	8
R17	Same as R14				
R18	Resistor, Composition 68kΩ, 1/4W, ±5%	801003	01121	CB6835	1
R19	Same as R14				
R20	Same as R15				
R21	Same as R14				
R22	Same as R6				
R23	Same as R1				
R24	Same as R2				
R25	Resistor, Metal Film 39kΩ, 1/4W, ±2%	807205	QPL	RL07S393G	1
R26	Resistor, Composition 10kΩ, 1/4W, ±5%	801006	01121	CB1035	6
R27	Same as R26				
R28	Same as R5				
R29	Resistor, Composition 62kΩ, 1/4W, ±5%	802082	01121	CB6235	1
R30	Resistor, Composition 30kΩ, 1/4W, ±5%	801396	01121	CB3035	2
R31	Same as R30				
R32	Resistor, Composition 180kΩ, 1/4W, ±5%	802903	01121	CB1845	1
R33	Same as R16				

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R34	Potentiometer, 50kΩ, ±10%	806911	32997	3299W503	7
R35	Resistor, Composition 3.9kΩ, 1/4W, ±5%	801409	01121	CB3925	6
R36	Resistor, Composition 27kΩ, 1/4W, ±5%	802256	01121	CB2735	3
R37	Resistor, Composition 1kΩ, 1/4W, ±5%	801004	01121	CB1025	3
R38	Resistor, Composition 4.7kΩ, 1/4W, ±5%	801407	01121	CB4725	3
R39	Same as R35				
R40	Resistor, Metal Film 232kΩ, 1/8W, ±2%	806937	16299	C4, 232K, 2%	1
R41	Same as R14				
R42	Same as R14				
R43	Resistor, Composition 51k, 1/4W, ±5%	801985	01121	CB5135	4
R44	Resistor, Composition 24kΩ, 1/4W, ±5%	801393	01121	CB2435	2
R47	Resistor, Composition 1.2kΩ, 1/4W, ±5%	801982	01121	CB1225	1
R48	Same as R34				
R49	Resistor, Composition 150kΩ, 1/4W, ±5%	802757	01121	CB1545	8
R50	Same as R43				
R51	Same as R43				
R52	Same as R49				
R53	Same as R49				
R54	Same as R35				
R55	Same as R36				
R56	Same as R37				
R57	Same as R38				
R58	Same as R35				
R59	Same as R35				
R60	Same as R36				
R61	Same as R37				
R62	Same as R38				
R63	Same as R35				

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R64	Resistor, Composition 160Ω, 1/4W, ±5%	804212	01121	CB1615	2
R65	Same as R2				
R66	Same as R64				
R67	Same as R5				
R68	Resistor, Variable 2kΩ	806942	18612	12002P2K	1
R69	Resistor, Composition 910Ω, 1/4W, ±5%	807165	01121	CB9115	3
R73	Resistor, Metal Film 15kΩ, 1/4W, ±.1%	808025	75042	MAR3, 15K, .1%	1
R76	Same as R1				
R77	Resistor, Composition 43Ω, 1/4W, ±5%	804062	01121	CB4305	3
R78	Same as R49				
R79	Same as R34				
R80	Same as R49				
R81	Resistor, Composition 470kΩ, 1/4W, ±5%	806093	01121	CB4745	1
R82	Resistor, Composition 9.1kΩ, 1/4W, ±5%	801008	01121	CB9125	1
R83	Resistor, Metal Film 22.1kΩ, 1/4W, ±1%	807168	16299	C4, 22.1K, 1%	1
R84	Resistor, Metal Film 16.5kΩ, 1/4W, ±1%	807166	16299	C4, 16.5K , 1%	2
R85	Same as R16				
R86	Resistor, Variable 10KΩ, 10%	806724	32997	3386P-1-103	3
R87	Resistor, Composition 20kΩ, 1/4W, ±5%	801636	01121	CB2035	2
R88	Resistor, Composition 3kΩ, 1/4W, ±5%	801406	01121	CB3025	2
R89	Same as R49				
R90	Resistor, Composition 750kΩ, 1/4W, ±5%	804324	01121	CB7545	1
R91	Resistor, Composition 11kΩ, 1/4W, ±5%	802255	01121	CB1135	1
R92	Same as R84				
R94	Resistor, Metal Film 38.3kΩ, 1/4W, ±1%	807167	16299	C4, 38.3K, 1%	1

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R95	Same as R86				
R96	Same as R87				
R97	Same as R88				
R101	Same as R49				
R102	Same as R16				
R110	Same as R49				
R111	Resistor, Composition 390kΩ, 1/4W, ±5%	801987	01121	CB3945	3
R112	Resistor, Composition 5.6kΩ, 1/4W, ±5%	801983	01121	CB5625	2
R113	Same as R112				
R114	Resistor, Composition 820kΩ, 1/4W, ±5%	804248	01121	CB8245	1
R115	Same as R86				
R116	Same as R43				
R117	Same as R44				
R118	Same as R26				
R119	Resistor, Composition 39kΩ, 1/4W, ±5%	802081	01121	CB3935	2
R120	Resistor, Composition 3.6kΩ, 1/4W, ±5%	801398	01121	CB3625	2
R121	Resistor, Metal Film 5kΩ, .3W, ±.1%	806932	75042	MAR5 T16, 5K, .1%	4
	Res., Wirewound (Alternate) 5kΩ, ±5PPM, ±.1%	807548	11880	MPC 1B, 5K, .1%	
R122	Resistor, Composition 2.4kΩ, 1/4W, ±5%	801408	01121	CB2425	2
R123	Same as R5				
R124	Resistor, Composition 240kΩ, 1/4W, ±5%	802084	01121	CB2445	2
R125	Same as R111				
R126	Same as R34				
R127	Same as R121				
R128	Resistor, Variable 200Ω,±10%	806913	32997	3299W-201	2
R129	Resistor, Metal Film 20kΩ, .3W, ±.1%	806919	75042	MAR5 T16, 20K, .1%	2
	Res., Wirewound (Alternate) 20kΩ, 1/4W, ±.1%, ±5PPM	807549	11880	MPC 1B, 20K, .1%	

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R130	Same as R14				
R131	Resistor, Metal Film 43.5kΩ, .3W, ±.1%	807323	75042	MAR5 T16, 43.3K, 1%	2
	Res., Wirewound (Alternate) 43.5kΩ, 1/4W, ±.1%, ±5PPM	807547	11880	MPC 1B, 43.5K, .1%	
R132	Resistor, Variable 500Ω, ±10%	807164	32997	3299W	2
R133	Resistor, Composition 36kΩ, 1/4W, ±5%	802904	01121	CB3635	2
R134	Resistor, Composition 2kΩ, 1/4W, ±5%	801094	01121	CB2025	2
R135	Same as R8				
R136	Resistor, Metal Film 40kΩ, .3W, ±.1%	806933	75042	MAR5 T16, 40K, .1%	2
	Res., Wirewound (Alternate) 40kΩ, 1/4W, ±.1%, ±5PPM	807550	11880	MPC 1B, 40K, .1%	
R137	Same as R14				
R138	Same as R16				
R139	Same as R69				
R140	Same as R26				
R141	Same as R77				
R142	Same as R16				
R143	Same as R34				
R144	Same as R119				
R145	Same as R120				
R146	Same as R121				
R147	Same as R34				
R148	Same as R111				
R149	Same as R122				
R150	Same as R5				
R151	Same as R124				
R152	Same as R121				
R153	Same as R128				
R154	Same as R129				
R155	Same as R133				
R156	Same as R134				
R157	Same as R8				

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R158	Same as R136				
R159	Same as R14				
R160	Same as R131				
R161	Same as R132				
R162	Same as R14				
R163	Same as R16				
R164	Same as R39				
R165	Same as R26				
R166	Same as R16				
R167	Same as R77				
R168	Same as R34				
R169	Same as R2				
R171	Same as R26				
R172	Resistor, Composition 200kΩ, 1/4W, ±5%	803243	01121	CB2045	1
R173	Resistor, Metal Film 4.53kΩ, 1/8W, ±.1%	808159	75042	MAR5 T16, 4.53K, .1%	1
R174	Resistor, Metal Film 7.5kΩ, 1/8W, ±1%	807585	QPL	RN55E7501F	1
XZ1	Socket, I.C., 14-pin	807473	09922	DILB-14P-11	26
XZ2	Same as XZ1				
XZ3	Same as XZ1				
XZ4	Same as XZ1				
XZ5	Same as XZ1				
XZ6	Same as XZ1				
XZ7	Same as XZ1				
XZ8	Same as XZ1				
XZ9	Same as XZ1				
XZ10	Same as XZ1				
XZ11	Same as XZ1				
XZ12	Same as XZ1				
XZ13	Same as XZ1				
XZ14	Same as XZ1				
XZ15	Same as XZ1				
XZ16	Same as XZ1				
XZ17	Same as XZ1				
XZ18	Same as XZ1				
XZ19	Same as XZ1				
XZ20	Same as XZ1				
XZ21	Same as XZ1				
XZ22	Same as XZ1				

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
XZ23	Socket	805671	82110	Type A23-2052	12
XZ24	Same as XZ23				
XZ25	Same as XZ23				
XZ26	Same as XZ1				
XZ27	Same as XZ23				
XZ29	Same as XZ23				
XZ30	Same as XZ23				
XZ31	Same as XZ23				
XZ33	Same as XZ1				
XZ34	Same as XZ23				
XZ35	Same as XZ23				
XZ36	Same as XZ23				
XZ37	Same as XZ23				
XZ38	Same as XZ23				
XZ39	Same as XZ1				
XZ40	Same as XZ1				
XZ42	Socket, I.C., 16-pin	807474	09922	DILB-16P-11	1
Z1	Integrated Circuit	805026	07263	946DC	5
Z2	Integrated Circuit	805807	07263	962DC	3
Z3	Same as Z2				
Z4	Integrated Circuit	805032	07263	930DC	1
Z5	Integrated Circuit	804344	07263	936DC	3
Z6	Same as Z1				
Z7	Same as Z5				
Z8	Same as Z1				
Z9	Same as Z5				
Z10	Integrated Circuit	804458	07263	949DC	3
Z11	Integrated Circuit	804883	01295	SN7400N	6
Z12	Same as Z11				
Z13	Same as Z11				
Z14	Same as Z11				
Z15	Same as Z10				
Z16	Same as Z11				
Z17	Integrated Circuit	804807	07263	9000DC	1
Z18	Integrated Circuit	806121	07263	7490ADC	1
Z19	Same as Z11				
Z20	Integrated Circuit	806961	01295	SN74121N	2
Z21	Same as Z20				
Z22	Same as Z2				

Replacement Parts List: A/D Converter - 783591 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
Z23	Operational Amplifier	807797	12040	LF356	2
Z24	Operational Amplifier	806051	12040	LM741CH	7
Z25	Operational Amplifier	806347	12040	LM301AH	1
Z26	Same as Z1				
Z27	Same as Z24				
Z28	Module Resistor Network	807208	07342	807208	1
Z29	Same as Z23				
Z30	Same as Z24				
Z31	Same as Z24				
Z33	Integrated Circuit	803802	07263	932DC	1
Z34	Same as Z24				
Z35	Same as Z24				
Z36	Integrated Circuit	807478	07342	Selected 301A	2
Z37	Same as Z24				
Z38	Same as Z36				
Z39	Same as Z10				
Z40	Same as Z1				
Z41	Precision Reference Source	808030	12040	LM399H	1
Z42	Integrated Circuit	807722	01295	SN74123N	1

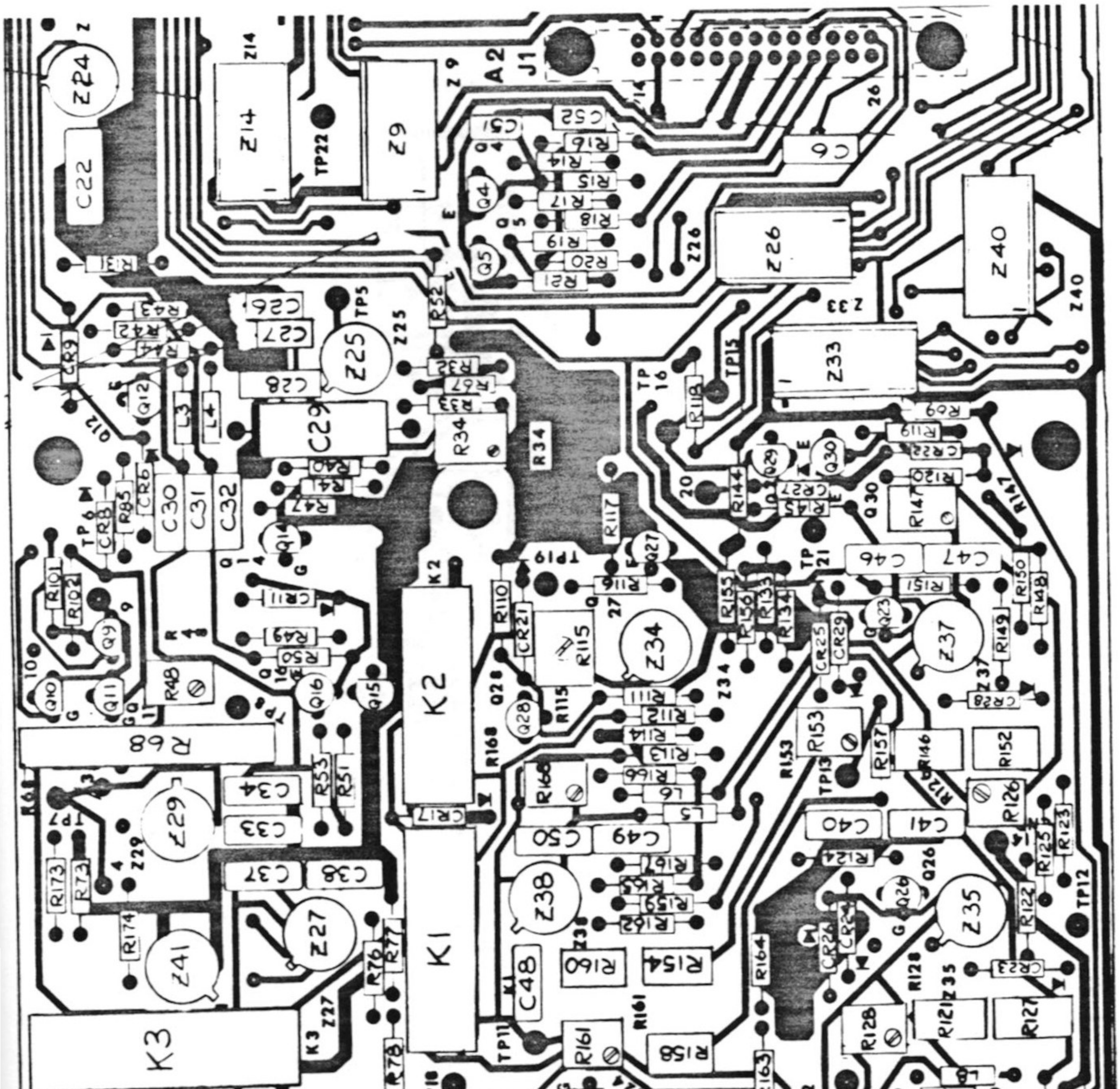


Figure 7-3. A/D Converter, Parts Locator (Sheet 1 of 2)

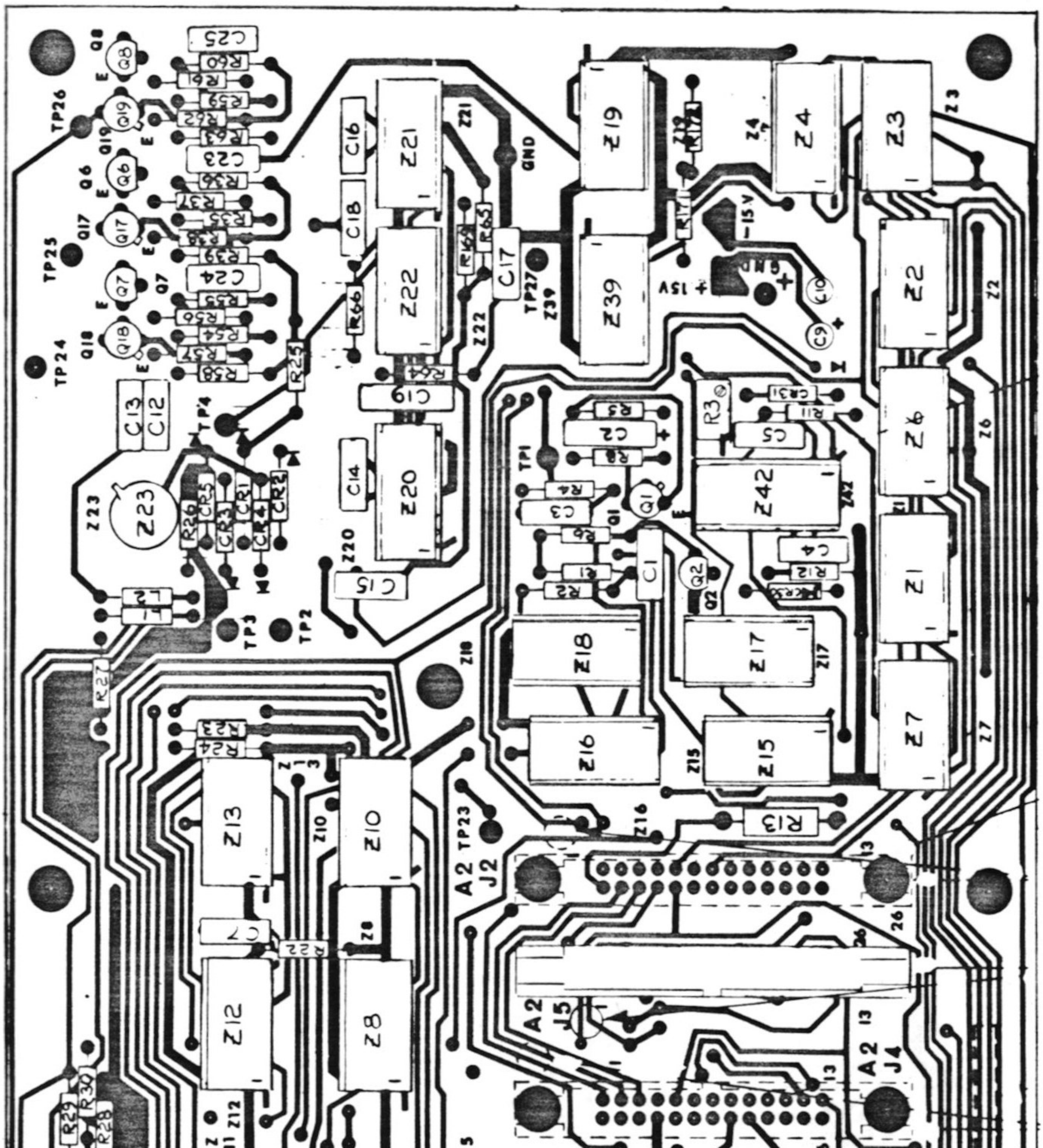


Figure 7-3. A/D Converter, Parts Locator (Sheet 2 of 2)

Replacement Parts List: Reference Isolation Board - 783601-2

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Polycarbonate 4µf, 50V, ±10%	807240	14752	625B-1A-405K	1
C2	Capacitor, Trim .25-1.5pf	806970	74970	273-0001-001	1
C3*	Capacitor, Mica 1pf, 500V, ±10%	802619	72136	DM15-010D	1
C4	Capacitor, Mica 75-pf, 300V, ±5%	802315	72136	DM15-751J	1
C6	Capacitor, Ceramic .01µf, 25V, +80-20%	880034	72982	5835-000-Y5U0103Z	2
C7	Same as C6				
C8	Capacitor, Elect. Tantalum 220µf, 30V, +20-15%	807656	56289	109D227X0030F2	2
C9	Same as C8				
C10	Capacitor, Mica 5pf, 500V, ±5%	802421	72136	DM15-050K	1
C11	Capacitor, Trim 2-8pf, 200-350WVDC	807216	72982	538-011-A-2-8PF	1
CR1	Diode	802924	07263	1N3069	3
CR2	Diode	804416	04713	1N4736A	2
CR3	Same as CR2				
CR4	Same as CR1				
CR5	Same as CR1				
CR6	Diode	803368	04713	1N4744A	2
CR7	Same as CR6				
DS1	Lamp	806963	24138	2203-AS25	1
K1	Relay	806971	20891	530-4-1A	1
Q1	Transistor	807247	04713	2N5777	1
Q2	Transistor	803529-2	04713	2N3499	1
Q3	Transistor	804899	04713	2N2219	1
Q4	Transistor	882328	04713	2N2905	1
R1	Resistor, Composition 1.5kΩ, 1/4W, ±5%	802232	01121	CB1525	1
R2	Resistor, Composition 16kΩ, 1/4W, ±5%	802227	01121	CB1635	1
R3	Resistor, Composition 24kΩ, 1/4W, ±5%	801393	01121	CB2435	1
R4	Resistor, Composition 2.4kΩ, 1/4W, ±5%	801408	01121	CB2425	1

*Some units have capacitors with selected nominal value of 2, 3, or 5pf.

Replacement Parts List: Reference Isolation Board - 783601-2 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R5	Resistor, Metal Film 499kΩ, 1/8W, ±1%	808722	01121	FM55X4993B	1
R6	Resistor, Metal Film 2.58kΩ, 1/10W, ±.1%	808723	01121	FM55X2581B	
R7	Resistor, Metal Film 92.0kΩ, 1/8W, ±.1%	808724	QPL	RNC55H9202FM	1
R14	Potentiometer 1kΩ, 1/2W	807227	32997	3299W-1-102	1
R16	Resistor, Composition 20kΩ, 1/4W, ±5%	801636	01121	CB2035	1
R17	Resistor, Composition 2kΩ, 1/4W, ±5%	801094	01121	CB2025	2
R18	Same as R17				
R19	Resistor, Composition 10kΩ, 1/4W, ±5%	803784	01121	CB1005	1
R20	Resistor, Composition 100kΩ, 1/4W, ±5%	801981	01121	CB1015	2
R21	Same as R20				
Z1	Operational Amplifier	808511	12040	LM310H	1
	Connector, 18-pin	807211	16512	NC-200148-01	1

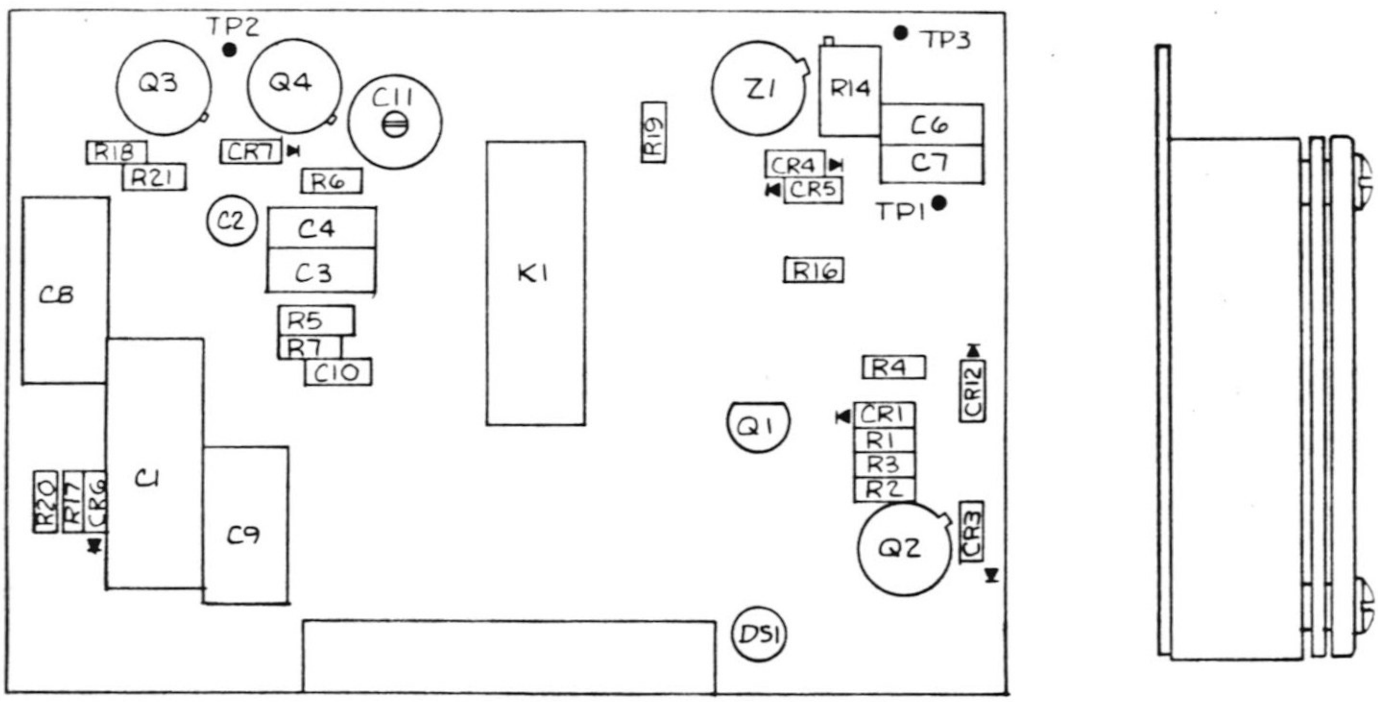


Figure 7-4. Reference Isolation Board, Parts Locator

Replacement Parts List: Signal Broadband Isolation Board - 783602-2

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Polycarbonate .68µf, 400V, ±10%	807647	12406	ZD4A684X	1
C2	Capacitor, Trim .25-1.5pf	806970	74970	273-0001-001	1
C3	Capacitor, Polystyrene .011µf, 100V, ±2%	807213	84171	1PTL113G	1
C4	Capacitor, Ceramic 820pf, 1000V, ±20%	806210	QPL	CK60AW821M	1
C5	Capacitor, Elect. Aluminum 47µf, 35V, +100-0%	807246	24138	PCD47PF35	1
C6	Capacitor, Ceramic .01µf, 25V, +80-20%	880034	72982	5835-000-Y5U0103Z	2
C7	Same as C6				
C8	Capacitor, Elect. Tantalum 220µf, 30V, +20-15%	807656	56289	109D227X0030F2	2
C9	Same as C8				
C10	Capacitor, Polystyrene 22pf, 750V, ±5%	808288	26625	M.I.A.C.602	2
C11	Same as C10				
C12	Capacitor, Mica 910pf, 500V, ±5%	802333	72136	DM19-911J	1
C13	Capacitor, Mica 33pf, 500V, ±5%	803610	72136	DM10E330J0500WV4CR	1
CR1	Diode	802924	07263	1N3069	3
CR2	Diode	804416	04713	1N4736A	2
CR3	Same as CR2				
CR4	Same as CR1				
CR5	Same as CR1				
CR6	Diode	803368	04713	1N4744A	2
CR7	Same as CR6				
CR8	Diode	803205	04713	1N972B	1
DS1	Lamp	806963	24138	2203-AS25	1
K1	Relay	808020	95073	808020	1
L1	Choke, 68µh	807649	83125	DD68	1
Q1	Transistor	807247	04713	2N5777	1
Q2	Transistor	803529	04713	2N3499	1
Q3	Transistor	804899	04713	2N2219	1
Q4	Transistor	882328	04713	2N2905	1

Replacement Parts List: Signal Broadband Isolation Board - 783602-2 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R1	Resistor, Composition 1.5kΩ, 1/4W, ±5%	802232	01121	CB1525	1
R2	Resistor, Composition 16kΩ, 1/4W, ±5%	802227	01121	CB1625	1
R3	Resistor, Composition 24kΩ, 1/4W, ±5%	801393	01121	CB2435	1
R4	Resistor, Composition 910Ω, 1W, ±5%	804162	QPL	RC32GF911J	1
R5	Resistor, Metal Film 10MΩ, 1/4W, ±10%	807342	03888	PME64T9	1
R6	Resistor, Metal Film 9.9kΩ, .3W, ±.1%	806923	75042	MAR5 T16 9.9K, .1%	1
R7	Potentiometer, 200kΩ, 1/2W	806913	32997	3299W201	1
R8	Resistor, Composition 10MΩ, 1/4W, ±5%	803389	01121	CB1065	1
R10	Resistor, Wirewound 27kΩ, 9W, ±5%	807231	91637	CW-7	1
R11	Resistor, Composition 51kΩ, 1/4W, ±5%	801985	01121	CB5135	2
R12	Same as R11				
R13	Resistor, Composition 20kΩ, 1/4W, ±5%	801636	01121	CB2035	2
R14	Potentiometer, 1kΩ, 1/2W	807227	32997	3299W-1-102	1
R16	Same as R13				
R17	Resistor, Composition 2kΩ, 1/4W, ±5%	801094	01121	CB2025	2
R18	Same as R17				
R20	Resistor, Composition 100kΩ, 1/4W, ±5%	801981	01121	CB1015	2
R21	Same as R20				
R22	Resistor, Composition 10kΩ, 1/4W, ±5%	803784	01121	CB1005	1
R23	Resistor, Wirewound 100kΩ, 2.5W, ±5%	807648	QPL	CB1005	1
Z1	Operational Amplifier	808511	12040	LM310H	1

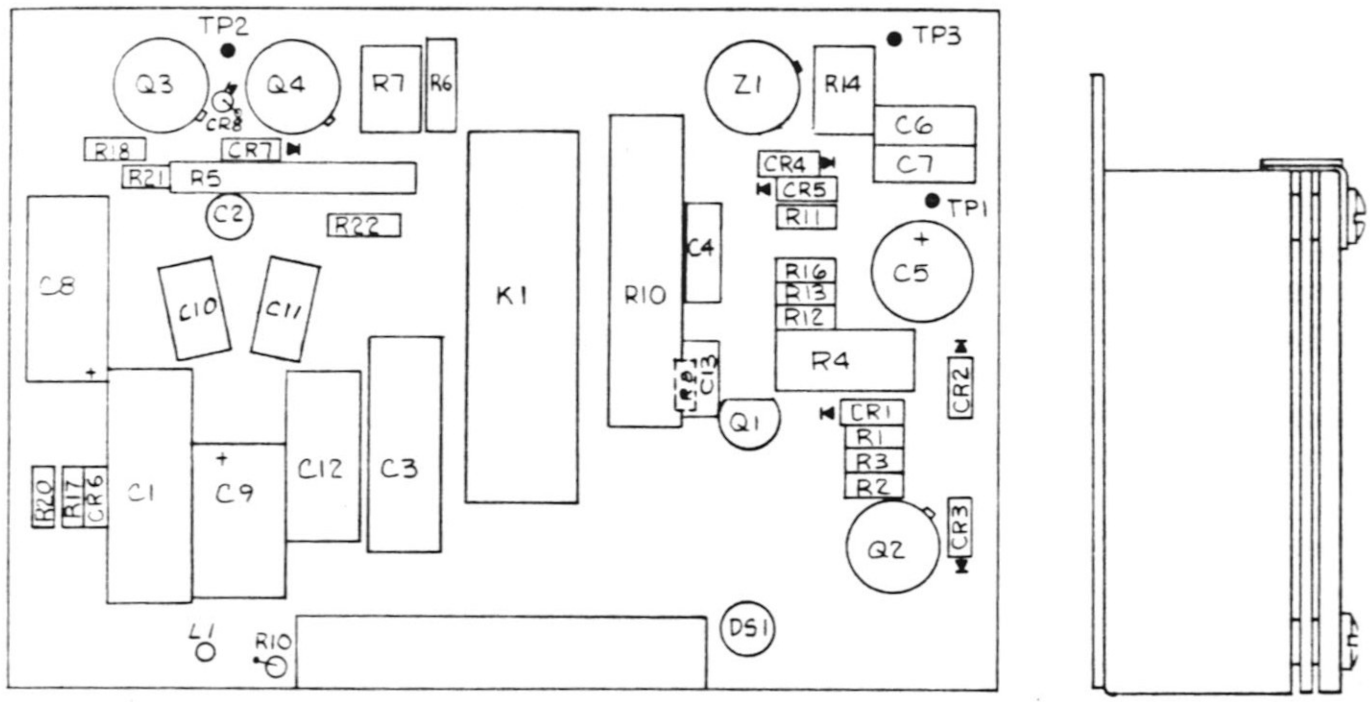


Figure 7-5. Signal Broadband Isolation Board, Parts Locator

Replacement Parts List: Null Meter - 783672

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
	Null Meter	205666	07342		1
	Null Meter (Alternate)	205677	07342		
A1	P.C. Board Assembly	500887	07342		1
CR1	Diode	802924	07263	1N3600	4
CR2	Same as CR1				
CR3	Same as CR1				
CR4	Same as CR1				
J1	Socket	807474	09922	DILB-16P-11	1
Q1	Transistor	805808	01295	TIS 75	2
Q2	Same as Q1				
Q3	Transistor	805059	04713	2N2906	2
Q4	Same as Q3				
R1	Resistor, Variable 10kΩ, 1/4W, ±10%	807507	32997	3299X-1-103	1
R2	Resistor, Composition 100kΩ, 1/4W, ±10%	805042	QPL	RCR07G104JP	1
R3	Resistor, Variable 1kΩ, 1/4W, ±10%	807296	32997	3299X-1-102	1
R4	Resistor, Composition 20kΩ, 1/4W, ±10%	805192	QPL	RCR07G203JP	1
R5	Resistor, Composition 4.7kΩ, 1/4W, ±10%	805278	QPL	RCR07G472JP	1
R6	Resistor, Composition 3.3kΩ, 1/4W, ±10%	803388	01121	CB3325	1
R7	Resistor, Composition 1MΩ, 1/4W, ±10%	802730	01121	CB1055	2
R8	Same as R7				
R9	Resistor, Composition 51kΩ, 1/4W, ±10%	805188	QPL	RCR07G513JP	6
R10	Same as R9				
R11	Same as R9				
R12	Same as R9				
R13	Same as R9				
R14	Same as R9				
Z1	Integrated Circuit	806952	01295	SN7426N	1
Z2	Integrated Circuit	806051	49956	RC741T	1
Z3	Integrated Circuit	804883	07263	9300DC	1

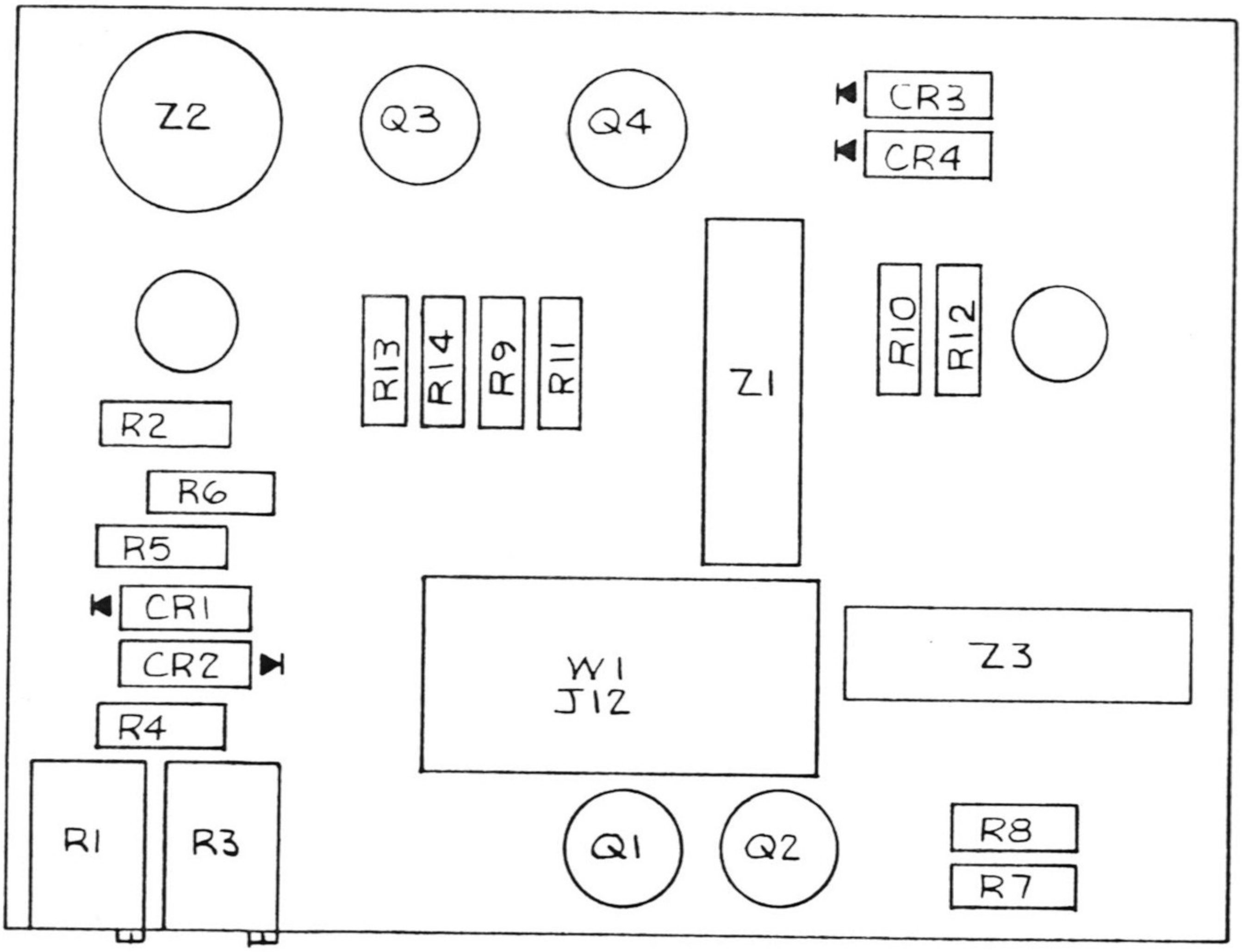


Figure 7-6. Null Meter, Parts Locator

Replacement Parts List: Frequency Board - 783599

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C6	Capacitor, Ceramic .1µf, 100V, ±10%	880640		CK06BX104K	4
C7	Same as C6				
C13	Same as C6				
C14	Same as C6				
C15	Capacitor, Elect. Aluminum 10µf, 25V +100-0%	806890	24138	PCD10PB25	7
C16	Capacitor, Ceramic .01µf, 25V, +80-20%	880034	72982	5835-000-Y5U0103Z	2
C19	Same as C16				
C20	Same as C15				
C21	Capacitor, Ceramic 150pf, 1000V, ±10%	806883	72982	831-000-X5F0-151K	2
C22	Same as C21				
C23	Same as C15				
C26	Capacitor, Mica 39pf, 500V, ±10%	802338	72136	DM15-390K	1
C29	Same as C15				
C31	Same as C15				
C32	Same as C15				
C33	Same as C15				
C34	Capacitor, Select at Test				
C39	Capacitor, Mica 150pf, 500V, ±5%	801365	72136	DM15F-151J	1
C40	Capacitor, Mica 5pf, 500V, ±10%	802421	72136	DM15-050K	2
C41	Same as C40				
CR1	Diode	802924	07263	1N3600	6
CR2	Same as CR1				
CR3	Same as CR1				
CR5	Diode	807217	04713	1N5229	2
CR6	Same as CR1				
CR8	Same as CR5				
CR9	Same as CR1				
CR10	Same as CR1				
L1	Choke, 33µh	804836	76493	9230-56	4
L2	Same as L1				

Replacement Parts List: Frequency Board - 783599 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
L3	Same as L1				
L4	Same as L1				
Q1	Transistor	804583	01295	TIS73	2
Q2	Same as Q1				
Q3	Transistor	808190	06001	GES6002	4
	(Alternate for Q3, Q11)	806949	04713	2N4123	
	(Alternate for Q7, Q8)	807479	06001	2N6002	
Q4	Transistor	803662	01295	2N3819	1
Q5	Transistor	805808	01295	TIS75	3
Q6	Same as Q5				
Q7	Same as Q3				
Q8	Same as Q3				
Q9	Transistor	805061	04713	2N2906	1
Q10	Transistor	804318	04713	2N4851	1
Q11	Same as Q3				
Q12	Transistor	882779	04713	2N5116	1
Q13	Same as Q5				
Q14	Transistor	806213	01295	2N5246	1
R7	Resistor, Composition 2.2MΩ, 1/4W, ±5%	804297	01121	CB2255	2
R8	Potentiometer, 50k, 1/2W,±5%	807251	32997	3299X-50KΩ	4
R9	Resistor, Metal Film 150kΩ, 1/4W, ±2%	806239	16299	C07, 150K, 1/4W, 2%	3
R16	Resistor, Metal Film 43Ω, 1/4W, ±2%	807344	16299	C07, 43Ω, 1/4W, 2%	3
R17	Same as R7				
R18	Same as R8				
R19	Resistor, Metal Film 20kΩ, 1/8W, ±1%	806544	16299	NC4, 20K, 1/8W, 1%	6
R20	Resistor, Composition 10kΩ, 1/4W, ±5%	801006	01121	CB1035	5
R22	Same as R19				
R23	Same as R20				
R24	Same as R20				
R25	Resistor, Composition 51kΩ, 1/4W, ±5%	801985	01121	CB5135	1

Replacement Parts List: Frequency Board - 783599 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R26	Same as R20				
R27	Resistor, Composition 2kΩ, 1/4W, ±5%	801094	01121	CB2025	3
R28	Same as R27				
R29	Resistor, Composition 15kΩ, 1/4W, ±5%	801988	01121	CB1535	2
R30	Same as R19				
R31	Same as R19				
R32	Same as R29				
R33	Same as R19				
R34	Same as R19				
R35	Same as R8				
R36	Resistor, Metal Film 22.1kΩ, 1/8W, ±1%	806936	16299	NC4, 22.1K, 1/8W, 1%	1
R37	Resistor, Composition 130kΩ, 1/4W, ±5%	801394	01121	CB1345	1
R38	Same as R20				
R39	Same as R16				
R40	Same as R9				
R41	Same as R8				
R42	Resistor, Composition 240kΩ, 1/4W, ±5%	802084	01121	CB2445	1
R43	Resistor, Composition 5.1kΩ, 1/4W, ±5%	801397	01121	CB5125	1
R44	Potentiometer, 5k, 1/2W, 10%	807250	32997	3299X-5K	1
R45	Resistor, Composition 200Ω, 1/4W, ±5%	802226	01121	CB2015	1
R46	Resistor, Metal Film 16.5kΩ, 1/4W, ±1%	807166	16299	C4, 16.5K, 1%	1
R47	Resistor, Composition 20kΩ, 1/4W, ±5%	801636	01121	CB2035	1
R48	Same as R27				
R49	Resistor, Composition 150Ω, 1/4W, ±5%	880200	01121	CB1515	1
R50	Same as R9				
R51	Same as R16				
R52	Resistor, Metal Film 93.1kΩ, 1/8W, ±1%	806931	16299	NC4, 93.1K, 1/8W, 1%	1

Replacement Parts List: Frequency Board - 783599 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R53	Resistor, Composition 12k , 1/4W, 5%	801721	01121	CB1235	2
R56	Same as R53				
XZ1	Socket, I.C., Op Amp	805671	82110	A23-2052	4
XZ2	Same as XZ1				
XZ3	Same as XZ1				
XZ4	Same as XZ1				
XZ5	Socket, I.C.	807473	09922	DILB-14P-11	1
Z1	Operational Amplifier	807428	12040	LM318H	2
Z2	Same as Z1				
Z3	Operational Amplifier	807517	27014	LM301AH	1
Z4	Operational Amplifier	807478		301A Selected	1
Z5	Integrated Circuit	806952	01295	SN7426N	1

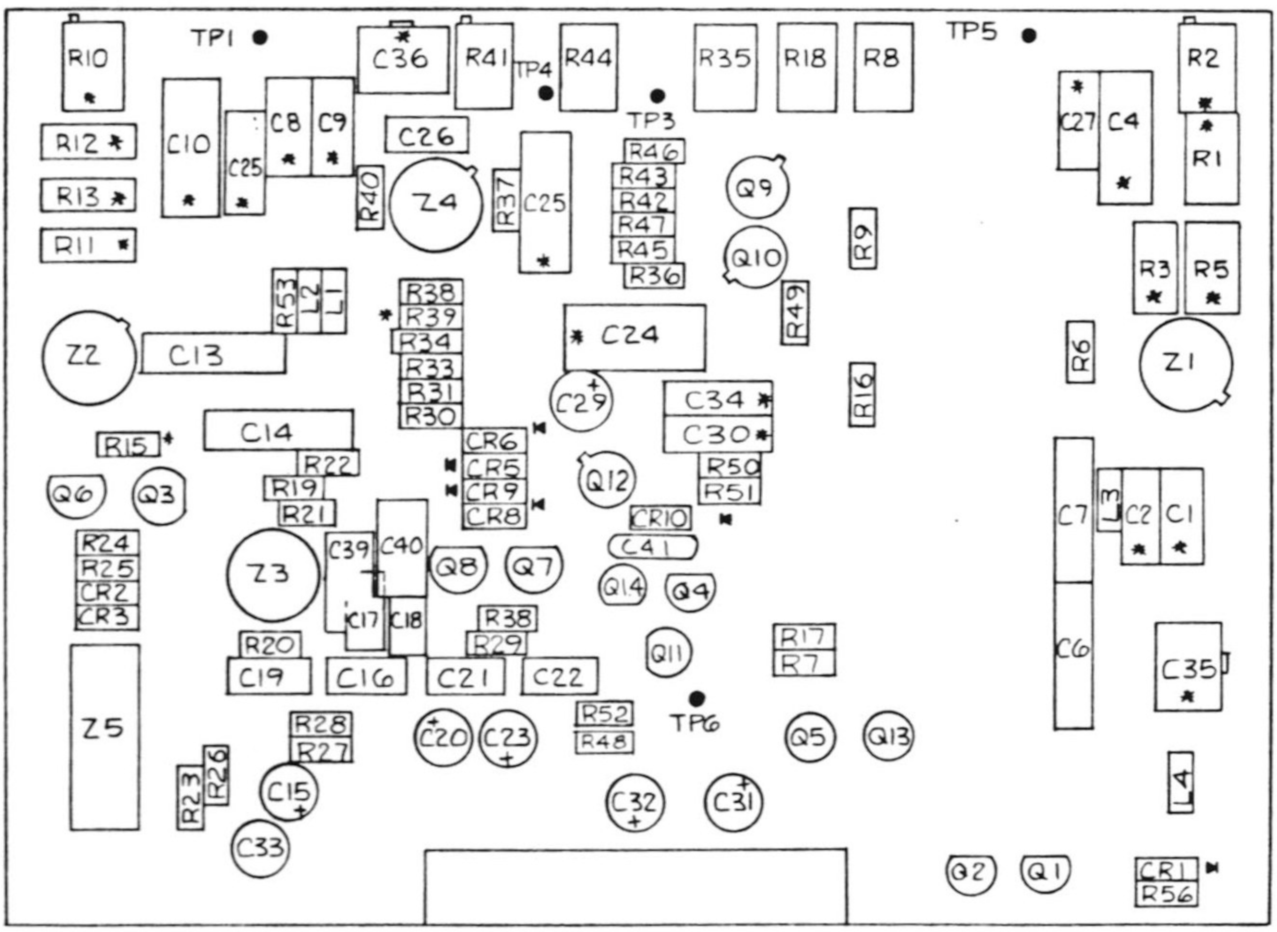


Figure 7-7. Frequency Board, Parts Locator

Replacement Parts List: Frequency Card - 19.2 KHz

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Mica 20pf, 500V, ±1%	807526	72136	DM15-D200F-4CR	2
C2	Capacitor, Mica 2pf, 500V, ±.5pf	802420	72136	DM15-020D	2
C4	Capacitor, Mica 430pf, 500V, ±2%	807529	72136	DM15-D431G-4CR	2
C8	Same as C1				
C9	Same as C2				
C10	Same as C4				
C24	Capacitor, Film .001µf, 400V, ±10%	802241	56289	192P10294	1
C25	Capacitor, Mica 470pf, 500V, ±5%	807257	72136	DM15-BD471J	1
C27	Capacitor, Mica 30pf, 500V, ±5%	807419	72136	DM15-300J	2
C28	Same as C27				
C30	Capacitor, Mica 47pf, 500V, ±5%	801184	72136	CM15E-470J	1
C35	Capacitor, Trim. .25-1.5pf	806970	74970	273-0001-D01	2
C36	Same as C35				
R1	Resistor, Metal Film 10kΩ, .3W, ±.1%	807176	75042	MAR5-T16(5PPM/°C) 10K, .3W, .1%	4
R2	Potentiometer, 500Ω	807655	32997	3299X-1-501	1
R3	Resistor, Metal Film 75kΩ, .3W, ±.1%	806920	75042	MAR5-T16 (5PPM/°C) 75K, .3W, .1%	2
R5	Same as R1				
R6	Resistor, Composition 82kΩ, 1/4W, ±5%	802083	01121	CB8235	1
R10	Potentiometer, 1kΩ, 1/2W	807296	32997	3299X-1-102	1
R11	Same as R3				
R12	Same as R1				
R13	Same as R1				
R15	Resistor, Composition 20kΩ, 1/4W, ±5%	801636	01121	CB2035	1

SECTION 8

UNIT SCHEMATICS

This section contains all schematics for the standard units of the DPAV. For schematics of the optional units, refer to the corresponding appendix of this manual.

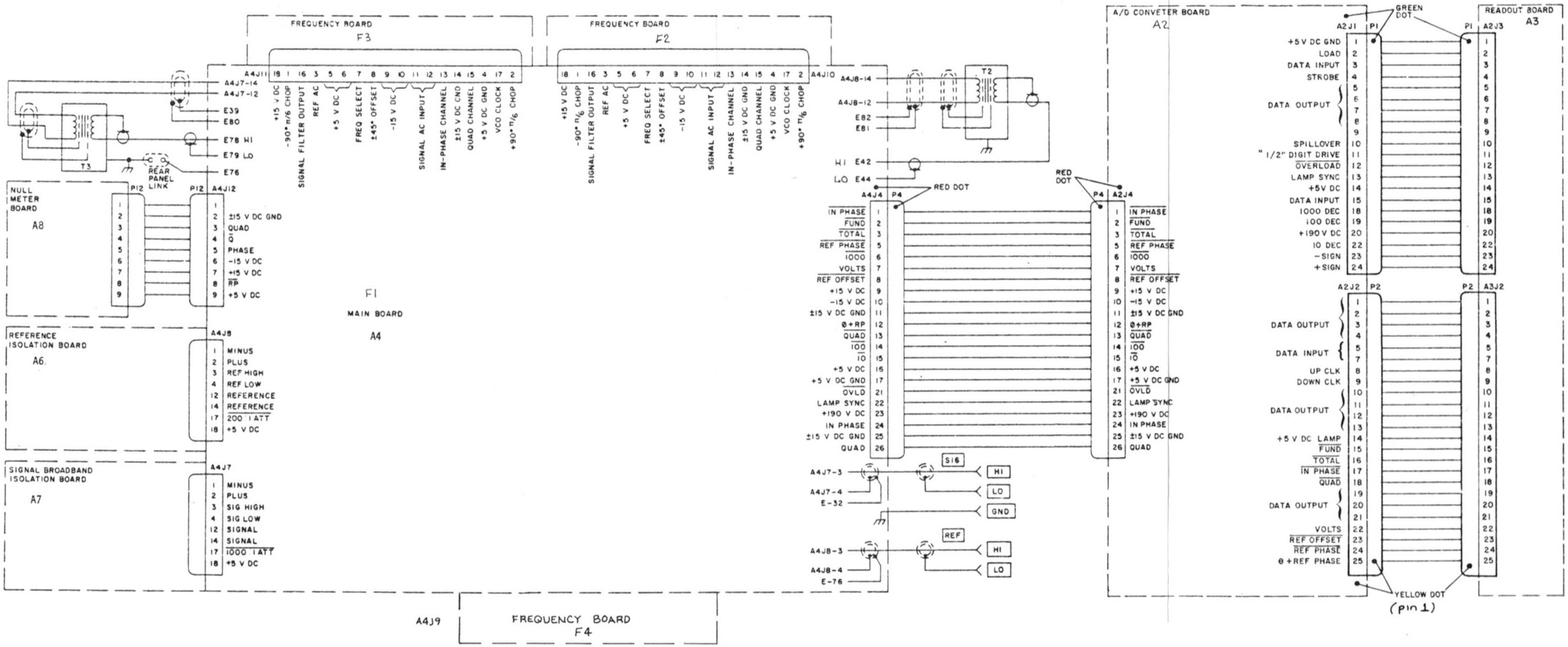
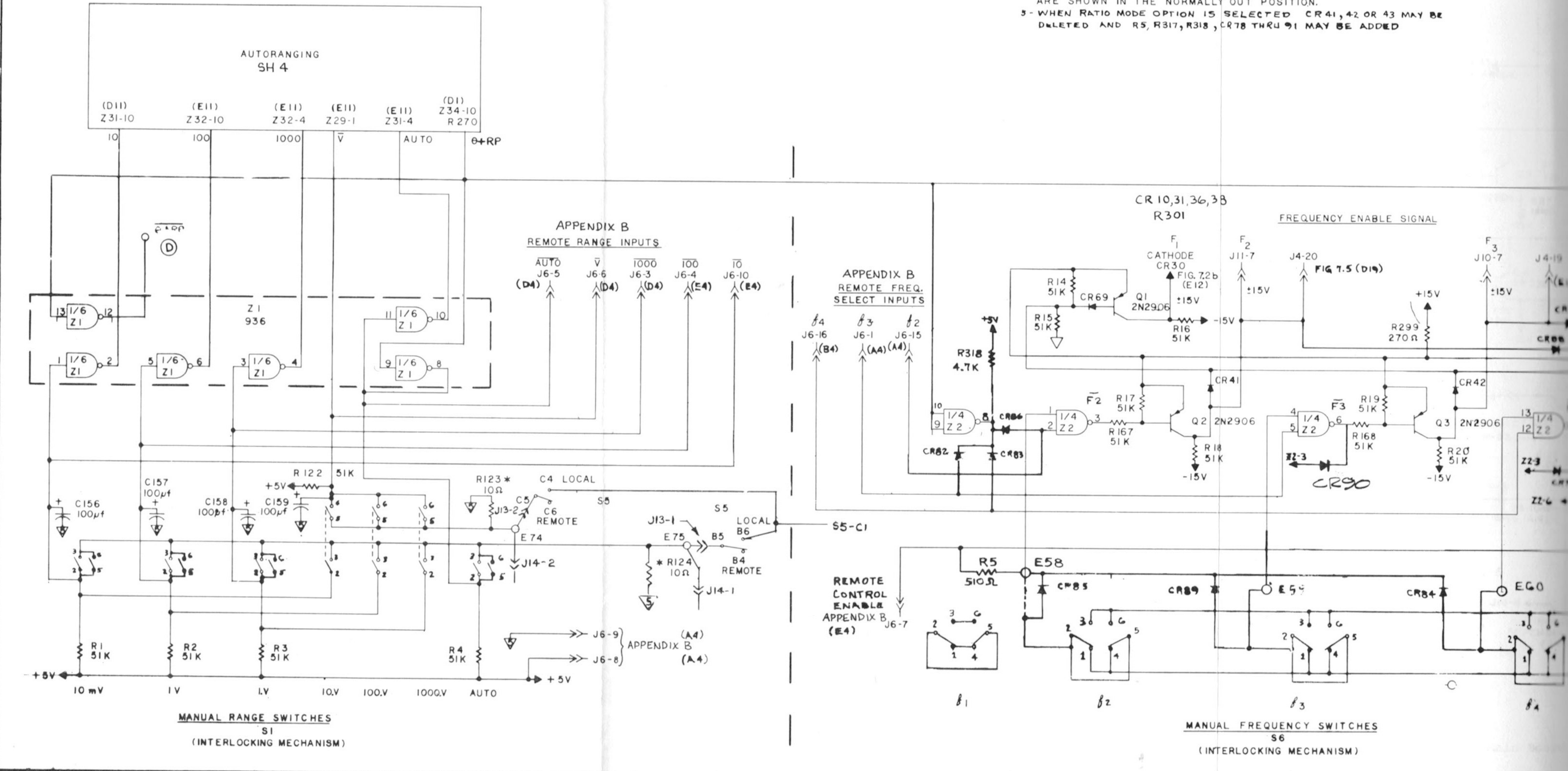


Figure 8-1. DPAV Schematic

C1

NOTES:

1 - 10Ω RESISTORS MARKED WITH AN ASTERISK (*) ARE DELETED FOR REMOTE CONTROL OPTION 03 OR IEEE OPTION 12.
2 - DESIGNATION FOR THE CONTROL SIGNALS ARE 0 & +5V POSITIVE LOGIC. e.g. "V̄" IS 0V WHEN A VOLT RANGE IS SELECTED; OR "θ" SIGNAL IS +5V WHEN IN PHASE ANGLE MODE IS SELECTED. SIGNALS DESIGNATED ±15 ARE -15V IN LOGIC "0", AND +15V IN LOGIC "1".
3 - ALPHA NUMERIC DESIGNATIONS AFTER FIGURE NUMBER AND IN ( ) ARE ZONE LOCATIONS.
4 - ALL PUSH BUTTON SWITCHES WITH THE SAME REFERENCE DESIGNATION PREFIX, i.e. S3-A, S3-B, ARE MECHANICALLY INTERLOCKED AND ARE SHOWN IN THE NORMALLY OUT POSITION.
5 - WHEN RATIO MODE OPTION IS SELECTED CR41, 42 OR 43 MAY BE DELETED AND R5, R317, R318, CR78 THRU 91 MAY BE ADDED



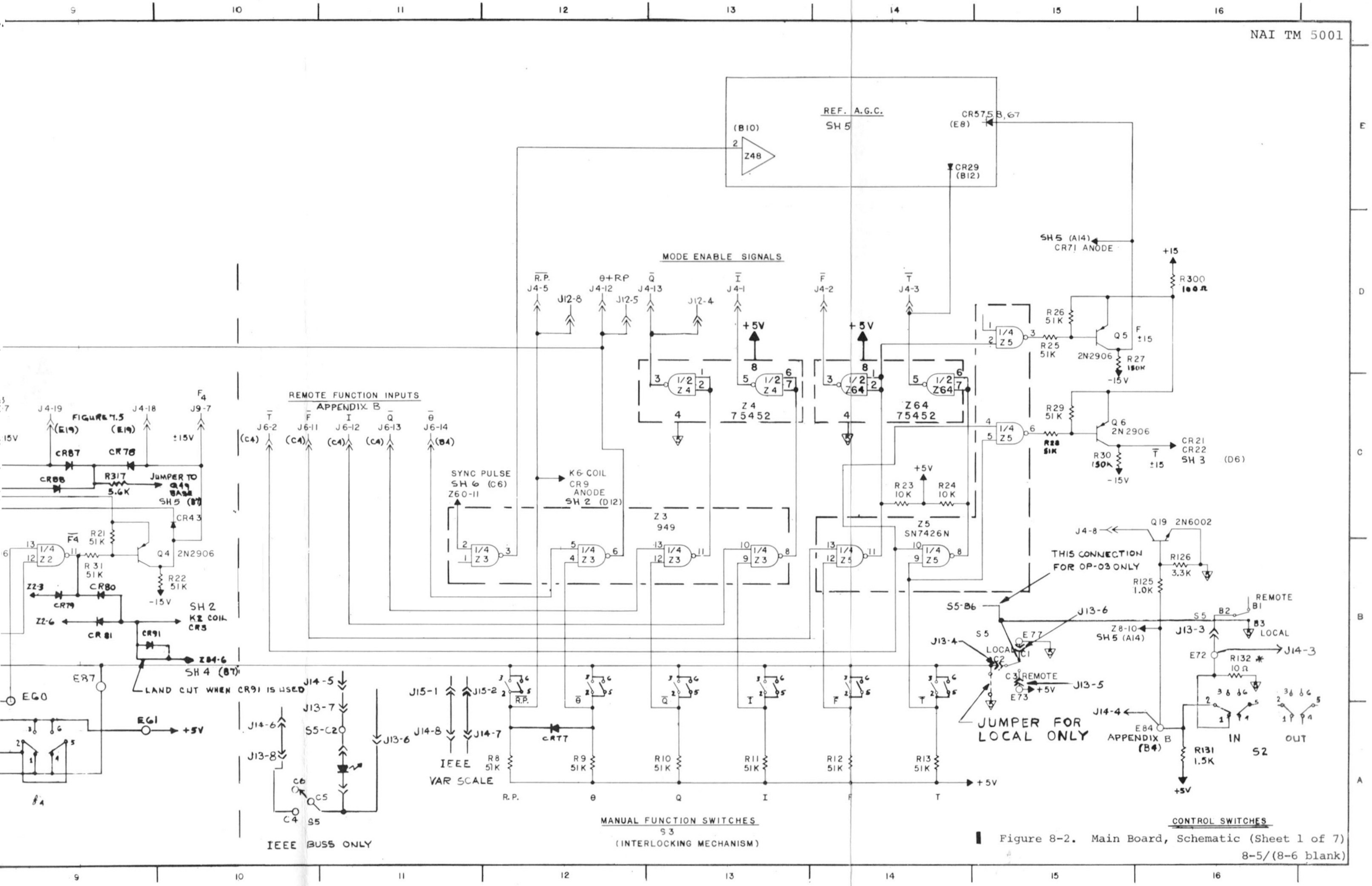
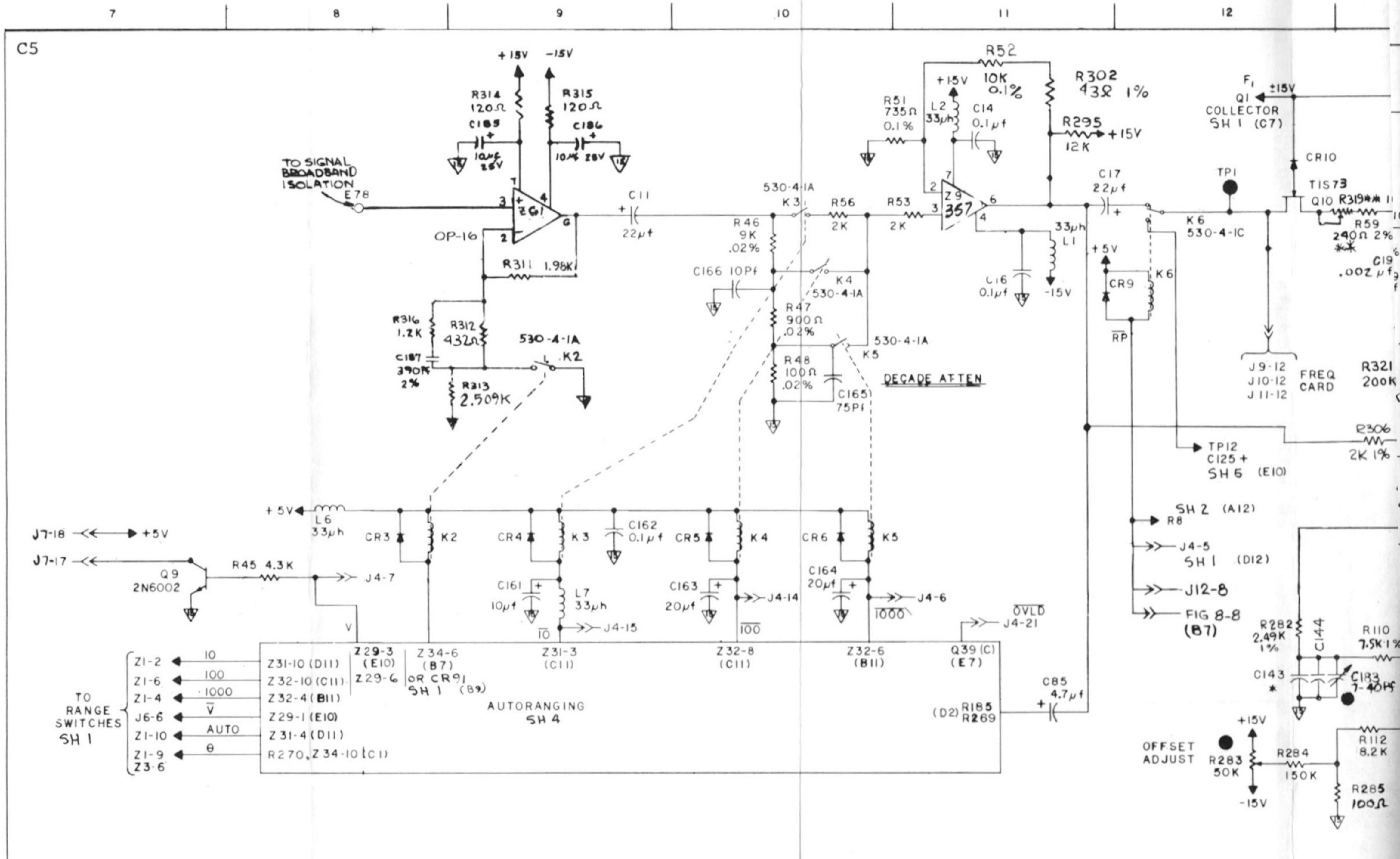


Figure 8-2. Main Board, Schematic (Sheet 1 of 7)

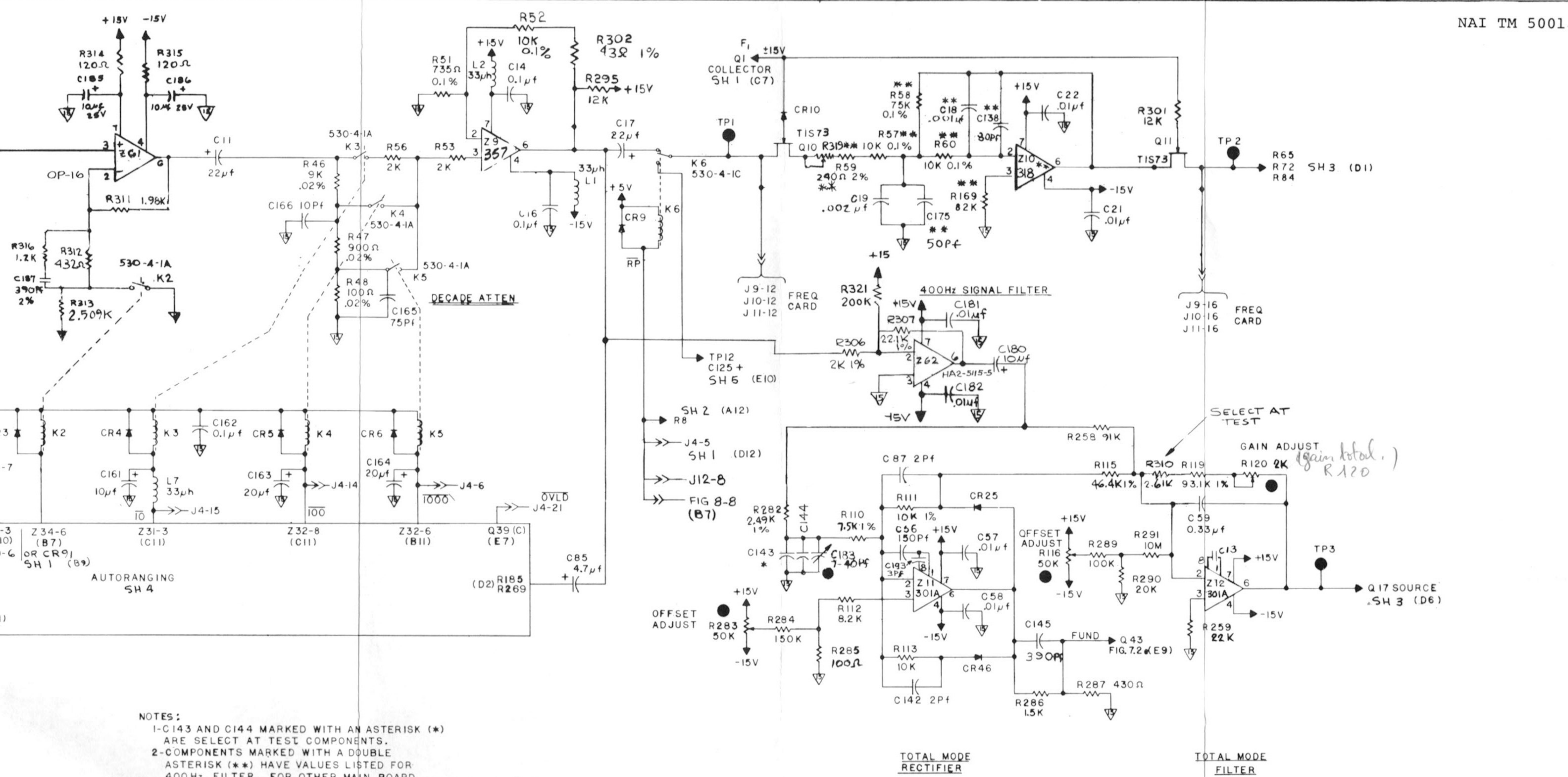


NOTES:

1-C143 AND C144 MARKED WITH AN ASTERISK (*) ARE SELECT AT TEST COMPONENTS.

2-COMPONENTS MARKED WITH A DOUBLE ASTERISK (**) HAVE VALUES LISTED FOR 400Hz FILTER. FOR OTHER MAIN BOARD FREQUENCY COMPONENT VALUES SEE PARTS LIST.

3-ALPHA-NUMERIC DESIGNATIONS AFTER FIGURE NUMBERS AND IN ( ) ARE ZONE LOCATIONS.



NOTES:
1-C143 AND C144 MARKED WITH AN ASTERISK (*) ARE SELECT AT TEST COMPONENTS.
2-COMPONENTS MARKED WITH A DOUBLE ASTERISK (**) HAVE VALUES LISTED FOR 400Hz FILTER. FOR OTHER MAIN BOARD FREQUENCY COMPONENT VALUES SEE PARTS LIST.
3-ALPHA-NUMERIC DESIGNATIONS AFTER FIGURE NUMBERS AND IN ( ) ARE ZONE LOCATIONS.

Figure 8-2. Main Board, Schematic (Sheet 2 of 7)

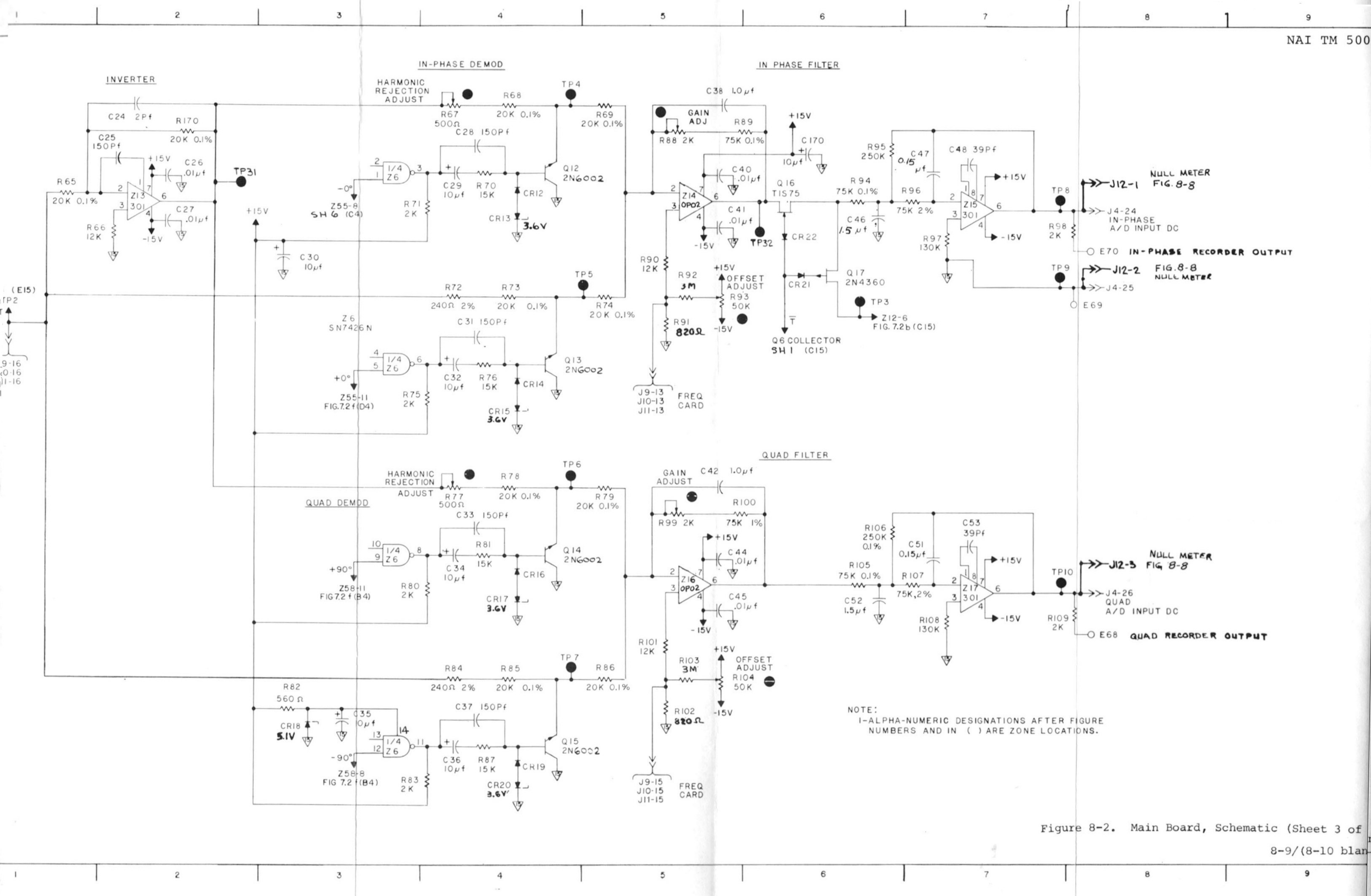
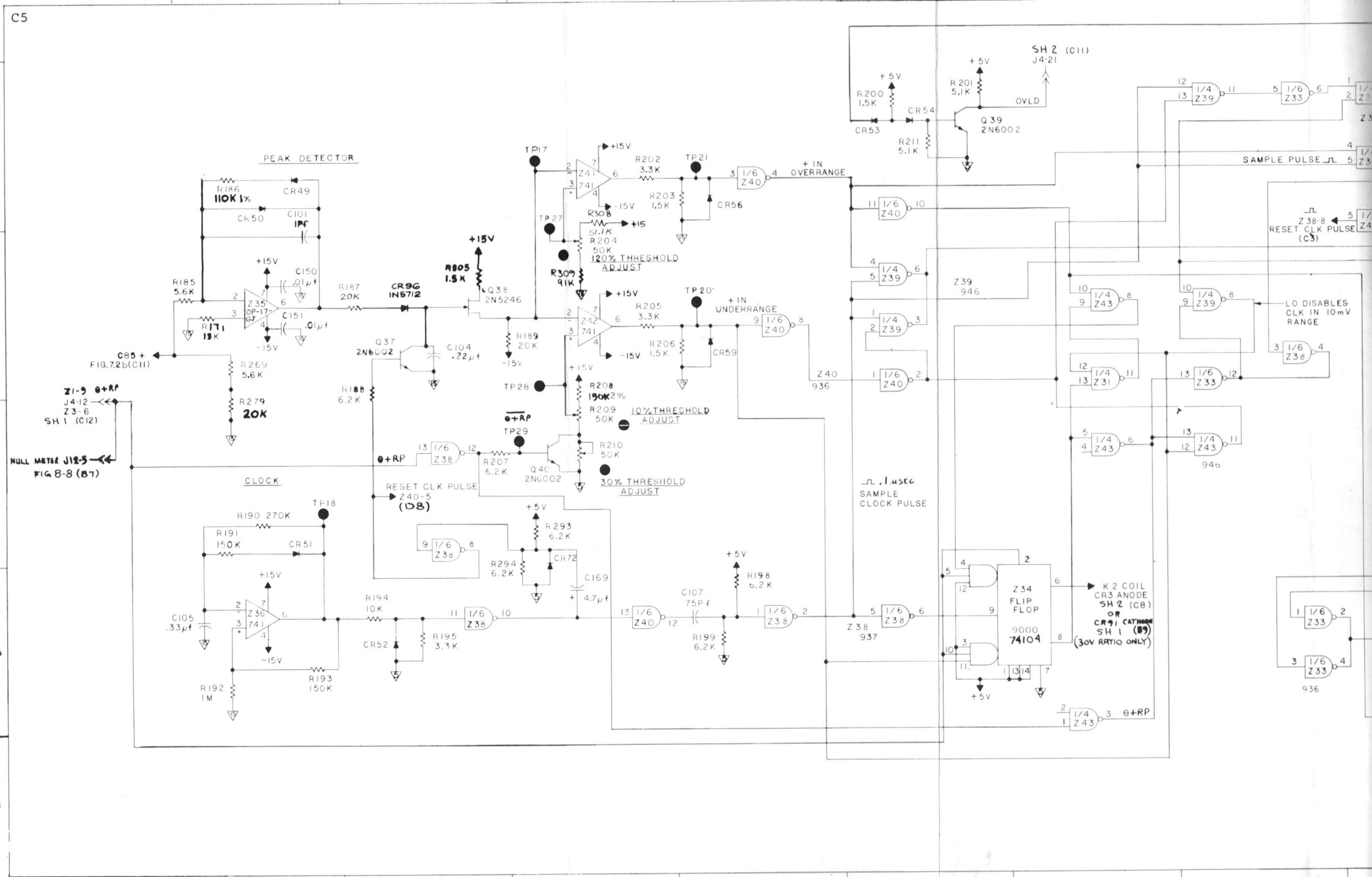


Figure 8-2. Main Board, Schematic (Sheet 3 of



C5
PEAK DETECTOR
CLOCK
SAMPLE CLOCK PULSE
RESET CLK PULSE Z40-5 (D8)
120% THRESHOLD ADJUST
10% THRESHOLD ADJUST
30% THRESHOLD ADJUST
+ IN OVERRANGE
+ IN UNDERRANGE
SAMPLE PULSE
LO DISABLES CLK IN 10mV RANGE
Z38-8 RESET CLK PULSE (C3)
SH 2 (C11) J4-21
OVLD
K2 COIL CR3 ANODE SH 2 (C8) OR CR91 CATHODE SH 1 (B9) (30V RATIO ONLY)
Z34 FLIP FLOP 9000 74104
NULL METER J12-5 FIG 8-8 (B7)
Z1-9 θ+RP J4-12 Z3-6 SH 1 (C12)
C85 + FIG.7.2b(C11)

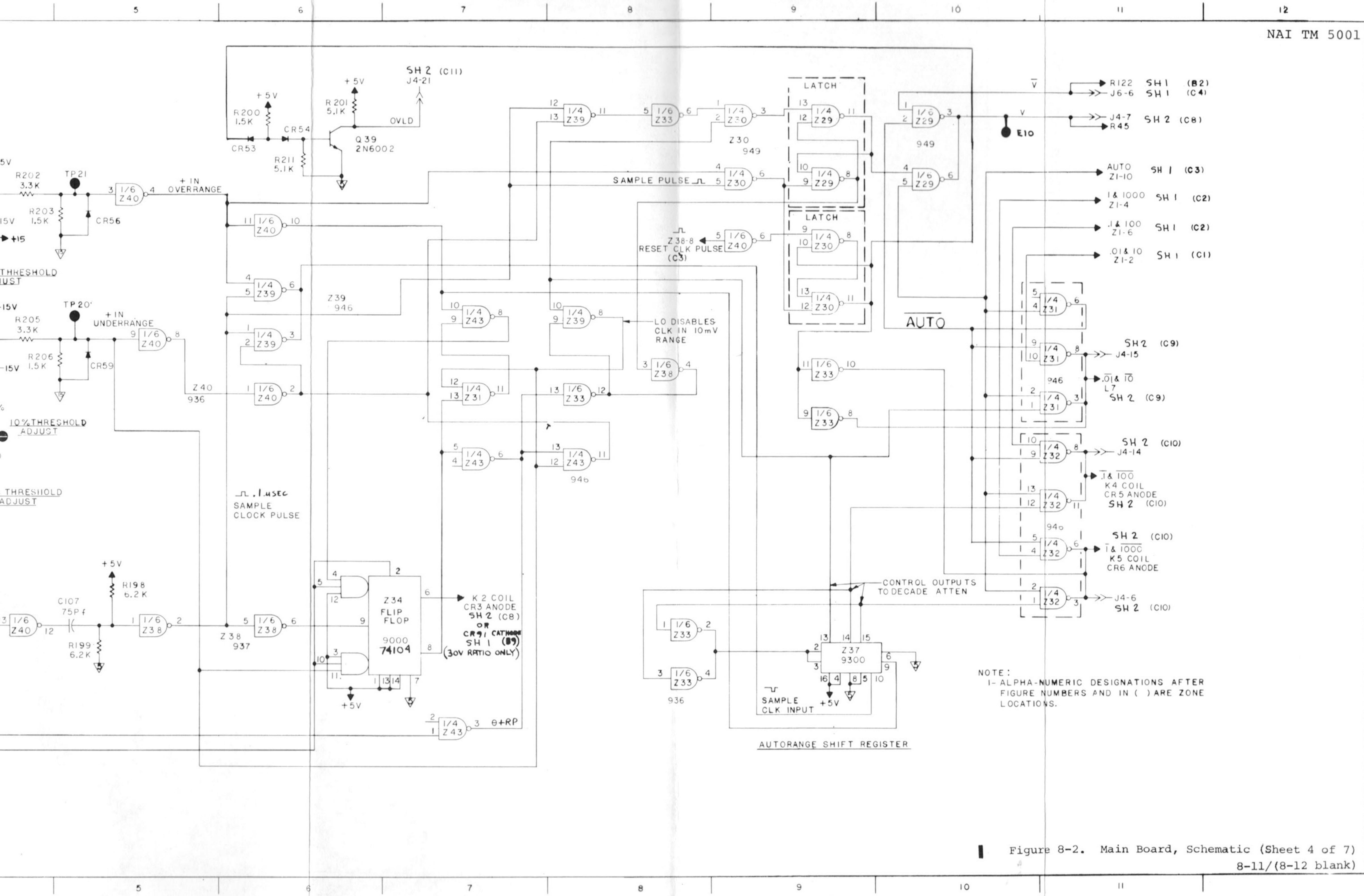
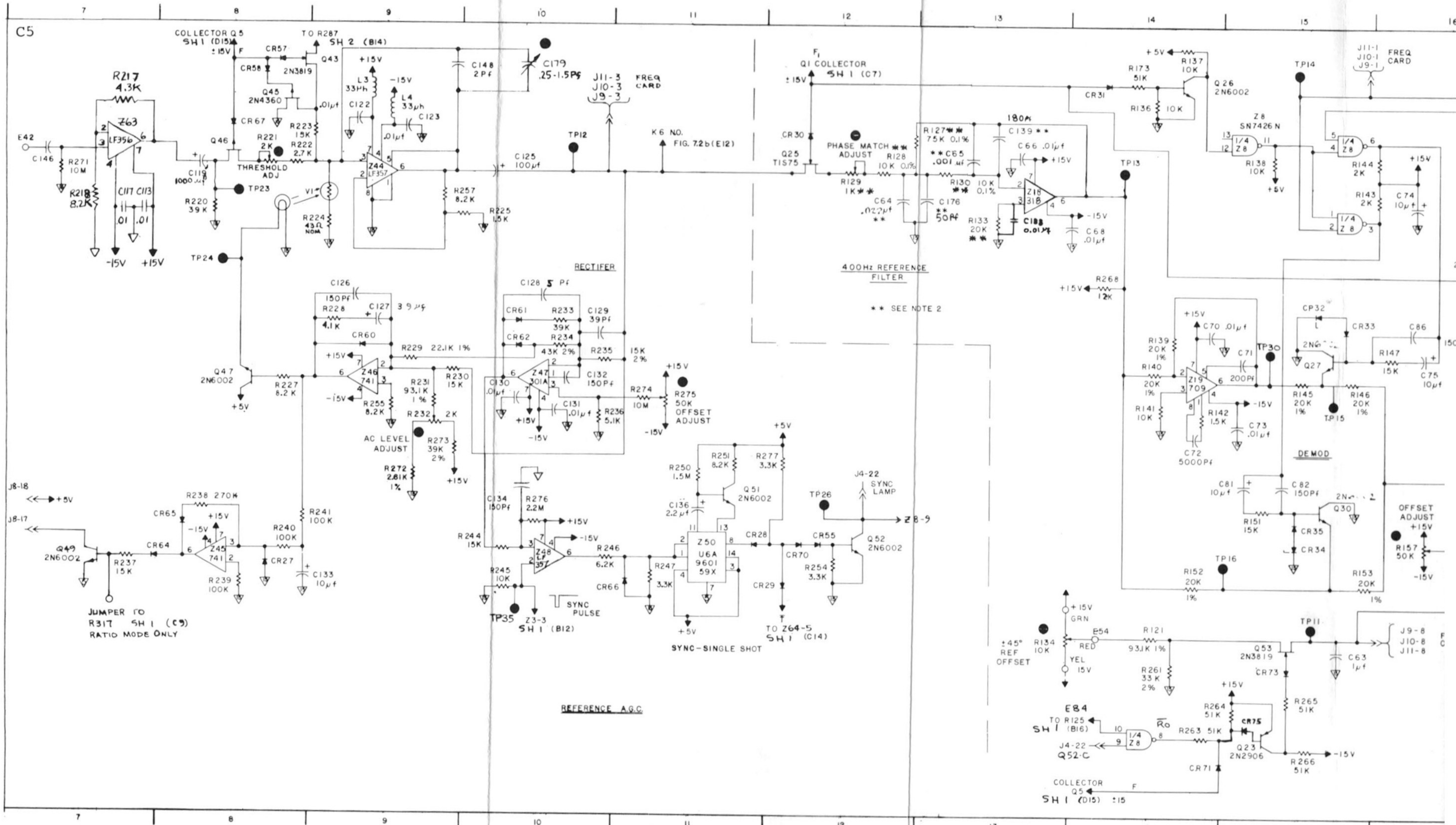
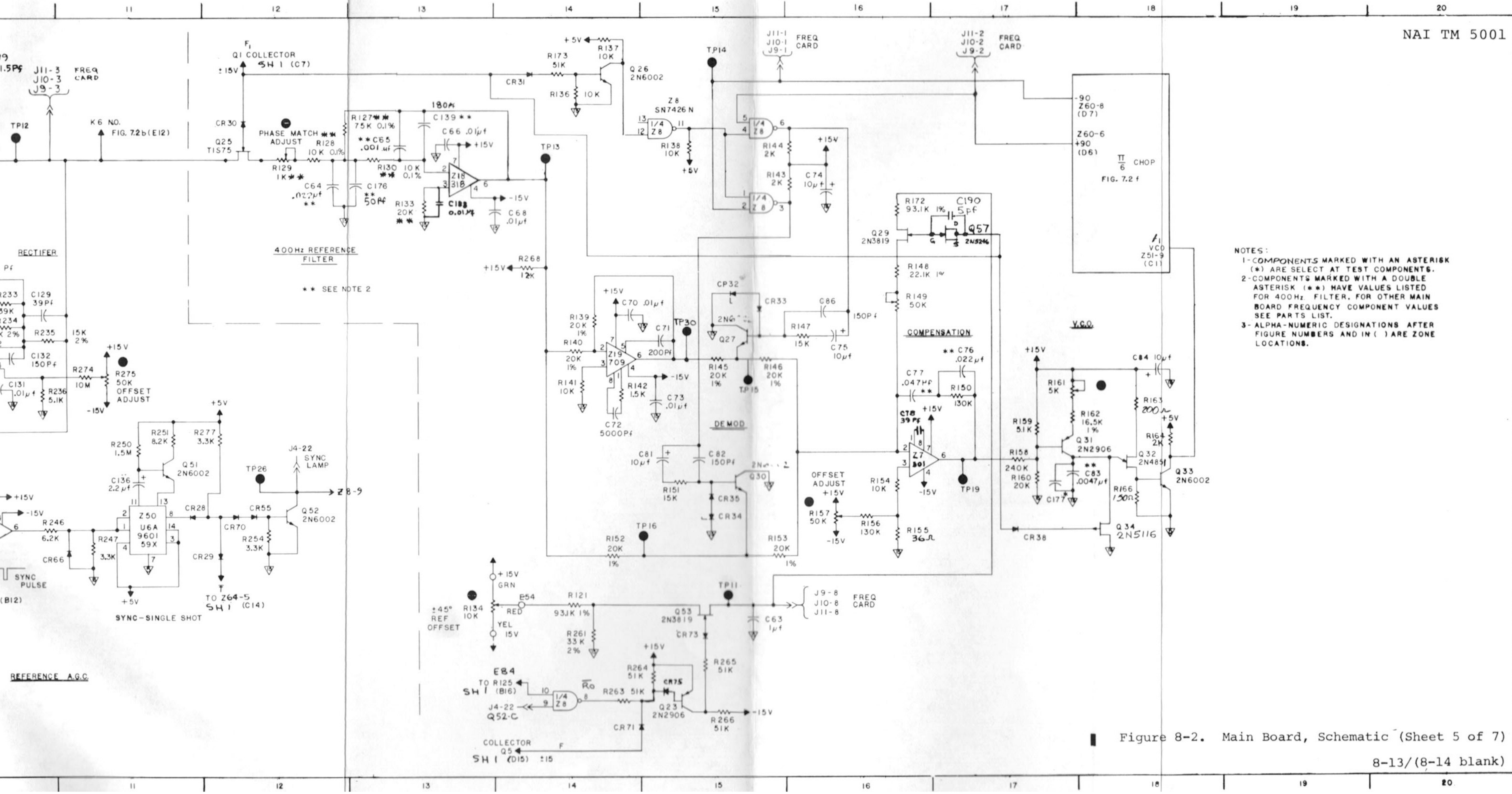


Figure 8-2. Main Board, Schematic (Sheet 4 of 7)


C5
R217 4.3K
LF356
TP23
TP24
THRESHOLD ADJ
Z44 LF357
C179 .25-1.5Pf
J11-3 J10-3 J9-3 FREQ CARD
TP12
K6 NO. FIG. 7.2b (E12)
Q1 COLLECTOR SH 1 (C7)
PHASE MATCH ADJUST
Z18 318
400Hz REFERENCE FILTER
** SEE NOTE 2
Z8 SN7426N
Q26 2N6002
TP14
J11-1 J10-1 J9-1 FREQ CARD
TP13
RECTIFER
Z46 741
Z47 301A
R275 50K OFFSET ADJUST
AC LEVEL ADJUST
Q47 2N6002
Z19 709
TP30
TP15
DEMOD
SYNC-SINGLE SHOT
Z50 U6A 9601 59X
Z48 LF357
Q51 2N6002
Q52 2N6002
J4-22 SYNC LAMP
TP26
TP35
Z3-3 SH 1 (B12)
SYNC PULSE
TO Z64-5 SH 1 (C14)
Z45 741
Q49 2N6002
JUMPER TO R317 SH 1 (C9) RATIO MODE ONLY
REFERENCE A.G.C.
OFFSET ADJUST
R157 50K
TP16
TP11
±45° REF OFFSET
Q53 2N3819
J9-8 J10-8 J11-8
E84 TO R125 SH 1 (B16)
J4-22 Q52-C
Q23 2N2906
COLLECTOR Q5 SH 1 (D15)



NOTES:
1-COMPONENTS MARKED WITH AN ASTERISK (*) ARE SELECT AT TEST COMPONENTS.
2-COMPONENTS MARKED WITH A DOUBLE ASTERISK (**) HAVE VALUES LISTED FOR 400Hz FILTER. FOR OTHER MAIN BOARD FREQUENCY COMPONENT VALUES SEE PARTS LIST.
3-ALPHA-NUMERIC DESIGNATIONS AFTER FIGURE NUMBERS AND IN ( ) ARE ZONE LOCATIONS.

Figure 8-2. Main Board, Schematic (Sheet 5 of 7)

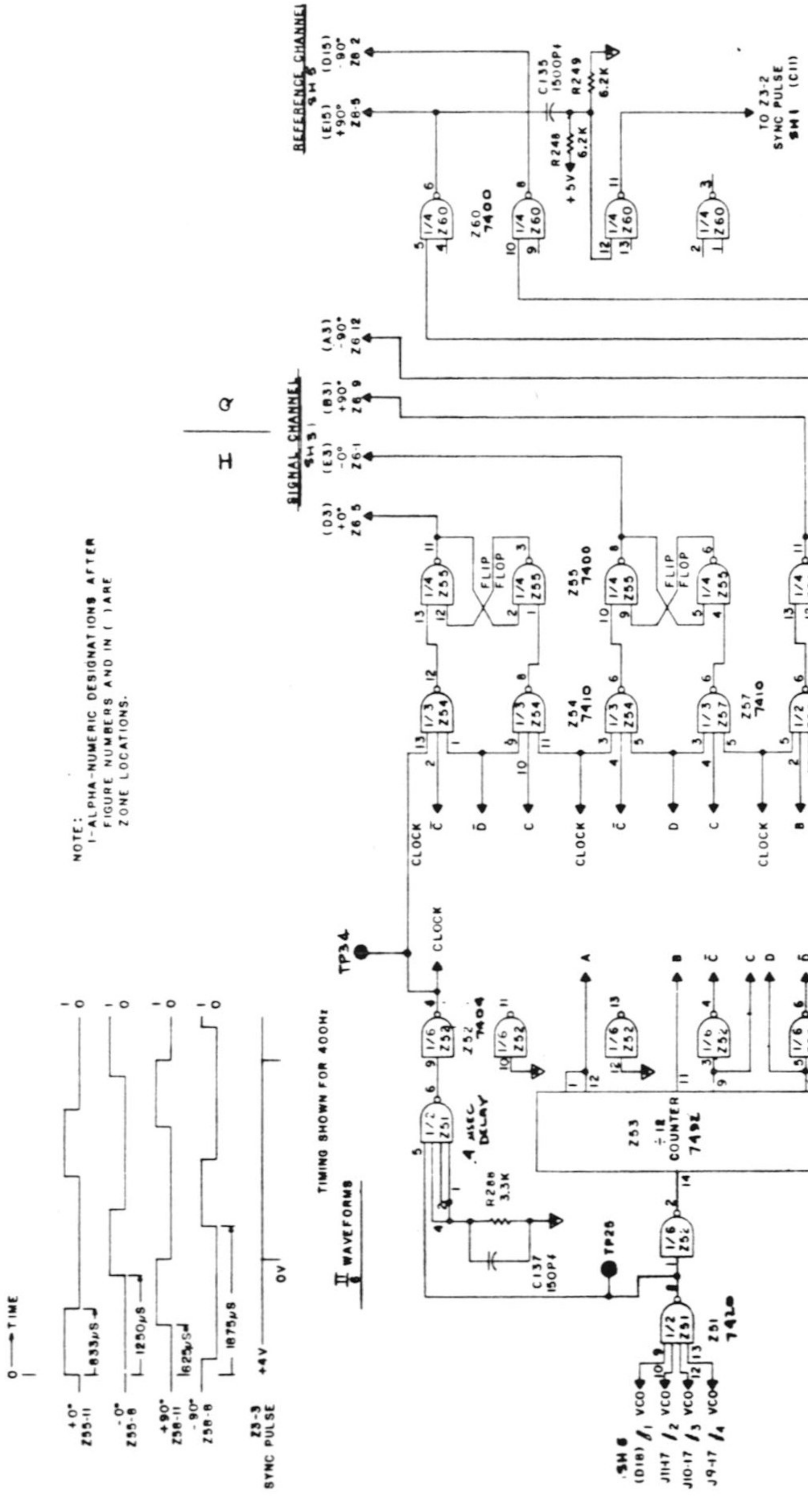


Figure 8-2. Main Board, Schematic (Sheet 6 of 7)

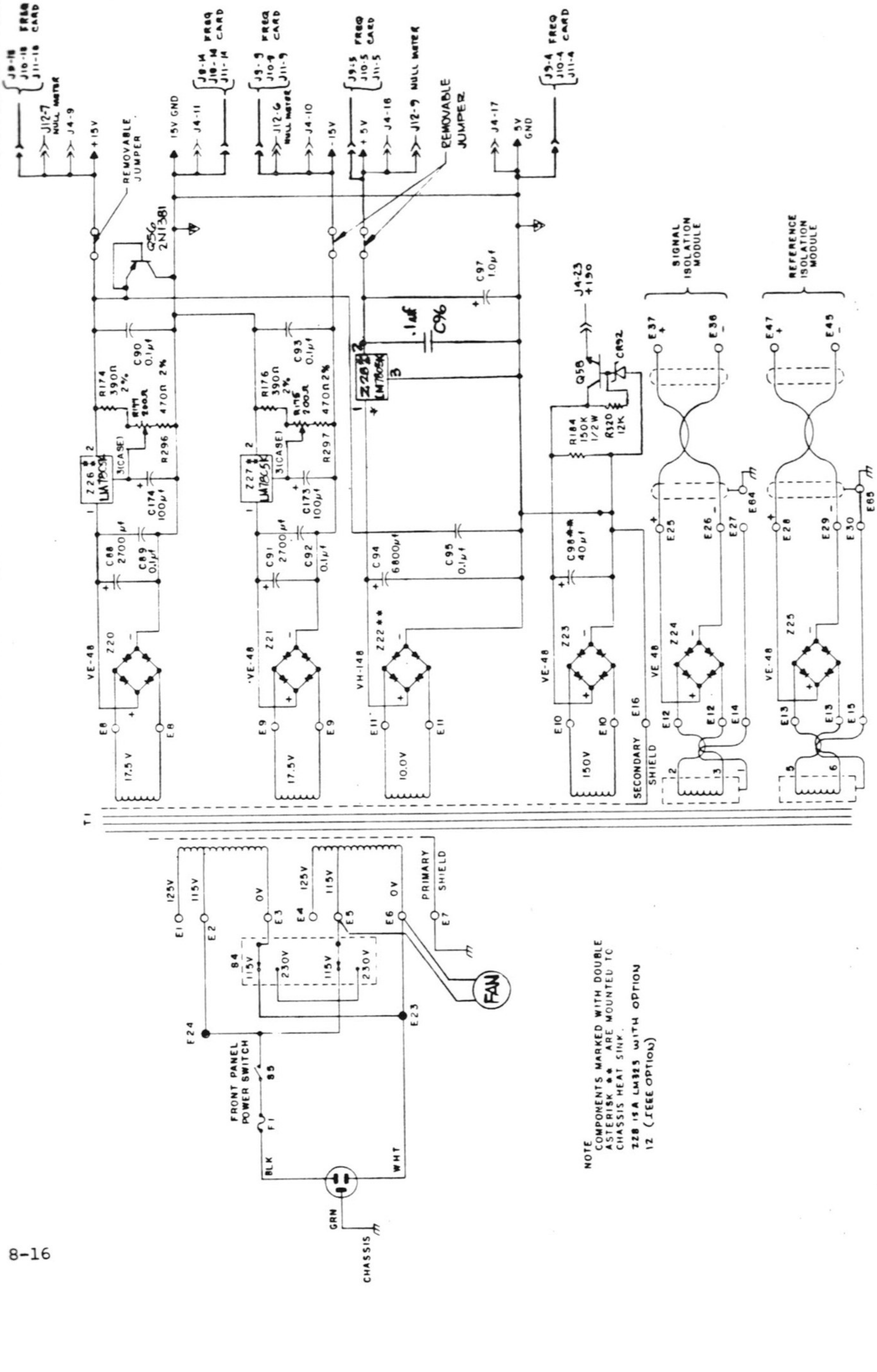
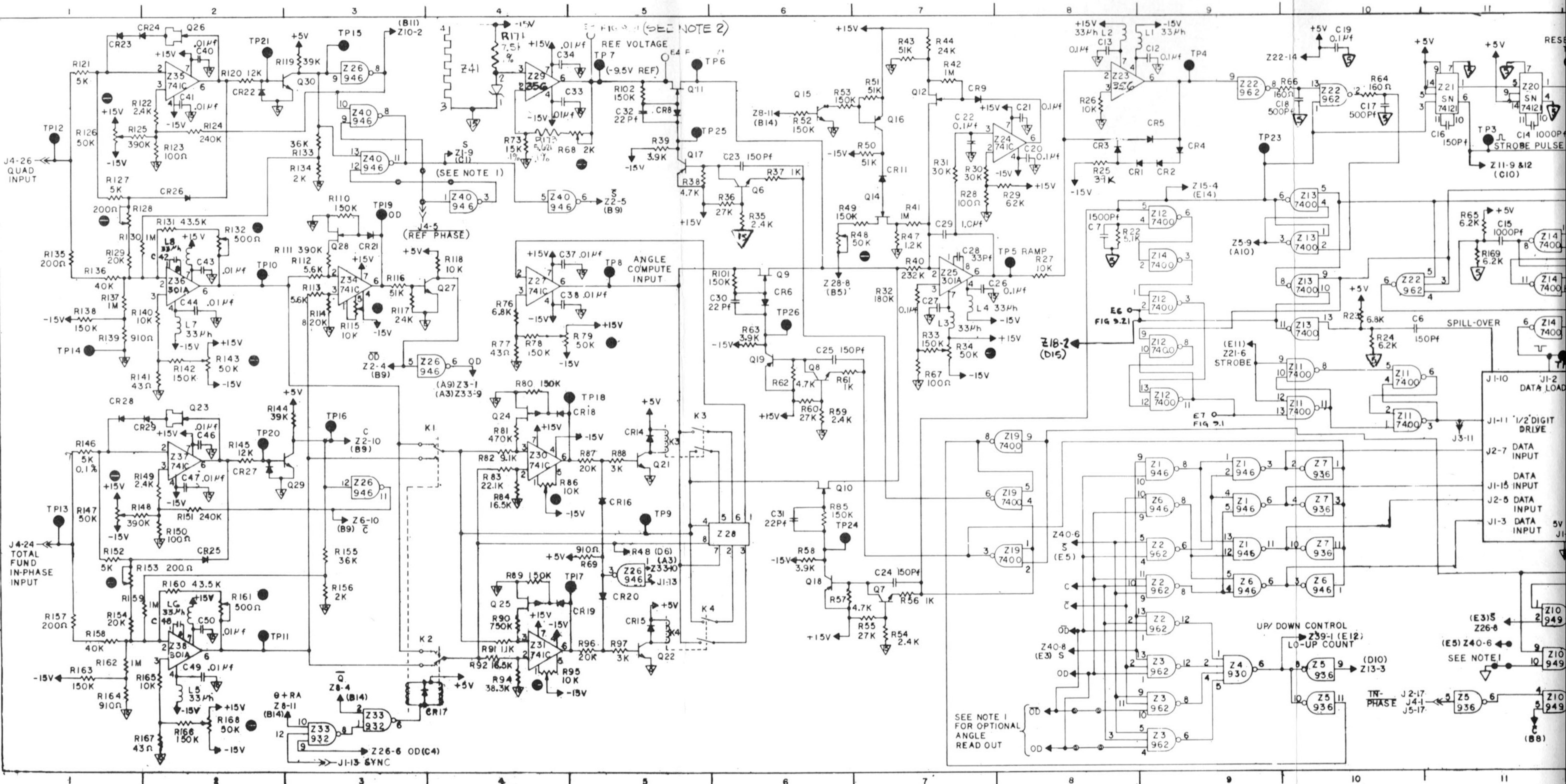
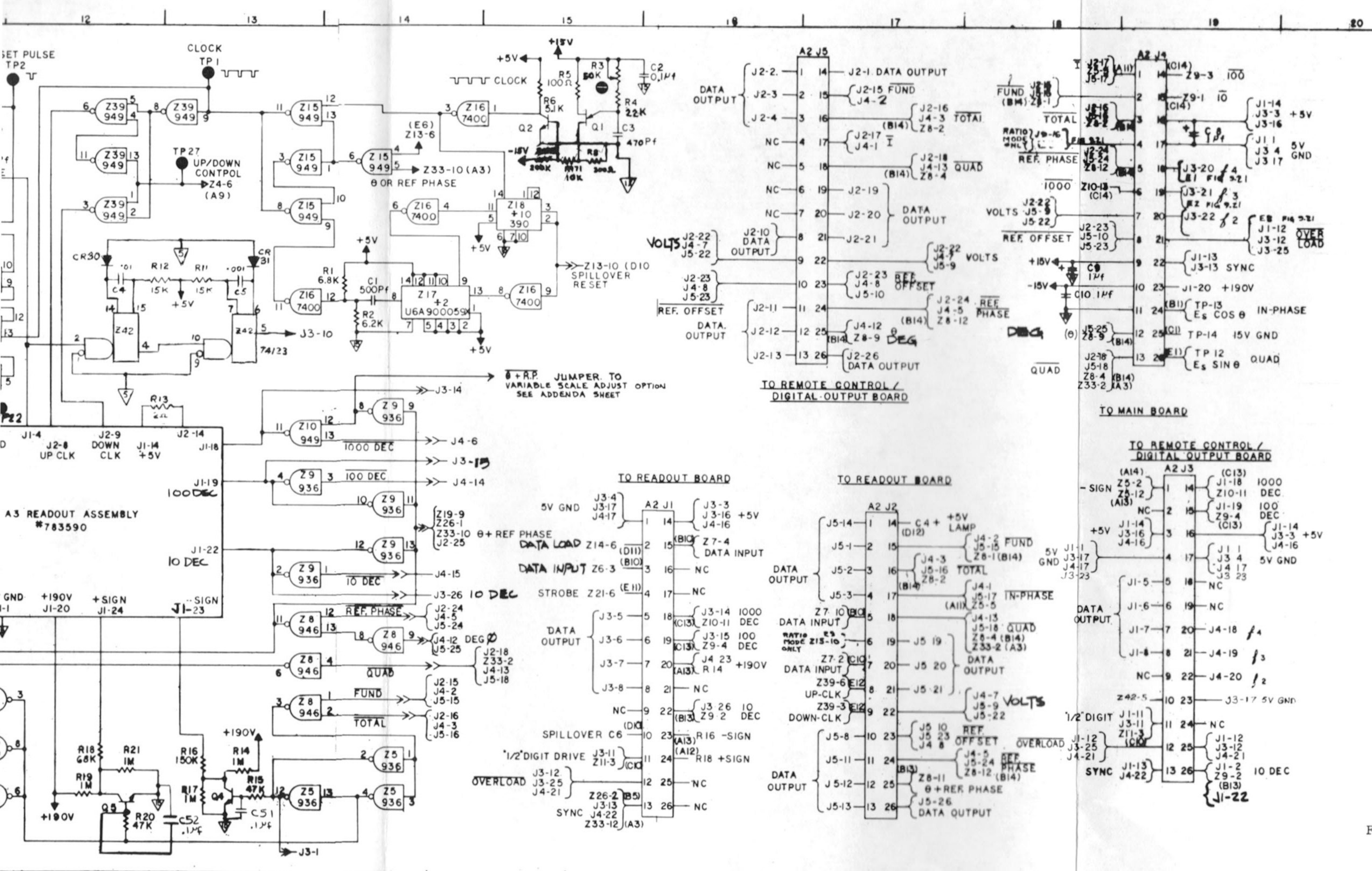


Figure 8-2. Main Board, Schematic (Sheet 7 of 7)



J4-26 QUAD INPUT
J4-24 TOTAL FUND IN-PHASE INPUT
REF VOLTAGE
(-9.5V REF)
(SEE NOTE 2)
(SEE NOTE 1)
J4-5 (REF PHASE)
ANGLE COMPUTE INPUT
TP5 RAMP
STROBE PULSE
SPILL-OVER
STROBE
DATA LOAD
1/2 DIGIT DRIVE
DATA INPUT
UP/ DOWN CONTROL
LO-UP COUNT
SEE NOTE 1
SEE NOTE 1 FOR OPTIONAL ANGLE READ OUT
IN-PHASE
J1-13 SYNC



NOTES:

1 SCHEMATIC AS SHOWN CONTAINS ALL PARTS FOR ALL VARIATIONS. WHEN OPTION 01 (ANGLE MODE AND ±45° PHASE ADJUST) IS ORDERED 360° LEAD PHASE ANGLE IS SUPPLIED AS STANDARD AS SHOWN.

FOR 360° LAG PHASE ANGLE DO THE FOLLOWING:

a) CUT THE CONNECTION FROM Z40-12 TO Z40-3 AND FROM Z40-9 TO Z40-1, J4-5. JUMPER FROM Z40-12 TO Z40-1 AND FROM Z40-9 TO Z40-3 (ZONE A3).

b) CUT CONNECTION FROM Z10-10 TO GND (ZONE A11)

FOR ±180° PHASE ANGLE DO THE FOLLOWING:

a) CUT THE CONNECTION FROM Z10-10 TO GND AND JUMPER FROM Z10-10 TO Z40-8 (ZONE A11)

b) CUT THE CONNECTION FROM Z3-10 TO Z2-1 AND FROM Z3-4 TO Z3-1. JUMPER FROM Z3-10 TO Z3-1 AND FROM Z3-4 TO Z2-1 (ZONE A8)

c) CUT CONNECTIONS TO Z1-9 AND Z1-2 IN ZONE C9 AND Z1-4, Z1-5 AND Z6-4 IN ZONE B9.

2 CUT LAND BETWEEN E3 & TP1 (ZONE E5) WHEN RATIO MODE IS USED.

Figure 8-3. A/D Converter, Schematic

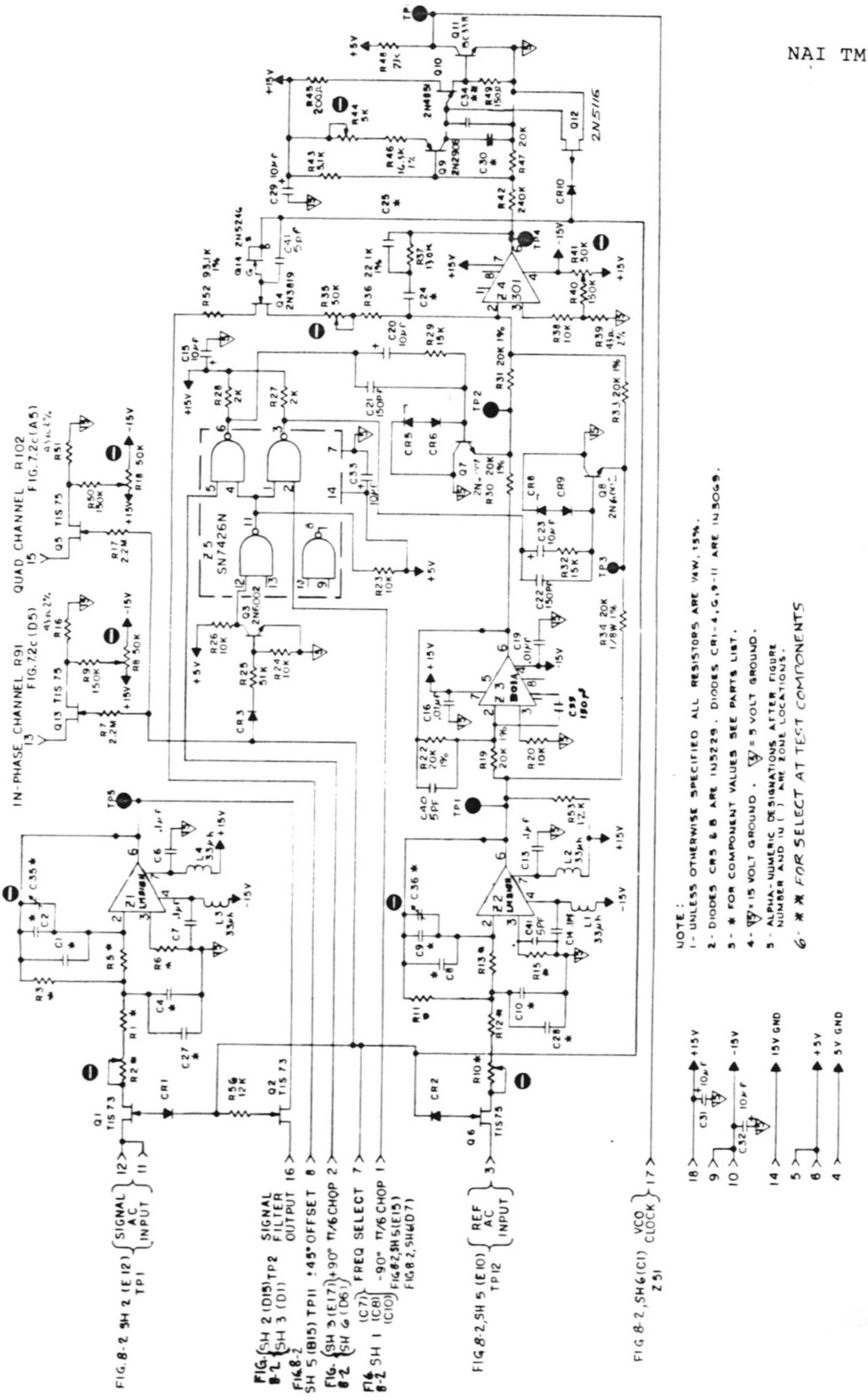
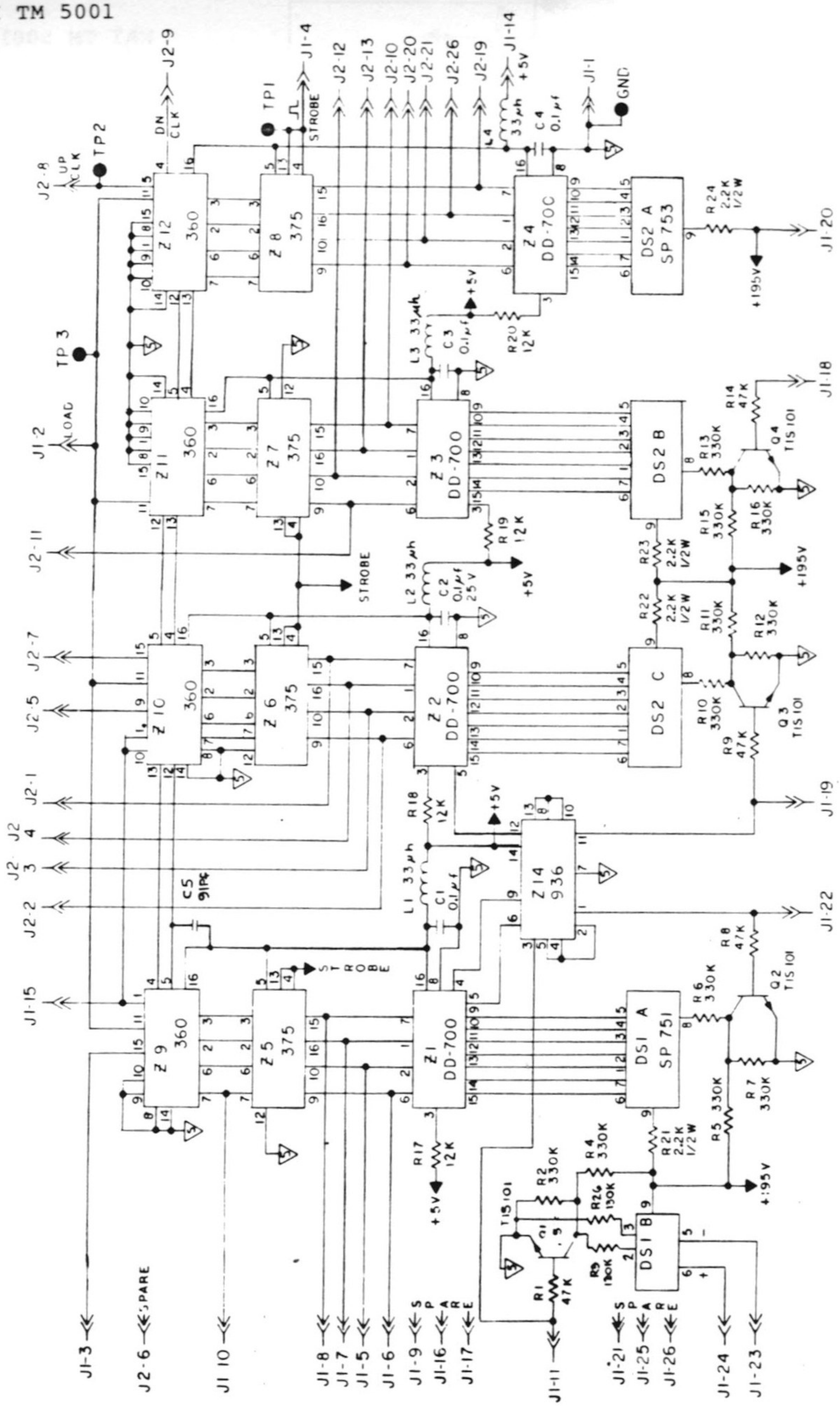


Figure 8-4. Frequency Board, Schematic



NOTE:
1- UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/4W, ±5%.
2- DS3 THRU 13 ARE 2203-AS25.
3- ALL GROUNDS ARE 5 VOLT GROUND.
4- PREFIX ALL REFERENCE DESIGNATIONS WITH A3

Figure 8-5. Readout Board, Schematic (Sheet 1 of 2)

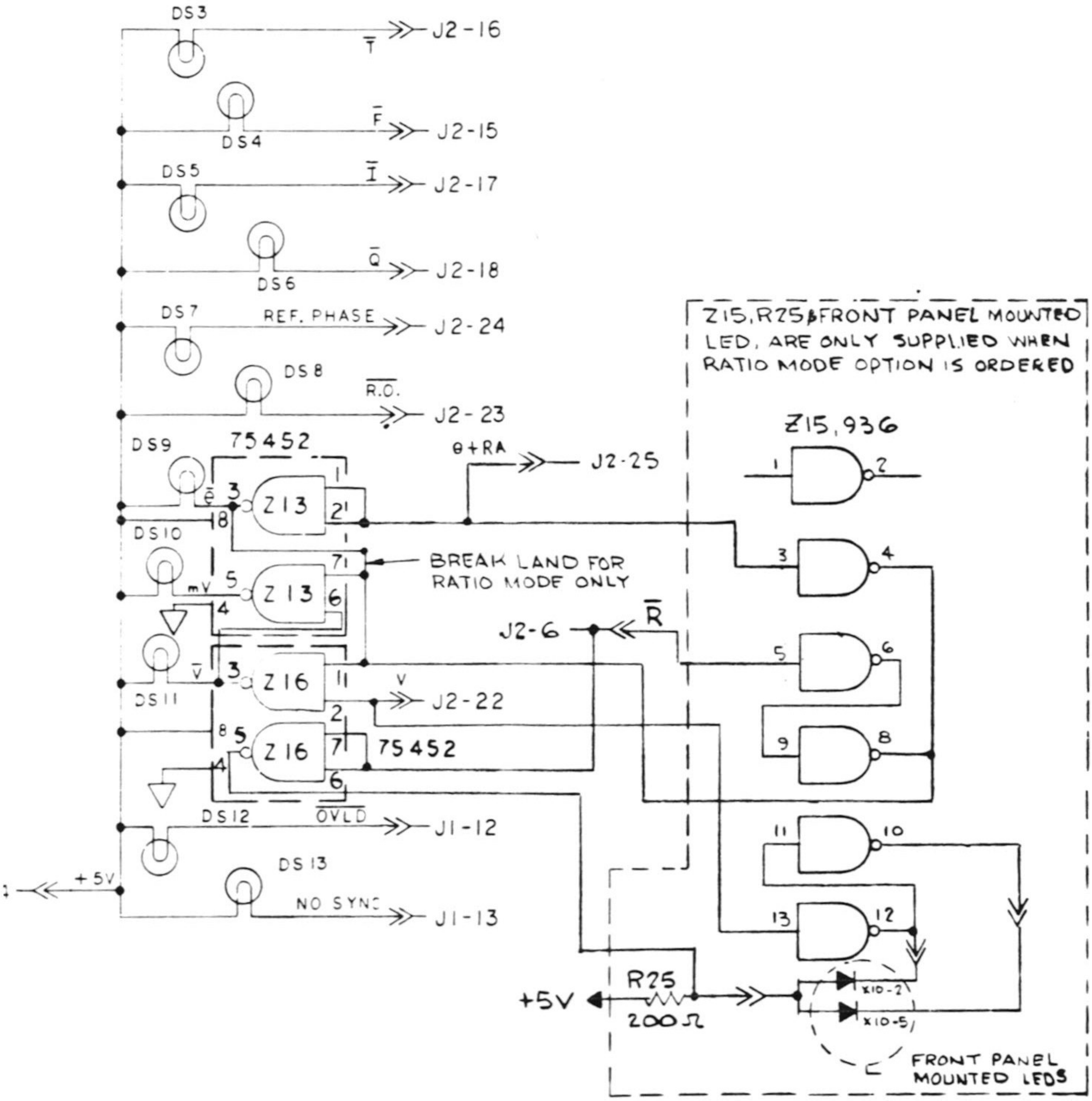


Figure 8-5. Readout Board, Schematic (Sheet 2 of 2)

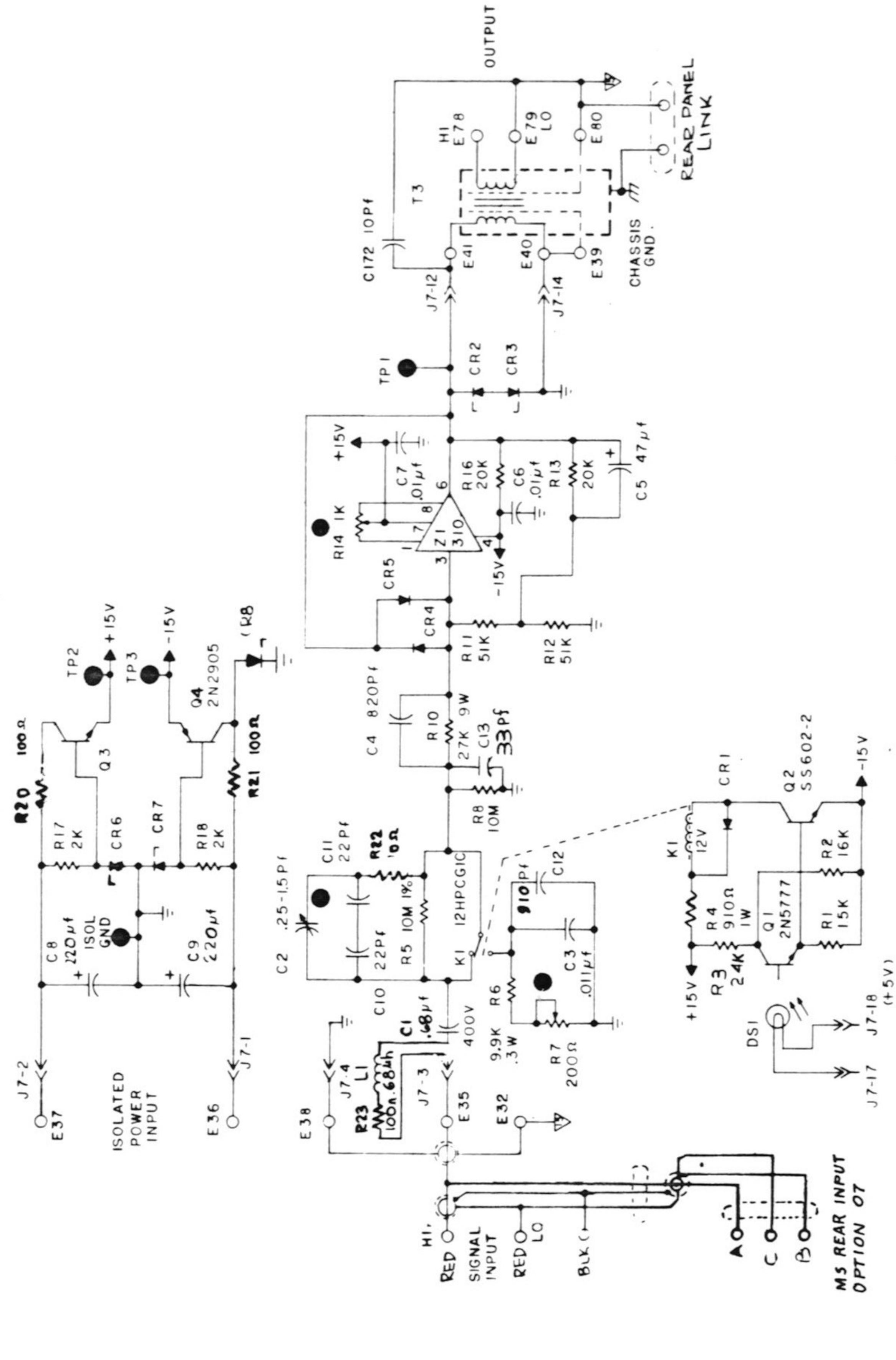


Figure 8-6. Signal Broadband Isolation Board, Schematic

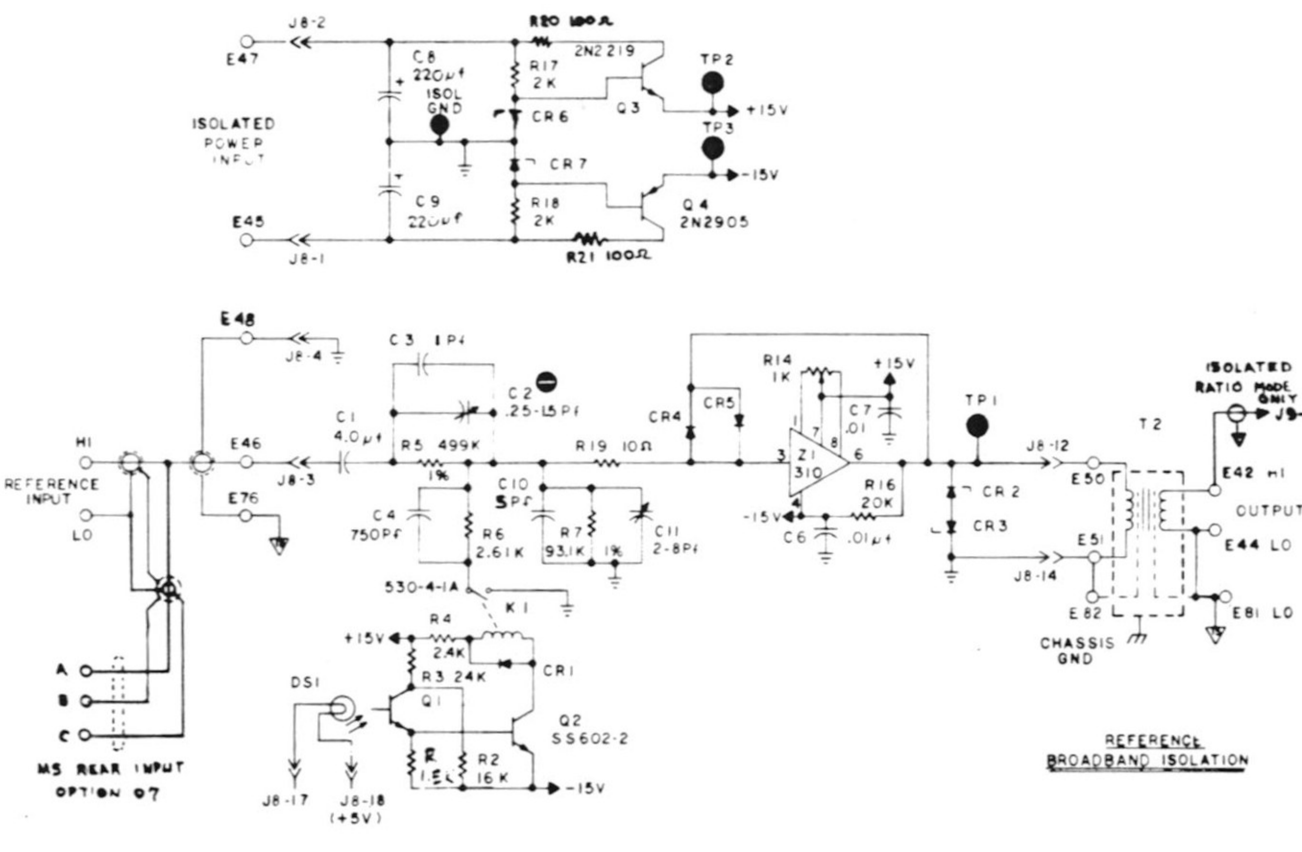


Figure 8-7. Reference Broadband Isolation Board, Schematic

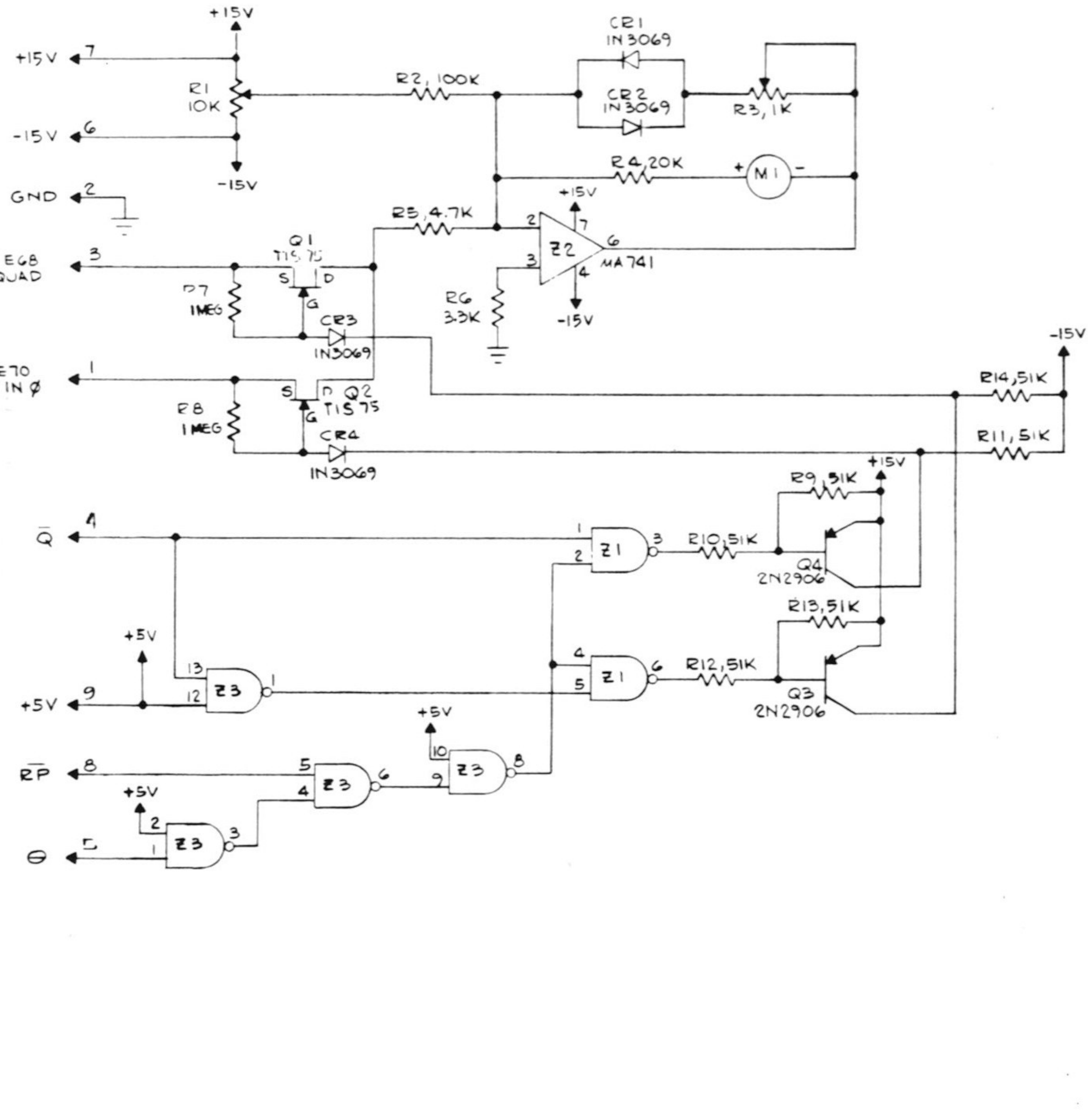


Figure 8-8. Null Meter, Schematic

APPENDIX A

GENERATION OF PHASE SHIFTED SIGNALS

A.1 GENERAL

The Phase Angle and Reference Phase modes require accurate phase shifted signals to verify performance. Some common approaches follow:

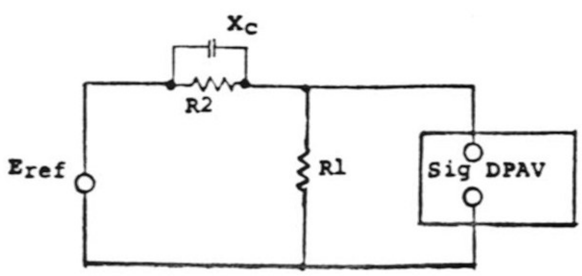
NOTE

Phase generator must generate phase shift from 50 Hz to 25.6 kHz with accuracy of:

25 to 50 Hz	- 0.17°
50 to 100 Hz	- 0.12°
100 Hz to 1.4 kHz	- 0.07°
1.4 to 25.6 kHz	- 0.11° + 0.013f (f in kHz)

A.2 RC PASSIVE PHASE SHIFTER

An RC passive phase shifter can be constructed using the equations shown in figure A-1. Components should be high quality, stable parts, such as metal film resistors and polystyrene capacitors and their values measured accurately.



Attenuation $= \frac{R1}{Z}$; Phase Shift $= \tan^{-1} \frac{R2}{X_C}$

if R1 << Z

$$Z = \frac{R1}{1 + j\frac{R2}{X_C}} \quad ; \quad Z = \frac{R2X_C \sqrt{X^2_C + R_2^2}}{X_C^2 + R_2^2}$$

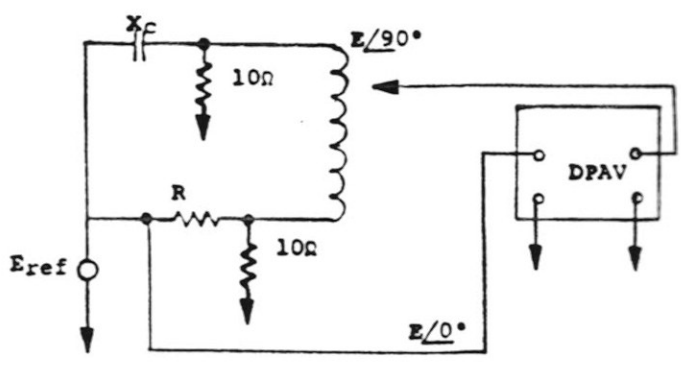
Figure A-1. RC Phase Shifter

A.3 RATIO BOX PHASE SHIFTER

The ratio box phase shifter (fig. A-2) requires an accurate 0° and 90° signal equal in amplitude and placed across the ratio box. The output amplitude will vary thru a minimum of 0.707 of the 0° and 90° signal at 45°.

NOTE

A number of instruments on the market generate precise phase angles and can be used in this checkout. It is important to add to the DPAV angle specification the accuracy of the input phase angle.



$\frac{X_C}{10} >> 1000$, $R = X_C$

Rating Setting $= \frac{1}{1+\text{cotan } \theta}$

where θ = desired phase angle

Figure A-2. Ratio Box Phase Shifter

APPENDIX B

REMOTE CONTROL/DIGITAL OUTPUT

B.1 SPECIFICATIONS

Remote control input and digital outputs are interfaced at rear panel connectors J1 and J2 respectively.

Positive logic is DTL, TTL compatible and in static parallel form.

B.1.1 Signal Description

Remote control inputs:

Low (0) = 0 V to +0.4 V (1.5 mA max.)
High (1) = +2.4 V to +5.5 V

B.1.2 Digital Outputs

Low (0) = 0 V to 0.5 V, 12 mA maximum sink current
High (1) = +2.4 V to +5 V, 6 kΩ source resistance

B.1.3 Mode Truth Table

	Remote Control J1 Pin			Digital Output J2 Pin		
	5	6	7	37	36	25
Total	0	0	1	0	0	1
Fund	0	1	0	0	1	0
Inphase	0	1	1	0	1	1
Quadrature	1	0	0	1	0	0
Phase Angle	1	0	1	1	0	1

	J1 Pin 1	J2 Pin 17
Ref Offset	1	1

B.1.4 Range Truth Table

	Remote Control J1 Pin			Digital Output J2 Pin		
	2	3	4	19	18	16
10 mV	0	0	0	0	0	0
100 mV	0	0	1	0	0	1
1000 mV	0	1	1	0	1	1
10 V	1	0	0	1	0	0
100 V	1	0	1	1	0	1
1000 V	1	1	1	1	1	1
Auto	1	1	0			

B.1.5 Frequency Truth Table

	Remote Control J1 Pin		Digital Output J2 Pin	
	8	15	35	34
F1	0	0	0	0
F2	0	1	0	1
F3	1	0	1	0
F4	1	1	1	1

B.1.6 Data Output (BCD) J2

		Pin 33		Pin 13
Polarity	+:	1	Over-range:	1
	-:	0		

	Most Sig. Digit				Next MSD			
	8	4	2	1	8	4	2	1
J2 Pin:	12	10	9	8	7	6	5	4

	Next LSD				Least SD			
	8	4	2	1	8	4	2	1
J2 Pin:	1	2	3	24	23	22	21	20

B.1.7 OVERLOAD Flag

Signal Overloaded: J2-15 / 1 (pulsing)

B.1.8 NO SYNC Flag

Out of Sync: J2-14 / 1

B.1.9 Data Request/Ready

Data Request Pulse: Logic 1 from 25 μs to 1 s duration.

Data Ready: Logic 1 pulse whose leading edge trails Data Request leading edge by approximately 5 μs; trailing edge to logic 0 is the Data Ready flag. The duration is a function of state of system, i.e., whether it is ranging, overloaded, or out of sync.

B.1.10 Connector Wiring

Remote Control (J1)

Pin	Function
1	REF OFFSET
2, 3, 4	Range Remote Control
5, 6, 7	Mode Remote Control
8	FREQ SELECT
9	Ground
10, 11, 12	Spares
13	Data Request
14	+5 V
15	FREQ SELECT

Digital Outputs (J2)

Pin	Function
1	8 of next LSD
2	4 of next LSD
3	2 of next LSD
4	1 of next MSD
5	2 of next MSD
6	4 of next MSD
7	8 of next MSD
8	1 of MSD
9	2 of MSD
10	4 of MSD
11	DATA READY
12	8 of MSD
13	Over-range digit
14	OUT OF SYNC flag
15	Overload flag
16	Range output
17	REF OFFSET
18	Range output
19	Range output
20	1 of LSD
21	2 of LSD
22	4 of LSD
23	8 of LSD
24	1 of next LSD
25	Mode output
26-32	Spares
33	Polarity
34	FREQ SELECT output
35	FREQ SELECT output
36	Mode output
37	Mode output

B.2 THEORY OF OPERATION

This option provides for computer interfacing and control of the DPAV. With the REMOTE push button depressed, all functions (except reference OFFSET knob position) are programmable through the option card mounted on the rear panel. The 16-wire ribbon cable and the signle jumper wire carry the control signals from the option card to the front control section of the DPAV. J1 connector on the rear panel is for the programming inputs.

The digital output signals are fed to J2 on the rear panel. They are derived from signals coming from the A/D converter via two 26-wire ribbon cables to the option card.

The DPAV issues a Print command on J2-11 in response to a Data Request input on J1-13 after a delay, dependent on the state of the instrument. That is, consideration is taken as to conditions of NO SYNC, OVERLOAD, Ranging and Mode to determine appropriate delay.

A positive Data Request pulse (A, fig. B-1) at J1-13, sets Z10 latch (pins 3 and 6). This transmits an enable signal through some delay gating to Z15 single shot, which generates a 2.5 second pulse, the trailing edge of which is the Data Ready (B, fig. B-1) flag (J2-11). This trailing edge, through Z12-3, resets Z10 latch.

If the unit is in Total mode and in a state of overload, Z14 single shot is enabled and will start its delay pulse when the unit comes out of overload by generating a negative pulse at Z14-1. This delay is set at approximately 6 seconds, since the recovery from overload in the Total mode is longer than in the other modes.

If the unit is still ranging after the Data Request pulse is received, a pulse train at Z13-3 will keep retriggering Z15 single shot so that the Data Ready flag will be delayed until the unit has stopped ranging and has had time to settle to a stable reading.

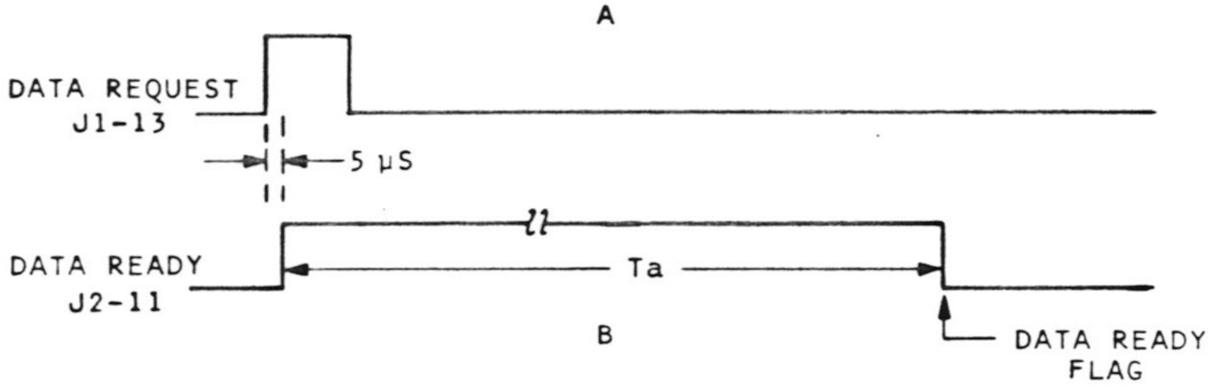


Figure B-1. Data Reference and Ready Pulses

The overload signal coming in at J3-12 is a switching voltage, changing between a logic 0 and 1. It is fed to Z15 single shot, retriggering it and delaying the Data Ready flag until the unit is out of overload and a stable reading achieved.

The sync signal coming in at J3-13 is normally at a logic 1 enabling the Data Request signal at Z10-10 through to Z15 single shot. If the unit is out of sync, Z10-9 will be low, disabling the Data Request signal to Z15 until a sync condition is reached, at which time the Z15 single shot starts its pulse.

Where the unit is not ranging, or overloaded or out of sync, Ta (B, fig. B-1) is approximately 2.5 seconds.

If, after a Data Request pulse, the unit is ranging, out of sync or overloaded, the Data Ready flag occurs 2.5 seconds after the unit reaches a stable operating condition.

Where the unit is in Total mode and is overloaded after Data Request, the Data Ready flag occurs approximately 6 seconds after unit comes out of overload.

B.3 PARTS LIST AND SCHEMATIC

Replacement Parts List: Remote Control/Digital Output - 783603

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Mica 1000pf, 100V, ±10%	801240	72136	DM15-102K	3
C2	Same as C1				
C3	Same as C1				
C4	Capacitor, Aluminum 1µf, 50V, -0+100%	807169	24138	PCD1PA50	1
C5	Capacitor, Tantalum 10µf, 10V, ±10%	803408	56289	150D106X9010B2	1
C6	Capacitor, Tantalum 3.3µf, 35V, ±20%	801311	56289	150D335X0035B2	1
J1	Connector, 15-pin	807393	71785	DAM-15P-14	1
J2	Connector, 37-pin	807394	71785	DCM-37P-A	1

*Used for Ratio Mode only.

Replacement Parts List: Remote Control/Digital Output - 783603 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
J3	Header	807107	76381	3429-2002	2
J5	Same as J3				
J6	Socket	807474	01295	C931602	1
Q1	Transistor	808190	06001	GES6002	2
Q2	Same as Q1				
Q3	Transistor	803662	01295	2N3819	3
Q4	Same as Q3				
Q5	Same as Q3				
R1	Resistor, Composition 4.3kΩ, 1/4W, ±5%	802188	01121	CB4325	1
R2	Resistor, Composition 6.2kΩ, 1/4W, ±5%	801395	01121	CB6225	6
R3	Same as R2				
R4	Same as R2				
R5	Same as R2				
R6	Same as R2				
R7	Resistor, Factory Trim .24MΩ, Nominal	804898	07342		1
R8	Resistor, Composition 2.2MΩ, 1/4W, ±5%	804297	01121	CB2255	1
R9	Same as R2				
R10	Resistor, Composition 51kΩ, 1/4W, ±5%	801985	01121	CB5135	6
R11	Same as R10				
R12	Same as R10				
R13	Same as R10				
R14	Same as R10				
R15	Same as R10				
R16	Resistor, Composition 200Ω, 1/4W, ±5%	802226	01121	CB2015	1
XZ	Socket, I.C.	807473	09922	DILB-14F-11	21
Z1	Integrated Circuit	806837	07263	U6A996251X	4
Z2	Same as Z1				
Z3	Same as Z1				
Z4	Integrated Circuit	805026	07263	U6A994659X	4

Replacement Parts List: Remote Control/Digital Output - 783603 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
Z5	Same as Z4				
Z6	Integrated Circuit	804344	07263	U6A993659X	2
Z7	Same as Z1				
Z8	Integrated Circuit	806505	01295	SN7404N	7
Z9	Same as Z6				
Z10	Same as Z4				
Z13	Same as Z4				
Z14	Integrated Circuit	805456	07263	U6A960159X	2
Z15	Same as Z14				
Z16	Same as Z8				
Z17	Same as Z8				
Z18	Same as Z8				
Z19	Same as Z8				
Z20	Same as Z8				
Z21	Same as Z8				

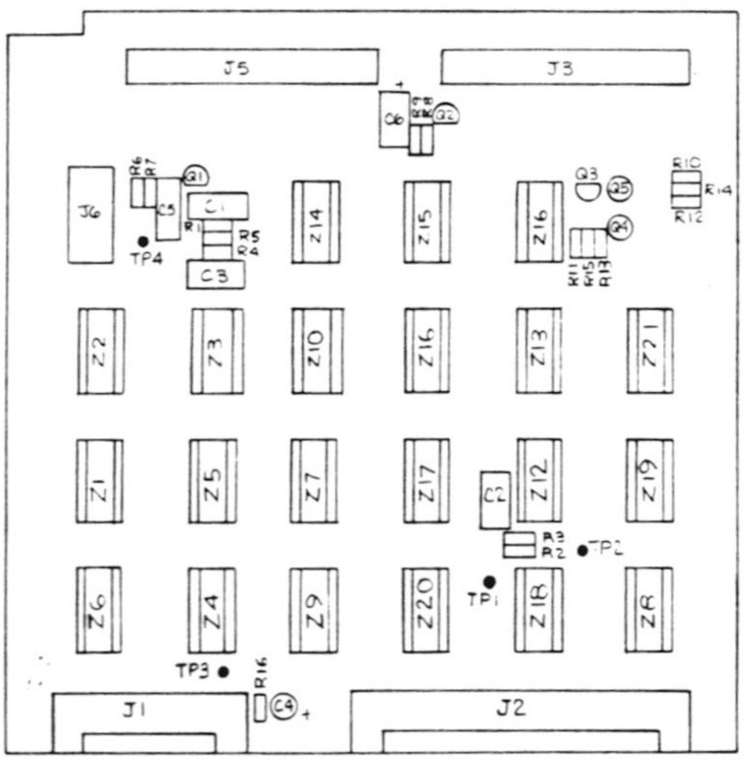


Figure B-2. Remote Control/Digital Output, Parts Locator

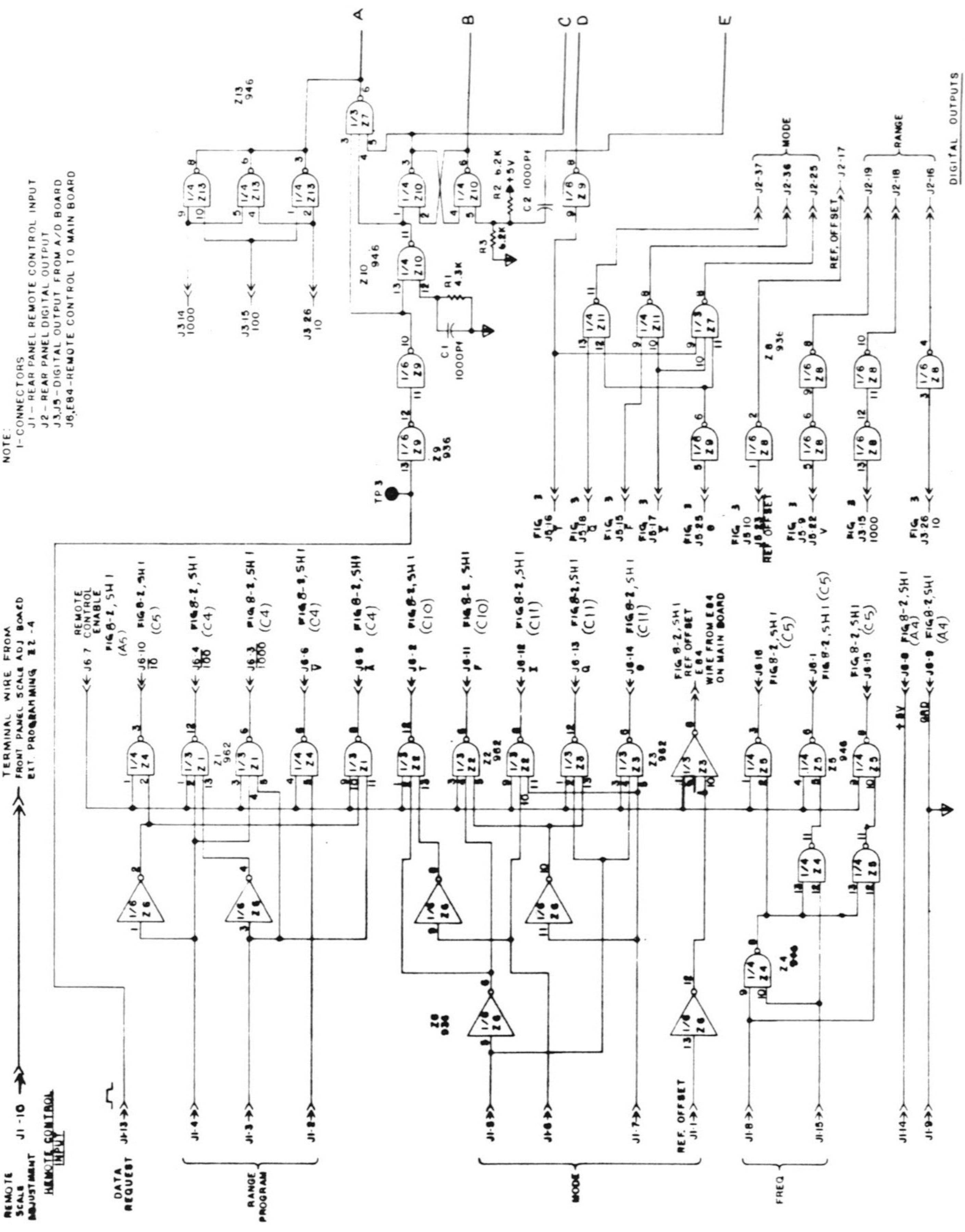


Figure B-3. Remote Control/Digital Output, Schematic (Sheet 1 of 2)

APPENDIX C

IEEE INTERFACE (OPTION 12)

C.1 IEEE STANDARD DIGITAL INTERFACE

This appendix describes the functions of the IEEE Standard Digital Interface for Programmable Instrumentation (488-1975) and the device dependent programming instructions for the Digital Phase Angle Voltmeter, Model 225.

The DPAV IEEE Standard 488 (Option 12) responds to a multiple of interface functions and subsets. Table C-1 lists the selected interface functions and subsets. The DPAV physically connects to the IEEE bus by a 24-pin connector on the rear panel. Table C-2 describes the 8 bidirectional data lines, 5 bus management lines and 3 data transfer lines. The Talk and Listen addresses of the DPAV are selected by means of a DIP switch assembly mounted on the rear panel of the DPAV. Table C-3 gives the switch settings and ASCII equivalents.

C.2 DPAV MESSAGE TRANSFER CAPABILITY

The DPAV is an intelligent, programmable measuring device capable of responding to IEEE bus commands and device dependent messages. Table C-4 describes the IEEE standard bus commands.

The DPAV is programmed to handle four types of device dependent messages, Listen (long and short format) and Talk (long and short format). The four messages use the ASCII seven-bit code characters. The long format Listen message permits the insertion of equal signs (=), commas (,) and comments to aid the operator in programming the DPAV (fig. C-1). The short format Listen message offers the more experienced operator a means to program the DPAV quickly. The long format Talk message provides a maximum description of all the DPAV Talk message fields and, if implemented, customized comments (fig. C-2). The short format Talk message outputs only the data field from the Talk message, eliminating all other fields.

The Listen device dependent messages, either long or short format, may be transmitted as a complete field in any order. If a Listen field is transmitted which is incorrect, no modification of that field will occur. A partial long format message will program those instruction fields included in the message. Unspecified instruction fields will also remain in their last programmed state. A short form message must be sent with all fields. The Listen message transmitted will not be applied until the message terminator is received. If an ATN or IFC Uniline message becomes true before receiving the message terminator, there will be no modification. The instructions and argument of both listen messages are identical with the exception of beginning delimiter (>) for long and ($) for short. Table C-5 describes the Listen device dependent message test and format.

The Talk device dependent message, long format, is capable of transmitting user specified comments. These comments are limited to three ASCII characters per instruction or argument, including before the beginning delimiter. The short format has no comment capability and transmits only twelve ASCII characters, including the message terminator. Table C-6 describes the Talk device dependent message test and format.

C.3 PROGRAM CONSIDERATIONS

The DPAV responds to the commands listed in Table C-4. Several of these commands are further developed in the following paragraphs. Table C-3 contains the addresses to which the DPAV can be set by the DIP switch on its rear panel. Table C-1 lists the DPAV's interface capabilities. Table C-2 lists standard bus signals as related to the DPAV. Tables C-5 and C-6 list DPAV Listener and Talker Device Dependent Messages.

Table C-1. Interface Function Capabilities

Interface function	Subset	Description
Source Handshake	SH1	Complete capability to transfer data on the DIO lines properly.
Acceptor Handshake	AH1	Complete capability to receive data from the DIO lines properly.
Talker	T6	Capability to send device dependent messages (basic talker), service request status information (serial poll) and unaddress if My Listen Address (MLA) or any other talk address is true.
Listener	L4	Capability to receive device dependent messages or interface commands (basic listener) and unaddress if My Talk Address (MTA) is true.
Extended Talker	TEØ	No capability.
Extended Listener	LEØ	No capability.
Service Request	SR1	Complete capability to request service from controlling device asynchronously.
Remote Local	RL1	Complete capability to select between front panel controls or bus interface instructions.
Parallel POLL	PPØ	No capability.
Device Clear	DC1	Complete capability to change current instruction set.
Device Trigger	DT1	Complete capability to start the measuring cycle.
Controller		No capability.

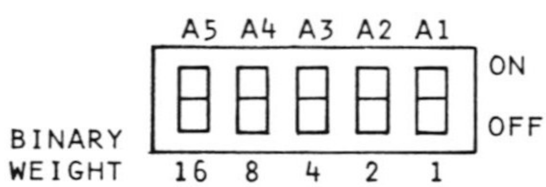
Table C-2. IEEE Standard Bus Signal Line Description

Signal	Mnemonic	Description
Data Input, Output	DIO1-DIO8	Eight bidirectional data lines used to carry bit-parallel, byte-serial messages.
Data Valid	DAV	When true, indicates valid data present on DIO lines.
Not Ready for Data	NRFD	When false (high) device is ready to accept data. When true (low) device is not ready to accept data.
Not Data Accepted	NDAC	When false (high) device has accepted data. When true (low) device has not accepted data.
Attention	ATN	When true (low) the DIO lines transmit in the command mode. The only valid data are addresses, unaddress commands, addressed commands and universal commands. When false (high) DIO lines transmit in the data mode (i.e., device dependent messages).
Interface Clear	IFC	Places DPAV interface in a quiescent condition. All interface functions transfer to an IDLE STATE. The SRQ lines is false, and the interface unaddressed.
Service Request	SRQ	When true (low) DPAV has completed measurement and should be serviced.
Remote Enable	REN	When true (low), the DPAV addressed to listen and the front panel remote switch in, the DPAV responds to device dependent messages. If the front panel remote switch is out, the DPAV will not respond to listener messages. However, the front panel switch may be overridden with the LLO command (MLA true). Local control is again returned when the GTL command is issued and the DPAV is listening. Whenever REN is false (high) the DPAV is controlled from the front panel.

Table C-3. DPAV Addressing

Address Switches					Talk	Listen
A5	A4	A3	A2	A1		
0	0	0	0	0	@	SP
0	0	0	0	1	A	!
0	0	0	1	0	B	"
0	0	0	1	1	C	#
0	0	1	0	0	D	$
0	0	1	0	1	E	%
0	0	1	1	0	F	&
0	0	1	1	1	G	'
0	1	0	0	0	H	(
0	1	0	0	1	I	)
0	1	0	1	0	J	*
0	1	0	1	1	K	+
0	1	1	0	0	L	,
0	1	1	0	1	M	-
0	1	1	1	0	N	.
0	1	1	1	1	O	/
1	0	0	0	0	P	Ø
1	0	0	0	1	Q	1
1	0	0	1	0	R	2
1	0	0	1	1	S	3
1	0	1	0	0	T	4
1	0	1	0	1	U	5
1	0	1	1	0	V	6
1	0	1	1	1	W	7
1	1	0	0	0	X	8
1	1	0	0	1	Y	9
1	1	0	1	0	Z	:
1	1	0	1	1	[	;
1	1	1	0	0		<
1	1	1	0	1	]	=
1	1	1	1	0	Λ	>

To set the address, use address switches A1 through A5 to set Binary address



Example: For address 5 push A1 and A3 to ON.

Table C-4 IEEE Standard 488 Bus Commands

Command	Symbol	Description
Unaddress Commands:		
Unlisten (UNL)	(?)	Unaddress all listeners presently addressed
Untalk (UNT)	(←)	Unaddress current talker. Addressing an unused Talker address will also clear bus of all talkers, i.e., only one talker may be addressed to transmit at a time.
Universal Commands:		
Local Lockout (LLO)	(DC1)	Disables the front panel remote/local push button allowing DPAV to respond to device dependent messages.
Device Clear (DCL)	(DC4)	Sets DPAV when in a remote state, to conditions specified by DIP switches (refer to "DPAV INITIALIZATION CONDITIONS" and figure C-1).
Serial Poll Enable (SPE)	(CAN)	Enables a serial poll sequence. Requires DPAV to provide a status byte including the service request bit (DIO7). Note DPAV status is available from the status byte as follows: Status Byte — DPAV Status Byte (STB) DIO8 — Not used DIO7 — RQ Request Service DIO6 — Not used DIO5 — STAB (Stability) DIO4 — Not used DIO3 — SYNC (Not Out of Synchronization) DIO2 — Not used DIO1 — $\overline{\text{OVLD}}$ (Not Overloaded)
Serial Poll Disable (SPD)	(EM)	Disables serial poll sequence.
Addressed Commands:		
Selective Device Clear (SDC)	(EOT)	SDC is an address command. It is otherwise the same as DCL.
Go to Local (GTL)	(SOH)	Returns DPAV, when addressed to Listen, to local control (front panel). GTL applies when REN is true. The GTL command will return the DPAV to local control after the LLO command has been issued while being addressed to Listen.
Group Execute Trigger (GET)	(BS)	Apply last program message (instruction set). The listen program message must include group trigger request=true in order for the DPAV interface to wait for the GET command before applying the present listen message. The GET command will always apply the last listen message when sent.

Table C-5. DPAV Listener Device Dependent Messages

A. Listener Long Format (fig. C-1)

1. Delimiter

> Greater than sign
Long Format listen message indicator

$ Dollar sign
Short Format listen message indicator

= Equal sign
Argument indicator. Instruction and argument field separator

, Comma
Instruction indicator argument and instruction field separator

2. Instructions

M - Mode
R - Range
F - Frequency
O - Reference Offset
V - Variable Scale
D - Data Output Form
S - Service Request
G - Group Trigger Request

3. Arguments

<u>Mode</u>

T - Total
F - Fundamental
I - In-Phase
Q - Quadrature
P - Phase Angle

<u>Range</u>

1 - 10 MV
2 - 100 MV
3 - 1000 MV
4 - 10 V
5 - 100 V
6 - 1000 V
A - AUTO

<u>Frequency</u>

1, 2, 3, 4 } Customer Options (See fig. C-4 for frequency locations)

<u>Reference Offset</u>

T - True Offset in
F - False Disabled

Table C-5. DPAV Listener Device Dependent Messages (Continued)

Variable Scale

T - True In
F - False Out

Data Format*

L - Long Format
S - Short Format

Service Request* (see para. C.9)

T - True	- Asserted on completion of stable measurement or after 64 conversions if measurement is not valid. Conversions are 250 to 500 ms long depending on reading, i.e., full scale = 500 ms, 0 V = 250 ms.)
F - False	- Never asserted
2 - 2 Measurements	- Asserts after 2 measurements
C - Continuous	- Asserts after first measurement and there after each data read operation

4. Comments

Comments are any ASCII characters (except listed delimiters) preceding a delimiter character and after an instruction or argument. Comments may not be inserted between a delimiter and the next instruction or a delimiter and the next argument. Comment character may also be inserted before the beginning delimiters.

Examples:

DPAV MODE=FUND, RANGE=AUTO, FREQ=3-800HZ ↲

MOD=QUAD, RANGE=6VOLTS, VARI=FALSE ↓

M=PHASE, OFFSET=TRUE, G=TRUE ↓

GROUP=T, SRQ=TRUE, MODE=TOTAL, F=1400HZ ↲

5. Message Terminators

↲ CARRIAGE RETURN

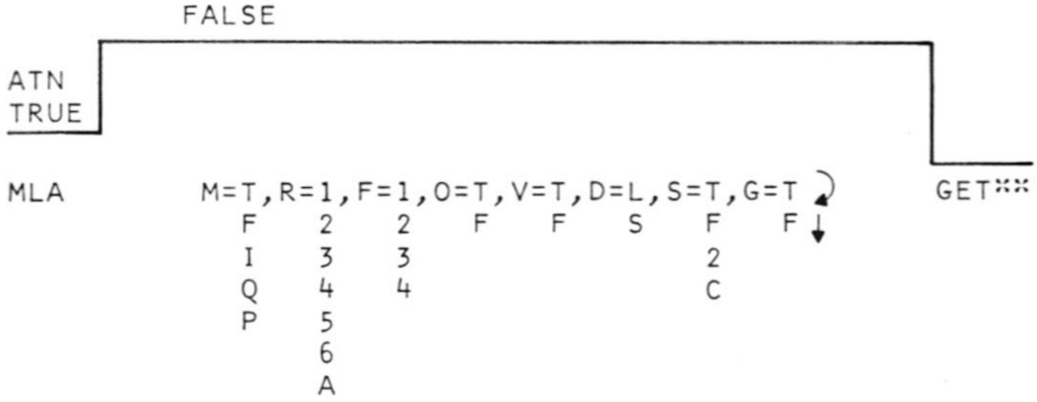
↓ LINE FEED

Either a carriage return or line feed may be used to terminate a message, but not both.

B. Listener Short Format (fig. C-1)

All instruction and argument ASCII characters are the same, and they are the only test permitted for short format programming. Equal sign, comma, and comments are omitted.

*These instructions are cleared (i.e., D=L, S=F, G=F) by SDC or DCC.

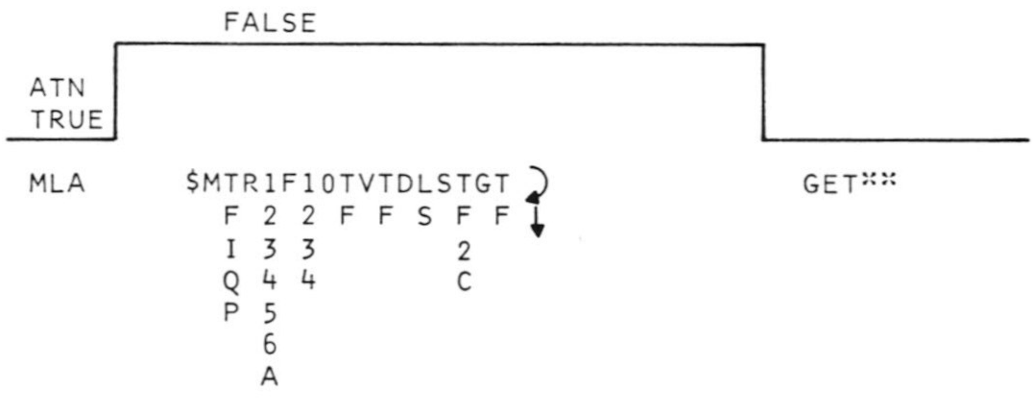


**GROUP TRIGGER COULD BE SENT AT THIS POINT

NOTE

ADDITIONAL CHARACTERS MAY BE INPUTTED TO CLARIFY INSTRUCTION FOR OPERATOR'S CONVENIENCE.

A. LONG FORMAT



B. SHORT FORMAT

Figure C-1. DPAV Listener Device Dependent Message

Table C-6. DPAV Talker Device Dependent Messages

A. Talker Long Format (fig. C-2)

1. Delimiter

< Less than sign
Beginning delimiter for long form messages.

D Letter "D"
Beginning delimiter for short form messages.

= Equal sign
Separates instruction text from argument text.

, Comma
Separates Talker fields

. Decimal Point
Located between the overrange digit and MSD of the data field and between NLSD and LDS of a degree date field.

± Plus or Minus sign
Indicates positive or negative data measurement and/or range exponent.

' Signal quote follows degrees measurement.

2. Instructions

M - Mode
D - Data or Degrees
R - Range
F - Frequency
O - Reference Offset
V - Variable Scale
N - Synchronization
L - Overload
S - Service Request

3. Arguments

<u>Mode</u>

T - Total
F - Fundamental
I - In-Phase
Q - Quadrature
P - Phase Angle

<u>Data</u>

Overrange
Either 1 or Ø. First digit after sign.

<u>Digits</u>

Either voltage or degrees. Voltage measure followed by "mV" millivolts or "V" volts. Degree measure followed by signal quote character.

Table C-6. DPAV Talker Device Dependent Messages (Continued)

Range

1 - 10 mV
2 - 100 mV
3 - 1000 mV
4 - 10 V
5 - 100 V
6 - 1000 V

Frequency

1, 2, 3, 4 } Customer Options

Reference Offset   0

T - True
F - False

Variable Scale   V

T
F

Synchronization   N

T (not sync.)
F (sync.)

Overload   L

T (overloaded)
F (no overload)

Service Request   S (shows mode programmed for)

T, F, 2, C

4. Comment (Optional)

Standard   Non supplied
Optional   Up to three characters, non-delimiters (see listen-comment examples table C-5).

CAUTION

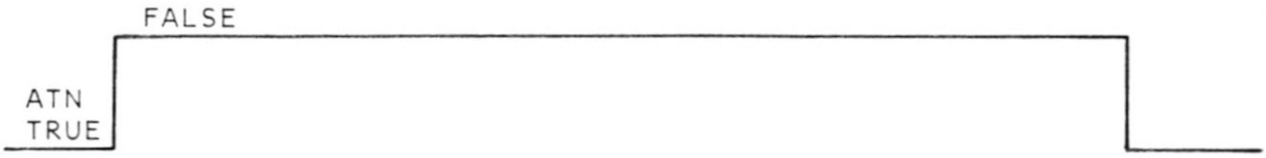
User's terminal line width must be considered when specifying comment character so as not to exceed user's terminal line limitation. Long format message contains 46 characters.

5. Message Terminators

CR-LF   Carriage Return

B. Talker Short Format (fig. C-2)

All talker fields are omitted except the data field. Either voltage or degrees are transmitted. (Single quote flags degree measurement.)



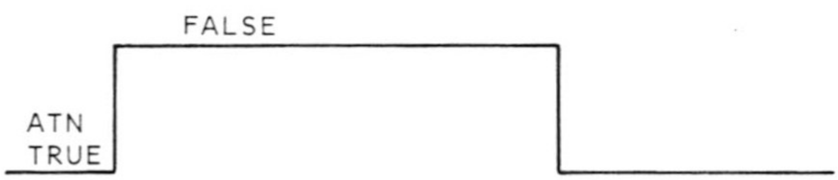

```
MTA       M=T,D=±XX.XXXMV,R=1,F=1,N=T,L=T,O=T,V=T,S=T ↲
            F     XXX.XXMV   2   2   F   F   F   F   F
            I     XXXX.XMV   3   3                   2
            Q     XX.XXXV    4   4                   C
            P     XXX.XXV    5
                  XXXX.XV    6

              ±XXX.X' (DEGREES)
```

NOTE

OPTIONAL COMMENTS MAY BE ADDED TO TEXT, LIMITED TO THREE (3) EXTRA CHARACTERS.

A. LONG FORMAT




```
MTA       D±XX.XXXMV ↲
            XXX.XXMV
            XXXX.XMV
            XX.XXXV
            XXX.XXV
            XXXX.XV
           ±XXX.X'  (DEGREES)
```

B. SHORT FORMAT

Figure C-2. DPAV Talker Device Dependent Message

C.4 POWER ON

The DPAV is powered on in the Local-State (LOCS). In this state, the front panel controls (fig. C-3) are operative and the DPAV can be operated manually. When going from LOCS to another state for the first time after power on, all instructions (table C-5) must be set.

If the LOC push button is depressed, you can go from LOCS to Local-With-Lockout State (RWLS). If you require local (manual) operation, you can return to LWLS.

If the REM push button is depressed, you can go from LOCS to the Remote State (REMS). If you require local (manual) operation, you can either push the LOC button in, or command the DPAV to Go-To-Local (DTL). In addition, you can go to RWLS from REMS. Once in a lockout state, you can return to LOCS by setting $\overline{\text{REN}}$. Operation of these functions are described below:

C.4.1 Power ON

Action	Response
Switch DPAV power on by depressing either LOC or REM push button. button.	DPAV goes to local state (LOCS). DPAV is operated by front panel controls.

C.4.2 Local With Local Switch ON

Enter Local-With-Lockout-State (LWLS), when DPAV is in LOCS and LOC push button is depressed, as follows:

Action	Response
a. DPAV in LOCS.	
b. Set REN true.	
c. Command Local-Lock-Out (LLO)	c. DPAV goes to LWLS. DPAV is operated by front panel controls.

NOTE

DPAV can be returned to LOCS by setting $\overline{\text{REN}}$. DPAV can be set to the Remote-With-Lockout-State (RWLS) by sending an addressed command.

C.4.3 Remote With Local Switch ON

The DPAV can be set to the Remote-With-Lockout-State (RWLS) (para. C.4.2) as follows:

Action	Response
a. Set LWLS per paragraph C.4.2.	
b. Send an addressed command to DPAV to initialize control settings (table C-5).	b. DPAV goes to RWLS. DPAV is operated by IEEE bus. Front panel controls are inoperative except for OFF.

NOTE

To return to LWLS so that DPAV can be operated by front panel controls proceed to step c:

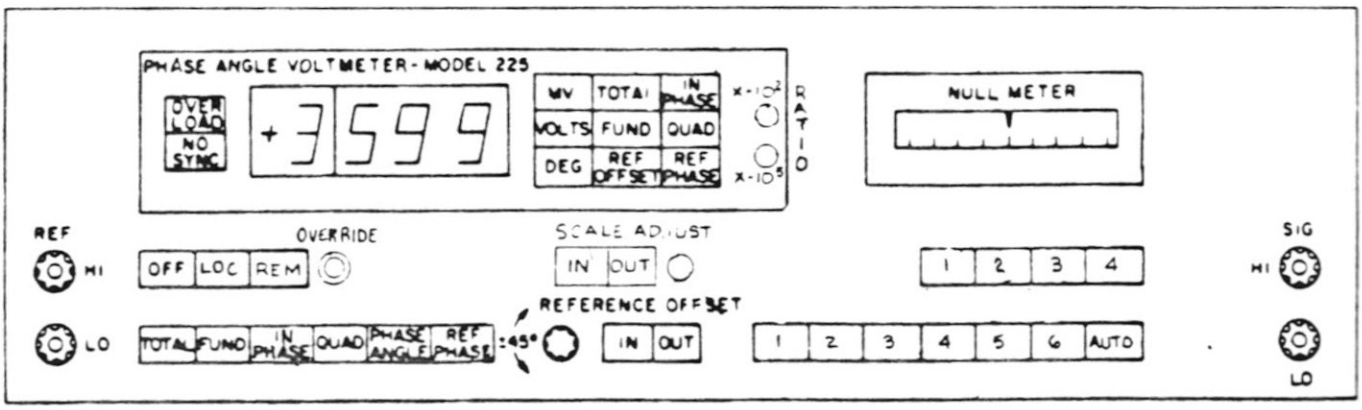


Figure C-3. DPAV Front Panel Controls Location and Nomenclature

Action	Response
c. Send Go-To-Local (GTL)	c. DPAV goes to LWLS. DPAV controls are operative.

NOTE

To return to LOCS, proceed to step d.

d. Set $\overline{\text{REN}}$	d. DPAV goes to LOCS

3.4.4 Remote With Remote Switch On

The DPAV can be set to the Remote-State (REMS) from the LOCS as follows:

Action	Response
a. Set DPAV to LOCS (para. C.4).	a. DPAV controls are operative.
b. Depress REM push button.	
c. Set REN.	
d. Send an addressed command to DPAV to initialize control settings.	d. DPAV goes to REMS and is controlled from bus. Front panel controls are inoperative.

NOTE

When required, return to LOCS using one of the following two steps:

e. Using LOC switch. Depress LOC push button.	e. DPAV goes to LOCS. Front panel controls are operative.
f. Using Addressed Command. Send GTL.	f. DPAV goes to LOCS. Front panel controls are operative.

NOTE

If desired, go to RWLS from REMS as follows:

g. Set DPAV to REMS.	g. DPAV controlled from bus.
h. Send LLO.	h. DPAV goes to RWLS and is controlled from bus.

3.5 DEVICE CLEAR

Two messages are used to clear the DPAV. These are Device Clear (DCL) and Selected Device Clear (SDC). DCL is a universal command and is always recognized by the DPAV. SDC is an addressed command. It is recognized when used with the address value set into the address switch of the DPAV.

DCL or SDC sets the DPAV to the values set in the DIP switches (fig. C-4). When the OLD/NEW switch on the expansion board, is in the OLD position, the switch values are not stored in memory. However, they are stored in the new position. Consequently, the values of the preceeding operation are not erased. These values can be recalled when the OLD/NEW switch is in OLD position by using a simple "addressed command" such as resetting the Mode value (table C-5).

NOTE

When the DIP switch is in NEW position, DCL or SDC will clear local lockout.

When the DPAV is in REMS or RWLS:

a. DCL sets DPAV to DIP switch values.
b. SDC sets DPAV to DIP switch values.

When the DPAV is in LWLS:

a. DCL has no effect.
b. SDC sets DPAV to DIP switch values and to RWLS.

When the DPAV is in LOCS:

a. DCL has no effect.
b. SDC sets DPAV to DIP switch values and to REMS.

C.5.1 Device and Selected Device Clear

NOTE

When the DIP switch is in the NEW position, DCL or SDC clears local lockout.

DCL and SDC are effective when in a remote state.

Action	Response
a. DPAV in a remote state.	
b. Command DCL or SDC.	b. DPAV controls set to values set in DIP switches (fig. C-4).

NOTE

DPAV can now be returned to its preceeding control settings as follows:

c. Command DPAV mode to same value used in preceeding operation.	c. DPAV controls set to value of mode just entered and other values stored in memory.

C.6 SERIAL POLL AND SERVICE REQUEST

The DPAV responds to serial poll by sending a status byte. Usually this is in response to a request for service from either the DPAV or another instrument on the bus. To perform a serial poll, consequently implies the existence of one other interface function. This is Service Request.

When DPAV power is turned on, the Service Request function is set to Negative Poll Response State (NPRS). In this state, the DPAV will not request service. Referring to table C-5, this corresponds to S = F.

However, when S = T (table C-1 or C-2), the DPAV enters the Service Request State (SRQS) In SRQS, the DPAV will give a service request following completion of a measurement. The status of the DPAV is contained in the status byte. The status byte indicates if the DPAV reading is not stable, synchronized, not overloaded, and if the SRQ line is set. This information is available by way of the Serial Poll function.

C.7 SERVICE REQUEST AND GROUP EXECUTE TRIGGER

Service Request and Group Execute Trigger are programmable functions. In combination, they provide four different ways of obtaining measurement and status data from the DPAV. The service request enable instruction is stored and need be programmed only once. The group trigger enable instruction however, is not stored and is normally false. Consequently, it must be enabled each time the group trigger function is to be used. The four variations of these instructions are described below:

C.7.1 Service Request and Group Trigger Functions Disabled

(S=F, G=F, table C-5). When the DPAV is addressed to talk, it will continuously transmit measured data.

C.7.2 Service Request Function Enabled

(S=T, G=F, table C-5). IRQ goes true when status byte (table C-4) is available. The status byte provides DPAV synchronization, overload, and stability information. If the status byte indicates that the current measurements are synchronized, not overloaded, and stable, the current measurement is valid. Measurements are made between GET and service request. The three variations of these instructions are described below:

a. Synchronization indicates that the DPAV measuring circuits are synchronized with the signal under test.

b. Overload indicates that the voltage of signal under test exceeds the selected range.

c. Stability indicates that for successive measurements the data is within ±4 least significant digits (±2 in Phase mode). Instability indication results from tracking a changing signal, from measuring a signal with a high noise level, an overload condition, or loss of sync.

C.7.3 Group Trigger Function Enabled

(S=F, G=T, table C-5). When a command is sent to the DPAV, which includes G=T in its instruction string, the application of the command is delayed until a GET command is sent. Before GET, the DPAV will operate according to the current instruction set. After GET, the DPAV will operate according to the new instruction set.

C.7.4 Both Service Request and Group Trigger Functions Enabled

(S=T, G=T, table C-5). When both functions are enabled the DPAV provides a way of changing instruction sets response to GET, and providing an indication of measurement validity using the service request function. Several seconds after GET, the service request line will go true. If the associated status byte (table C-4) shows DPAV stability, synchronization, and no overload, than the current measurement is valid. Measurements between GET and service request true may not be valid.

C.8 STATUS BYTE

The status byte function is illustrated below:

7	6	5	4	3	2	1	0
	RQS		STAB		SYNC		$\overline{\text{OVLD}}$

$\overline{\text{OVLD}}$ - When 0, unit is overloaded.
SYNC - When 1, unit is synchronized.
STAB - When 1, unit is stable.
RQS - When 1, unit is requesting service.

C.9 SERVICE REQUEST MODES

Four service request modes are available to the user:

a. S = F
In this mode, service request will never be asserted by the DPAV.

b. S = T
In this mode, service request will be asserted:

(1) When data is stable
(2) If data does not stabilize after 128 data measurements.

c. S = 2
In this mode, service request will be asserted after the second data measurement, regardless of data stability.

d. S = C
In this mode, service request will be asserted after the first data measurement and after each data measurement following a serial poll sequence. This mode does not depend on data stability, but the status byte will indicate stability when valid.

C.10 DCL AND SDC SWITCH SETTINGS

This paragraph describes the procedure for selecting the device clear conditions for the mode, range, frequency, reference offset, and variable scale programmable instructions. Two DIP switches (fig. C-4) mounted on the expansion board provide the means for selecting the input to be applied to the DPAV. This feature is desirable for a variety of reasons, the most important of which is the ability to change program instructions and potentially eliminate program steps. The DCL or SDC command will read these two switch assemblies and apply them to the DPAV. (DPAV input refers to those connections from the interface board to the DPAV main board). Note that the remote enable uniline message must be true (low). The switch identification and positions are shown in figure C-4.

C.11 INITIALIZATION

When the DPAV is first addressed, its instruction set must be initialized. A command string should be sent to the DPAV according to table C-5 to set Mode, Range, Frequency, Reference Offset, Variable Scale, Data Output Form, Service Request, and Group Trigger Request. This places the DPAV in a defined state.

C.12 PROGRAMMING EXAMPLE

The following is a sample program for the Commodore Pet Model 4016.

```
100 OPEN 5,5: REM DPAV ADDR SW = 5
110 PRINT #5, "$MTR5F10FVFDLSFGF"
120 REM DPAV NOW SET TO TOTAL MODE RANGE
    =5, FREQ =1, DATA FORMAT = LONG
130 INPUT #5, A$, B$, C$, D$, E$, F$, G$,
    H$
140 PRINT A$;",";B$;",";C$;",";D$;",";E$;",
    ";F$;",";G$;","H$
150 REM DISPLAYS DPAV DATA
160 CLOSE 5,5
170 END
```

The input statement had to be broken up into a number of strings because the Commodore Pet interprets a comma as a delimiter and in long format the DPAV transmits commas between variables.

C.13 BLOCK DIAGRAM DISCUSSION

The IEEE interface connects the DPAV to the IEEE Std-488 bus. The interface consists of two printed circuit boards (prime and expansion). The prime board provides interface control and the expansion board provides I/O expansion required to connect the interface to the DPAV. Figure C-5 represents the prime board and figure C-6 represents the expansion board.

The prime board (fig. C-5), accepts control signals and control data from the IEEE bus, and outputs control signals, data and status data to the IEEE bus. All data transfers on the bus use the ASCII. The IEEE bus is connected to J5 on the back of the DPAV and interconnected to J1 on the interface.

The prime board responds to the bus by providing control signals to and accepting BCD and status data words from the expansion board. These functions are connected from J2 of the prime board to J2 of the expansion board. The expansion board distributes and collects signals from the DPAV.

The interface accepts control signals and data while in the listen mode. It transmits data in the talk mode. Control of the interface is performed by a 6802 micro-

SWITCH 1

	POSITION	OFF ON	
MODE	1	T	TOTAL
	2	F	FUNDAMENTAL
	3	I	IN-PHASE
	4	Q	QUADRATURE
	5	P	PHASE ANGLE
	6	RO	REFERENCE OFFSET
	7	V	VARIABLE SCALE
	8	AUTO	AUTO RANGE

SWITCH 2

	POSITION	OFF ON	
RANGE	1	10	10^1
	2	100	10^2
	3	1000	10^3
	4	VOLT	VOLT OR MILLIVOLT
FREQUENCY	5	F2	SECOND FREQUENCY
	6	F3	THIRD FREQUENCY
	7	F4	FOURTH FREQUENCY
	8	NEW/OLD*	SOFTWARE SELECT

SWITCH 2 TRUTH TABLES

RANGE

1	2	3	4	
10	100	1000	VOLT	
ON				10MV
	ON			100MV
		ON		1000MV
ON			ON	10V
	ON		ON	100V
		ON	ON	1000V

FREQUENCY

5	6	7	
F2	F3	F4	
ON	ON	ON	1
	ON	ON	2
ON		ON	3
ON	ON		4
	ON		4 RATIO

* Selects revised software. For compatibility with older DPAVs use OLD position, otherwise use NEW position (para. C.5).

Figure C-4. Expansion Board DIP Switch Positions

processor and the program stored in the ROM. Under control of the program the µP (U4) checks control lines, sets registers, converts BCD to ASCII and transmits data and status words.

The interface consists of a power-up reset, a µP, address and data line buffers, ROMs, decoders, PIA, transceivers, tristate buffers, and multiplexers. The function of each group is described in the following paragraphs.

The power-up reset circuit resets the µP every time power is turned on. While in this state, address line A0 of the µP is set to 0 and address lines A1-A15 are set to 1. This is the address of the MSB of the power-up routine located in the ROM. When the power reset state ends, the µP places the next address on the address bus Address lines A0-A15 all go to 1. This is the LSB of the address of the power-up routine. The µP than places the address of the power-up routine on the address bus and commences to initialize the registers within the interface.

PIA U11 transfers control and status data between the IEEE bus control lines and the data bus of the µP. These lines are EOI, DAV, NRFD, NDAC, IFC, SRQ, ATN, and REN

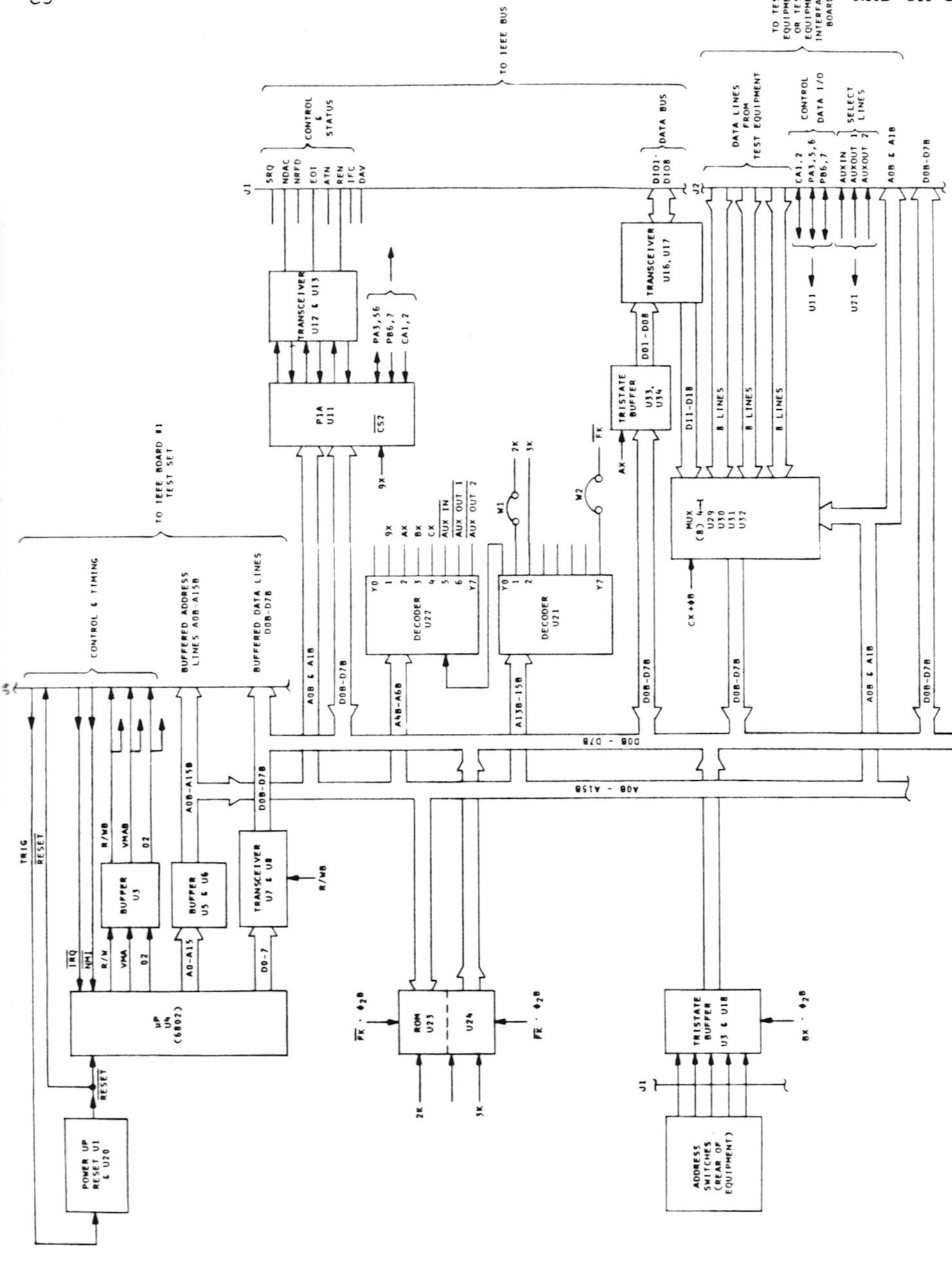


Figure C-5. Block Diagram of IEEE Interface Prime Board

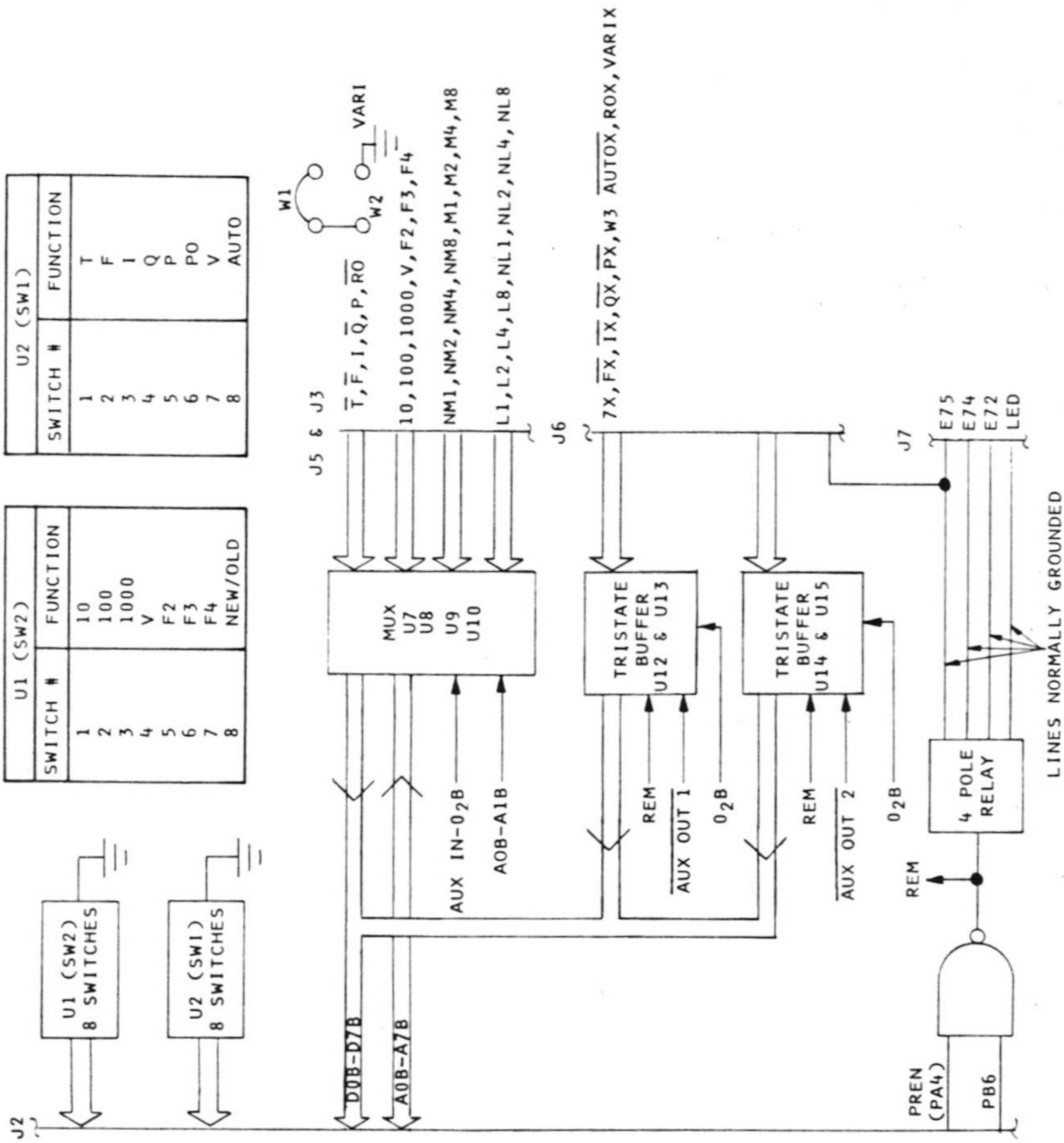


Figure C-6. Block Diagram of IEEE Interface Expansion Board (fig. C-9). It transfers these signals by way of transceivers U12 and U13. The transceiver receives or transmits on command from the µP.

Before the PIA (or any of the other devices connected to the data bus) can accept or place data on the bus it must be selected (enabled) by decoder U22. The decoder enables, one-at-a-time, the different bus-connected devices according to the state of address lines A10B-A12B connected to its input. Devices are selected as follows:

Address Code				Decoder (U22)	Device Connected
A7	A6	A5	A4	Output	to Bus (Expansion)
1	0	0	0	NC	
1	0	0	1	9X	PIA U11
1	0	1	0	AX	TRI STATE BUF U33 & U34
1	0	1	1	BX	TRI STATE BUF U3 & U18
1	1	0	0	CX	MUX U29, U30, U31, & U32
1	1	0	1	AUXIN	
1	1	1	0	AUXOUT 1	
1	1	1	1	AUXOUT 2	

A second decoder (U21) is used for overall selection. It is controlled by address lines A13B-A15B as follows:

Address Code			Decoder (U21)	
A15B	A14B	A13B	Output	Groups Enabled
0	0	0	IEX	All above devices
0	0	1	2K	U
0	1	0	3K	U
0	1	1	NC	
1	0	0	NC	
1	0	1	NC	
1	1	0	NC	U
1	1	1	FK	

U21 acts to enable all devices when A13B-A15B are all zero. U21 acts to enable the high PROM when A13B-A15B is all ones. This fact is used with power-up reset. When power-up reset is enabled, A10B-A15B are all ones. From the two preceeding tables, all ones enables (U22) AUXOUT 2 and FK. AUXOUT 2 and FK enable the high ROM (U23 and U24). In addition, AØB=0 and A1B-A19B=1 during reset. This condition addresses the next to least byte in the high ROM. The next to last and last bytes contain the address of the power-up routine in the ROM and are needed as discussed before to initialize the interface.

U21 enables U7, U8, U9, and U10 on the expansion board when 2K is true. This allows BCD and status data to be selected from the DPAV and placed on the µP data bus. 3K and NC enable U12, U13, U14, and U15 on the expansion board and allow control signals to be transferred from the µP bus to the DPAV.

The address of the interface is selected by a five-bit DIP switch available on the back panel. The switch setting is transferred to the data bus by tristate buffers U3 and U18. These buffers are enabled by BX when the current address setting is required by the ROM program.

Tristate buffers U33 and U34 allow data on the µP to be connected by way of transceivers U16 and U17 to the data lines of the IEEE bus. U33 and U34 are enabled by AX. This is the talker or source mode.

Conversely, data can pass from the data lines of the IEEE bus through the transceivers to multiplexers U29, U30, U31, and U32. When the multiplexers are enabled by CX, and A0B and A1B are 00, data from the IEEE bus is connected to the µP bus. When A0B and A1B are 10 or 11, data is transferred from the DIP switches on the expansion board to the µP data bus. When A0B and A1B are 01, status data is transferred from the DPAV by way of the expansion board to the data bus.

The expansion board also contains a relay which is used to switch the DPAV between remote and local operation. Remote or local operation is selected by way of the interface.

Utilizing the hardware described above, the program in ROMs U23 and U24 can perform any IEEE function required to control the DPAV, transfer data from the DPAV to the IEEE bus and respond with a status word on request.

C.11 PARTS LIST AND SCHEMATICS

This paragraph contains the parts lists, parts locator diagrams and schematics for the prime and expansion board.

Replacement Parts List: IEEE Interface (Prime Board) - 783777-03

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
	Sub-Assembly	500928-1			
C1	Capacitor, Elect. Tantalum 10µf, 25V, ±10%	808259	56289	138D106X9025CZ	2
C2	Same as C1				
C6	Capacitor, Ceramic .1µf, 12V, +80-20%	803406	72982	5835-000-Y5U-103Z	25
C7	Same as C6				
C8	Same as C6				
C9	Same as C6				
C10	Same as C6				
C11	Same as C6				
C12	Same as C6				
C13	Same as C6				
C14	Same as C6				
C15	Same as C6				
C16	Same as C6				
C18	Same as C6				
C19	Same as C6				
C20	Same as C6				
C21	Same as C6				
C22	Same as C6				
C23	Same as C6				
C24	Same as C6				
C25	Same as C6				
C26	Same as C6				
C27	Same as C6				
C28	Same as C6				
C29	Same as C6				
C30	Same as C6				
C31	Same as C6				
C32	Capacitor, Ceramic .1µf, 12V, ±20%	880636	72982	5655-000-Y5F0-104M	2
C33	Same as C32				
C34	Capacitor, Ceramic .47µf, 50V, ±20%	880817	71590	CY20C474M	1
R1	Resistor, Composition 100Ω, 1/4W, ±5%	801981	01121	CB1015	1

Replacement Parts List: IEEE Interface (Prime Board) - 783777-03 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R3	Resistor, Composition 3.3kΩ, 1/4W, ±5%	803388	01121	CB3325	3
R4	Same as R3				
R5	Resistor, Composition 4.7kΩ, 1/4W, ±5%	880088	01121	CB4725	1
R6	Resistor, Composition 2MΩ, 1/4W, ±5%	807094	01121	CB2055	2
R7	Same as R6				
R8	Same as R3				
U1	Integrated Circuit	808412	01295	SN75452BP	1
U3	Integrated Circuit	808342	01295	74LS125N	2
U4	Integrated Circuit	808421	04713	MC6802P	1
U5	Integrated Circuit	808373	01295	74LS244N	2
U6	Same as U5				
U7	Integrated Circuit	808374	01295	74LS243N	2
U8	Same as U7				
U9	Integrated Circuit	808341	01295	74LS04N	1
U10	Integrated Circuit	808137	01295	74LS00N	2
U11	Integrated Circuit	808131	04713	MC6820P	1
U12	Integrated Circuit	808339	04713	MC3440P	2
U13	Same as U12				
U14	Same as U10				
U15	Integrated Circuit	808127	01295	74LS32N	2
U16	Integrated Circuit	808139	04713	MC3441P	2
U17	Same as U16				
U18	Same as U3				
U19	I.C., Resistor Network 1K	808371	56289	216CH102X2PD	1
U20	Integrated Circuit	808411	01295	NE555P	1
U21	Integrated Circuit	808135	01295	74LS138N	2
U22	Same as U21				
U23*	Integrated Circuit, Prog.	884781			1
U24*	Integrated Circuit, Prog.	884782			1
U29	Integrated Circuit	808344	01295	74LS253N	4
U30	Same as U29				

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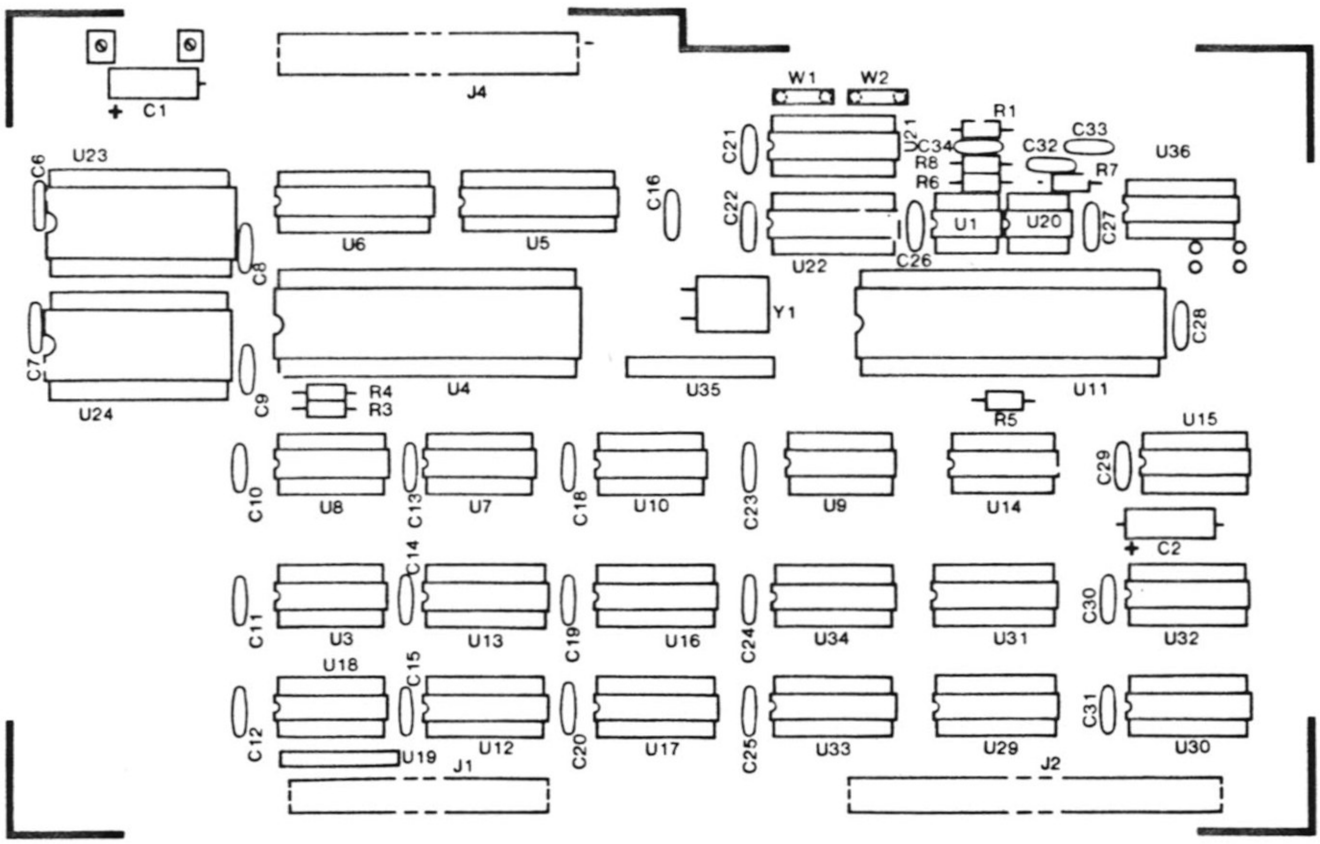
Replacement Parts List: IEEE Interface (Prime Board) - 783777-03 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
U31	Same as U29				
U32	Same as U29				
U33	Integrated Circuit	808343	01295	74LS173N	2
U34	Same as U33				
U35	I.C., Resistor Network 10K	808410	73138	785-1-R10K	1
U36	Same as U15				
XU1	Socket, 8-pin	808406	09922	DILB8P-108	2
XU3	Socket, 14-pin	807473	01295	C931402	9
XU4	Socket, 40-pin	808409	18677	US-2-40-110NB	2
XU5	Socket, 20-pin	808408	09922	DILB20P-108	2
XU6	Same as XU5				
XU7	Same as XU3				
XU8	Same as XU3				
XU9	Same as XU3				
XU10	Same as XU3				
XU11	Same as XU4				
XU12	Socket, 16-pin	807474	01295	C931602	12
XU13	Same as XU12				
XU14	Same as XU12				
XU15	Same as XU3				
XU16	Same as XU12				
XU17	Same as XU12				
XU18	Same as XU3				
XU20	Same as XU1				
XU21	Same as XU12				
XU22	Same as XU12				
XU23	Socket, 24-pin	808004	00779	530018-1	2
XU24	Same as XU23				
XU29	Same as XU12				
XU30	Same as XU12				
XU31	Same as XU12				
XU32	Same as XU12				
XU33	Same as XU12				
XU34	Same as XU12				
XU36	Same as XU3				
Y1	Crystal, 3 MHz	808336	12749	CY3A	1



NOTE

WHEN REPLACING U23 or U24, INSTALL PROM MARKED 885068-1 INTO U23 POSITION AND 885068-2 INTO U24 POSITION.

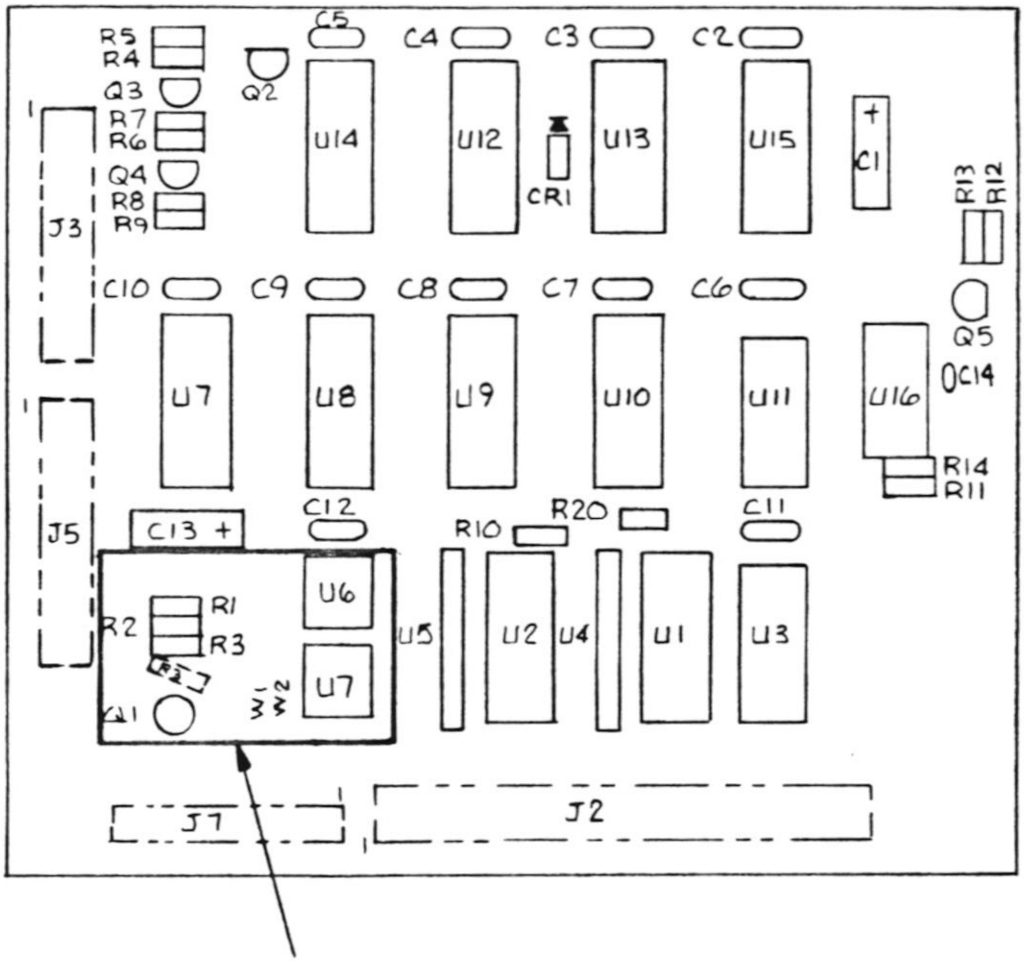
Figure C-7. IEEE Interface Prime Board, Parts Locator

Replacement Parts List: IEEE Interface (Expansion Board) - 783778

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Elect. Tantalum 10µf, 25V, ±10%	808259	56289	138D106X9025CZ	2
C2	Capacitor, Ceramic .01µf, 25V, +80-20%	803406	72982	5835-000-Y5U-103Z	11
C3	Same as C2				
C4	Same as C2				
C5	Same as C2				
C6	Same as C2				
C7	Same as C2				
C8	Same as C2				
C9	Same as C2				
C10	Same as C2				
C11	Same as C2				
C12	Same as C2				
C13	Same as C1				
C14	Capacitor, Elect. Tantalum 10µf, 25V, ±10%	808270	90201	TDC106K025FL	1
CR1	Diode	883449	09182	5082-HSCH-1001	1
Q1	Transistor	882178	QPL	JAN 2N2907	1
	Transipad, TO-18	882406	07047	10172N	
Q2	Transistor	803662	01295	2N3819	3
Q3	Same as Q2				
Q4	Same as Q2				
Q5	Transistor	803631	04713	2N3904	1
R1	Resistor, Composition 2kΩ, 1/4W, ±5%	801094	01121	CB2025	2
R2	Resistor, Composition 1kΩ, 1/4W, ±5%	880084	01121	CB1025	4
R3	Resistor, Composition 150Ω, 1/4W, ±5%	803672	01121	CB1515	1
R4	Resistor, Composition 51kΩ, 1/4W, ±5%	801985	01121	CB5135	6
R5	Same as R4				
R6	Same as R4				
R7	Same as R4				
R8	Same as R4				
R9	Same as R4				
R10	Same as R2				
R11	Same as R1				
R12	Resistor, Composition 470kΩ, 1/4W, ±5%	806093	01121	CB4745	1

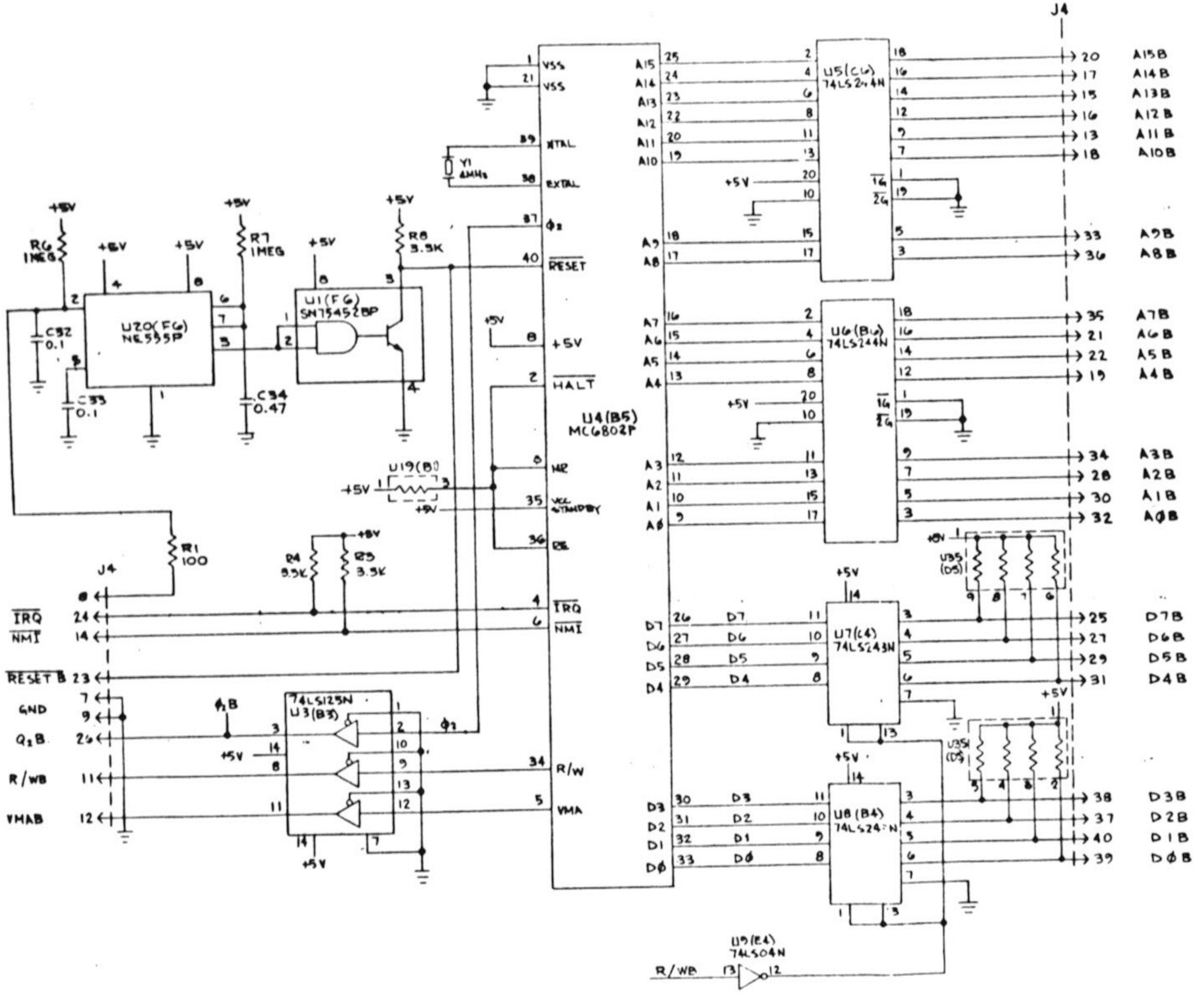
Replacement Parts List: IEEE Interface (Expansion Board) - 783778

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R13	Resistor, Composition 10kΩ, 1/4W, ±5%	801006	01121	CB1035	1
R14	Same as R2				
R20	Resistor, Composition 1kΩ, 1/4W, ±5%	880084	01121	CB1025	1
U1	Integrated Circuit Switch	808372	00752	SE2AV591-8	2
U2	Same as U1				
U3	Integrated Circuit	808137	01295	74LS00N	1
U4	I.C., Resistor Network, 1K	808371	56289	216CH102X2PD	2
U5	Same as U4				
U6	Driver	808412	01295	SN75452BP	2
U7	Integrated Circuit	808344	01295	74LS253N	4
U8	Same as U7				
U9	Same as U7				
U10	Same as U7				
U11	Integrated Circuit	808127	01295	74LS32N	1
U12	Integrated Circuit	808343	01295	74LS173N	4
U13	Same as U12				
U14	Same as U12				
U15	Same as U12				
U16	Integrated Circuit	805456	07263	8601DC	1
U17	Same as U6				
XJ6	Socket, 16-pin	807474	01295	C931602	9
XU3	Socket, 14-pin	807473	01295	C931402	3
XU6	Socket, 8-pin	808406	09922	DILB8P-108	2
XU7	Same as XJ6				
XU8	Same as XJ6				
XU9	Same as XJ6				
XU10	Same as XJ6				
XU11	Same as XU3				
XU12	Same as XU6				
XU13	Same as XU6				
XU14	Same as XJ6				
XU15	Same as XJ6				
XU16	Same as XU3				
XU17	Same as XU6				



ON REV. C1 AND BELOW BOARDS, U6 AND U17 ARE MOUNTED ON ASSEMRLY 787066 AND R3 IS MOUNTED AS SHOWN IN DASHED LINES.

Figure C-8. IEEE Interface Expansion Board, Parts Locator



NOTE:
1- UNLESS OTHERWISE SPECIFIED:
RESISTANCE VALUES ARE IN OHMS 1/4W, 5%.
CAPACITANCE VALUES ARE IN MICROFARADS.
2- W1 ENABLES PROMS.
3- W2 ENABLES THE RESET ADDRESS IN THE PROMS
4- USE W3 WITH API.
5- USE W4 WITH DPAK
6- DIODE CR1- SHEET 2 ZONE A7 USED ONLY WITH ASSEMBLY D-788777-04

7. GROUND AND VOLTAGE CHART

I.C #	TYPE	+5	GND
U1	SN75452N	8	4
U3,18	74LS125N	14	7
U4	MC6802P	8	1,21
U5,U6	74LS244N	20	10
U7,U8	74LS243N	14	7
U9	74LS04N	14	7
U10,14	74LS00N	14	7
U11	MC6820P	20	1
U12,U13	MC3440P	16	8
U15,U32	74LS32N	14	7
U16,U17	MC3441P	16	8
U20	NE555P	4	1
U21,U22	74LS138N	16	8
U23,U24	2716	24	12
U29-32	74LS253N	16	8
U33,34	74LS173N	16	8

Figure C-9. IEEE Interface Prime Board, Schematic (Sheet 1 of 3)

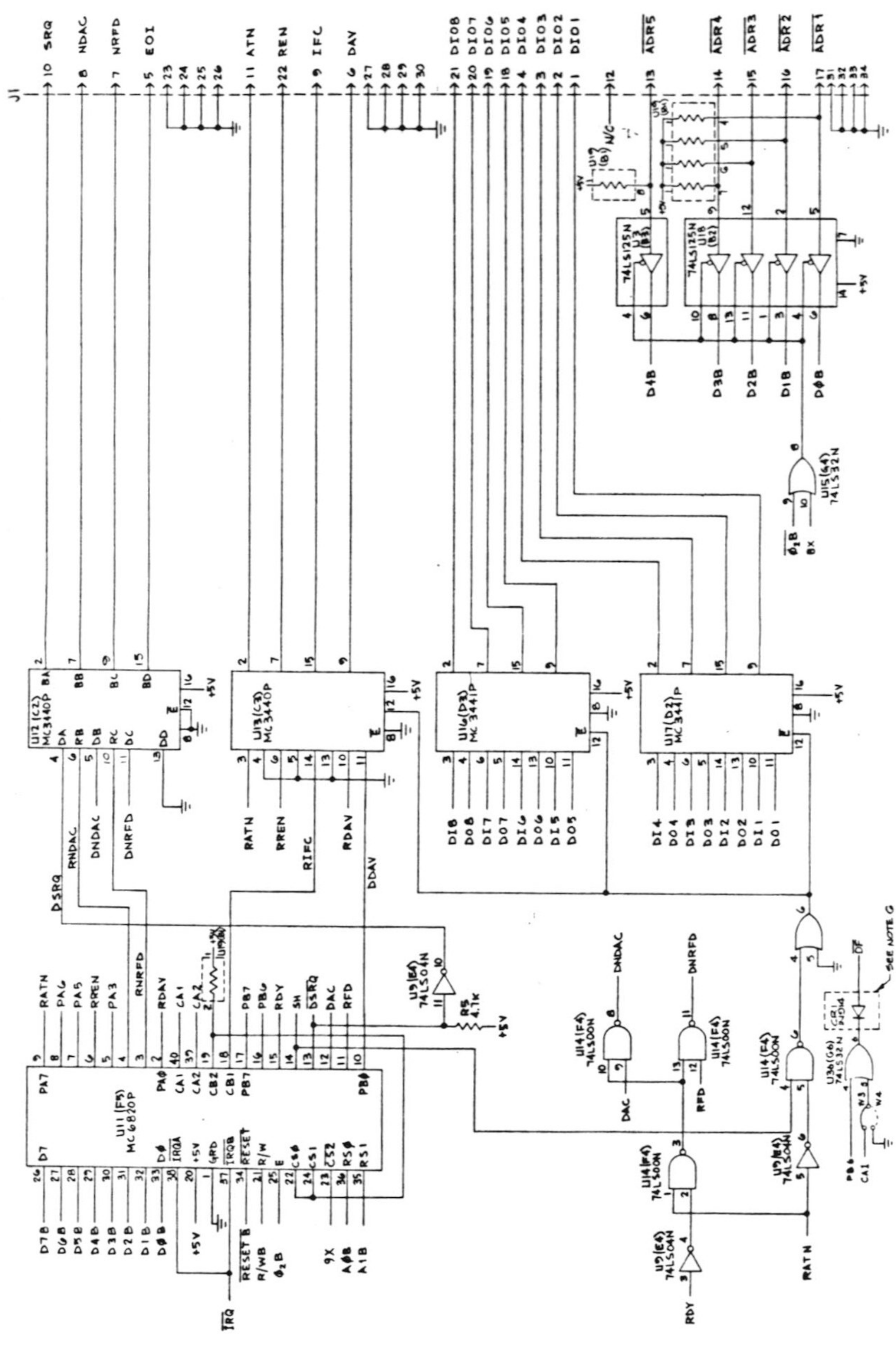


Figure C-9. IEEE Interface Prime Board, Schematic (Sheet 2 of 3)

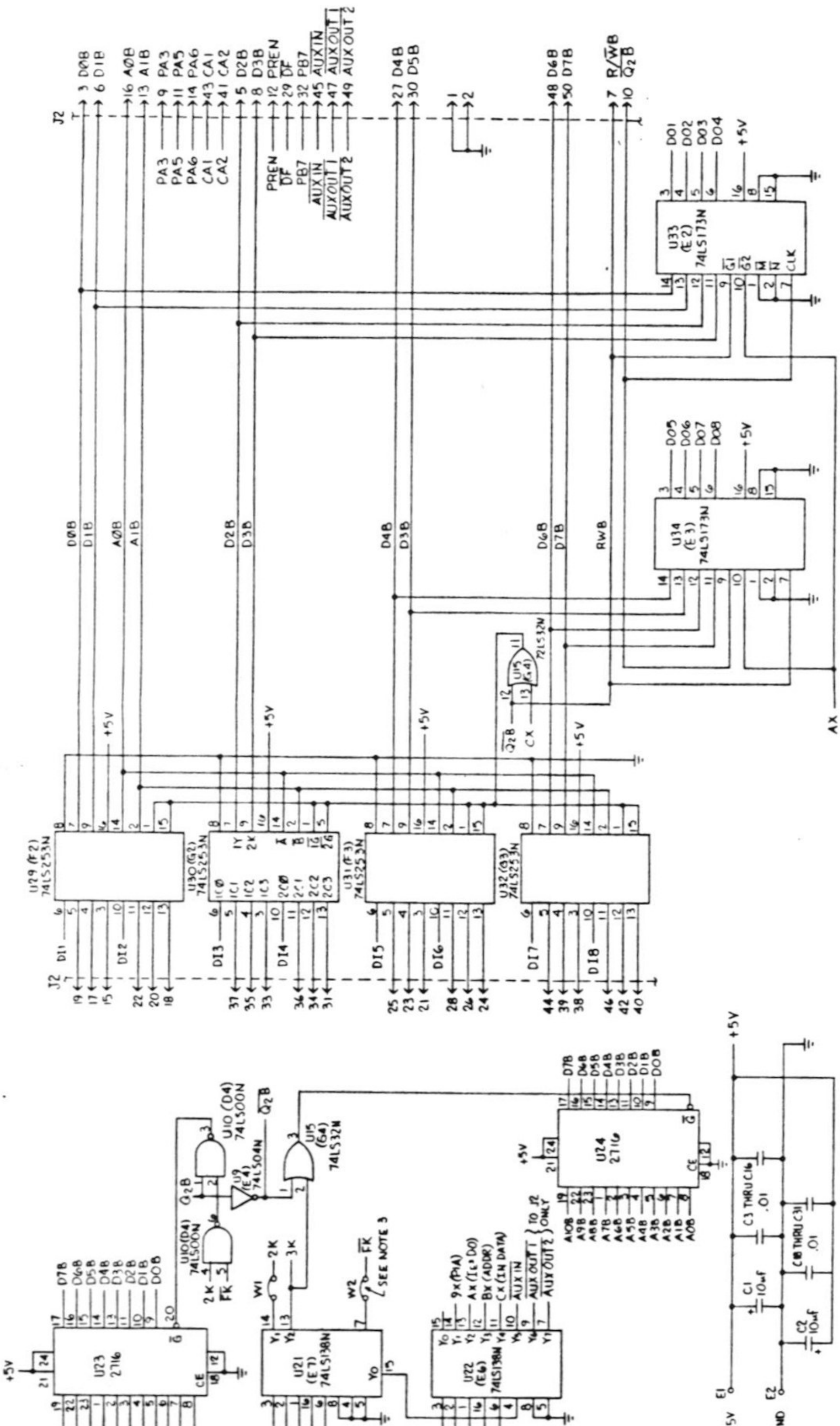


Figure C-9. IEEE Interface Prime Board, Schematic (Sheet 3 of 3)

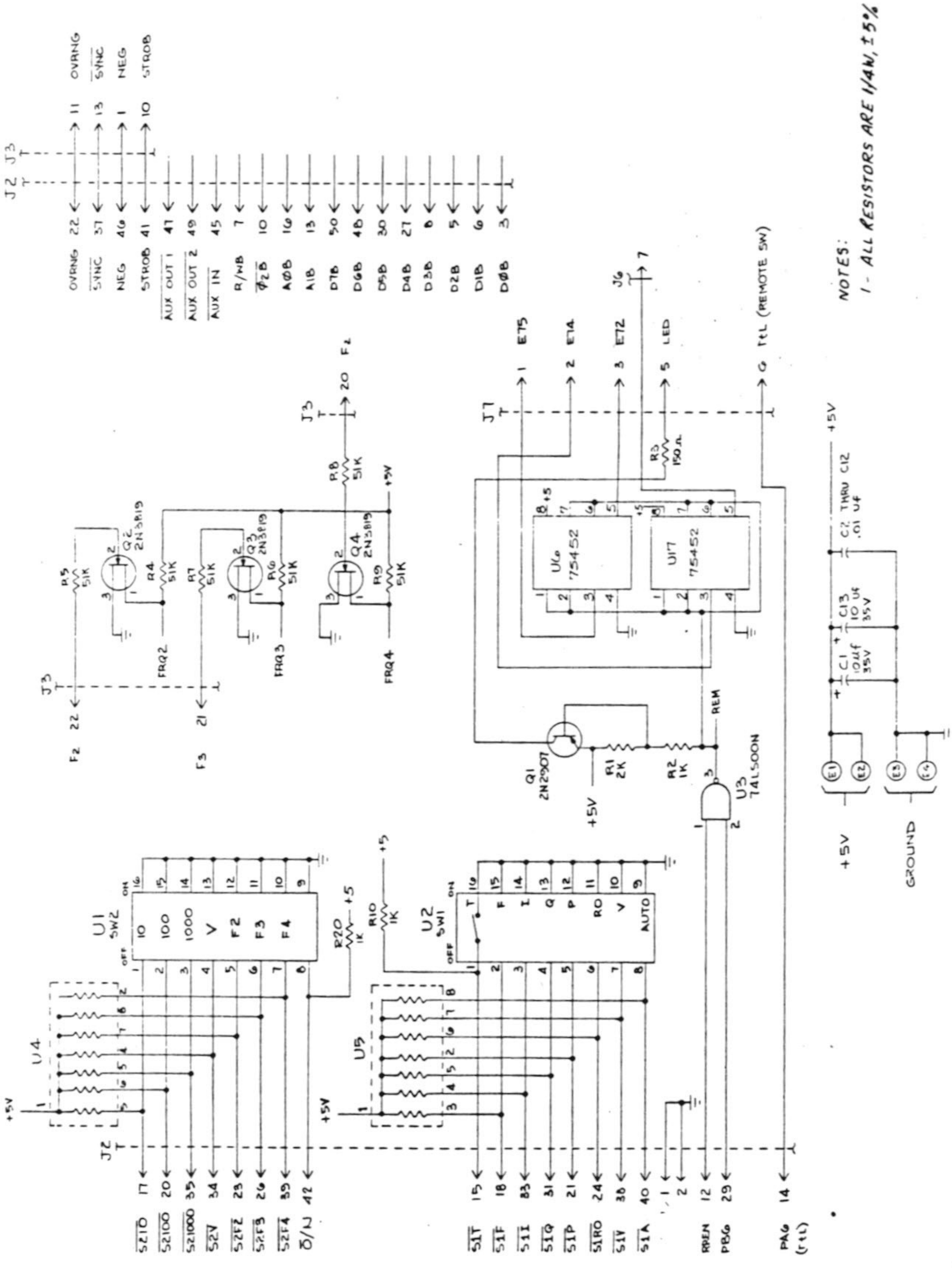


Figure C-10. IEEE Interface Expansion Board, Schematic (Sheet 1 of 2)

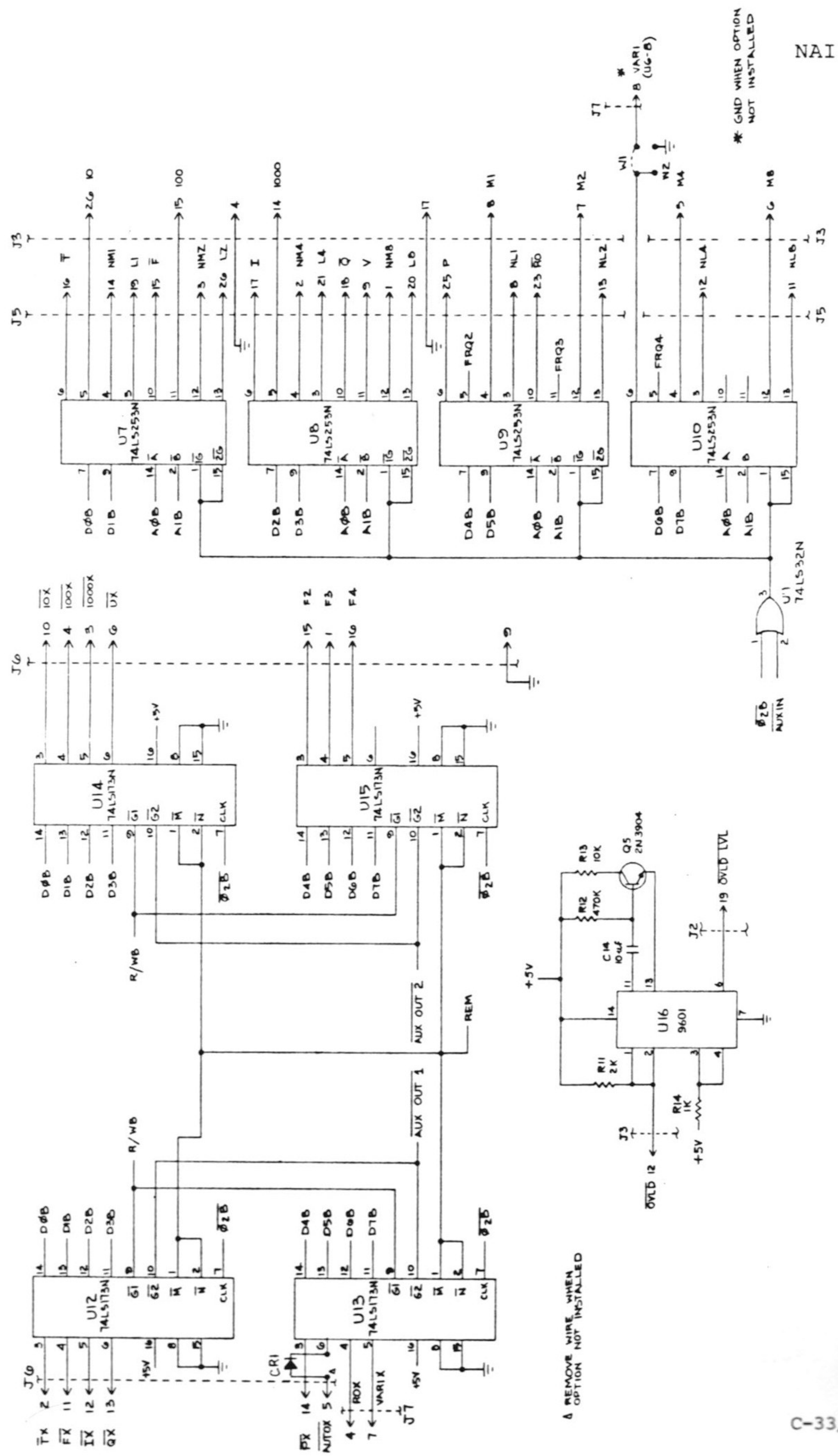


Figure C-10. IEEE Interface Expansion Board, Schematic (Sheet 2 of 2)

APPENDIX D

RATIOMETER

D.1 SPECIFICATIONS

a. Reference Input Voltage:

100 V Ratio unit = 100 V, 126 V rms maximum
30 V Ratio unit = 30 V, 37.8 V rms maximum
10 V Ratio unit = 10 V, 12.6 V rms maximum

b. Reference Input Impedance: 500 KΩ

c. Ratio Ranges:

For 100 V and 30 V Ratio units:

Voltage Range	Full Scale Ratio Range	Maximum Display
10 mV	20 $x10^{-5}$	19.999 $x10^{-5}$
100 mV	200 $x10^{-5}$	199.99 $x10^{-5}$
1000 mV	2000 $x10^{-5}$	1999.9 $x10^{-5}$
10 V	20 $x10^{-2}$	19.999 $x10^{-2}$
100 V	200 $x10^{-2}$	199.99 $x10^{-2}$
500 V	2000 $x10^{-2}$	1999.9 $x10^{-2}$

For 10 V Ratio Unit:

Voltage Range	Full Scale Ratio Range	Maximum Display
10 mV	20 $x10^{-4}$	19.999 $x10^{-4}$
100 mV	200 $x10^{-4}$	199.99 $x10^{-4}$
1000 mV	2000 $x10^{-4}$	1999.9 $x10^{-4}$
10 V	20 $x10^{-1}$	19.999 $x10^{-1}$
100 V	200 $x10^{-1}$	199.99 $x10^{-1}$
500 V	2000 $x10^{-1}$	1999.9 $x10^{-1}$

OVERLOAD light flags excessive ratio, signal and reference levels.

d. Accuracy (23° ±5°C)

Where: V_{ref} = The actual voltage put into the REF channel

VR_{in} = The ratio voltage designation, i.e., 10 V, 30 V or 100 V Ratio unit.

(1) Inphase and Quadrature Modes:

26 Hz to 60 Hz:
(0.025% F.S. +0.05% reading) $\frac{VR_{in}}{V_{ref}}$ +0.16% reading

61 Hz to 1.5 kHz:
(0.025% F.S. +0.05% reading) $\frac{VR_{in}}{V_{ref}}$ +0.08% reading

>1.5 kHz to 20 kHz:
(0.05% F.S. +0.08% reading) $\frac{VR_{in}}{V_{ref}}$ +0.25% reading

>20 kHz to 32 kHz:
(0.075% F.S. +0.10% reading) $\frac{VR_{in}}{V_{ref}}$ +0.30% reading

>32 kHz to 54 kHz:
(0.15% F.S. +0.30% reading) $\frac{VR_{in}}{V_{ref}}$ +0.40% reading

(2) Total Mode:

61 Hz to 30 kHz:
(0.05% F.S. +0.1% reading) $\frac{VR_{in}}{V_{ref}}$ +0.15% reading

30 Hz to 60 Hz >30 kHz to 100 kHz:
(0.05% F.S. +0.1% reading) $\frac{VR_{in}}{V_{ref}}$ +0.50% reading

e. Orthogonality:

Frequency	(23° ±5°C)	Temp coef. (0° to 18°C 28° to 50°C)
26 Hz to 60 Hz	0.15°	0.01°/°C
60 Hz to 5 kHz	0.09°	0.007°/°C
5 kHz to 20 kHz	0.15°	0.01°/°C
20 kHz to 32 kHz	0.2°	0.015°/°C
32 kHz to 54 kHz	0.4°	0.030°/°C

f. Temperature Coefficients:

(0° to 18°C, 28° to 50°C)

(1) Inphase and Quadrature Modes:

26 Hz to 60 Hz:
(0.0015%/°C F.S. +0.003%/°C reading)

$\frac{VR_{in}}{V_{ref}}$ +0.015%/°C reading

61 Hz to 1.5 kHz:
(0.0015%/°C F.S. +0.003%/°C reading)

$\frac{VR_{in}}{V_{ref}}$ +0.006%/°C reading

>1.5 kHz to 20 kHz:
(0.002%/°C F.S. +0.004%/°C reading)

$\frac{VR_{in}}{V_{ref}}$ +0.016%/°C reading

>20 kHz to 32 kHz:
(0.0025%/°C F.S. +0.005%/°C reading)

$\frac{VR_{in}}{V_{ref}}$ +0.02%/°C reading

>32 kHz to 54 kHz:
(0.005%/°C F.S. +0.017%/°C reading)

$\frac{VR_{in}}{V_{ref}}$ +0.035%/°C reading

(2) Total Mode:

26 Hz $\leq$TC $\leq$60 Hz	TC = 0.017%/°C
60 Hz $\leq$TC $\leq$30 kHz	TC = 0.015%/°C
30 kHz $\leq$TC $\leq$100 kHz	TC = 0.017%/°C

g. Response Time: Same as normal voltage mode.

h. Frequency: 1 or 2 frequencies which are the same as those in the phase measurement modes. Each ratio frequency replaces one of the four-phase measurement frequencies.

i. Remote Programming and Digital Outputs: Yes.

D.2 DESCRIPTION AND OPERATING INSTRUCTIONS

The ratiometer in the DPAV is offered at one or two frequencies, which are the same as the phase-sensitive frequencies in the instrument. Each ratio frequency replaces one of the four phase sensitive frequencies The ratiometer is selected by a push button adjacent to the regular frequency push button, or by remote control.

The measurement in this mode is the ratio of the signal voltage to the reference voltage. In the Inphase and Quadrature modes, the harmonics are rejected as defined in the normal voltage mode specifications. Total mode measurement is the ratio of total signal voltage (including harmonics and noise) to the fundamental of the reference voltage.

The OVERLOAD light flags if the reference voltage exceeds 126% or ratio exceeds 1.9999, in addition to flagging excessive signal level.

The displayed reading must be interpreted according to the range to get the actual ratio. On the millivolt ranges, the reading is multiplied by 10^{-5}; on the volt ranges, 10^{-2} to obtain the ratio. For example, if the reference was 100 V and the signal 50 mV, the reading on the 100 mV scale would be 50.00. The actual ratio is 50 x 10^{-5}, obtained simply by multiplying the reading by 10^{-5}. For VR10, use 10^{-4} and 10^{-1} respectively.

For reference voltage less than approximately 60% of VR, care must be taken when in the Autorange mode, since the range selected by the Autoranging loop could resule in a ratio in excess of 2.0. It is best to downrange manually until overloaded and then go to the next higher scale.

D.3 THEORY OF OPERATION

In brief, the ratiometer digital output defines the ratio of the signal voltage divided by the reference voltage. (Refer to figure D-1).

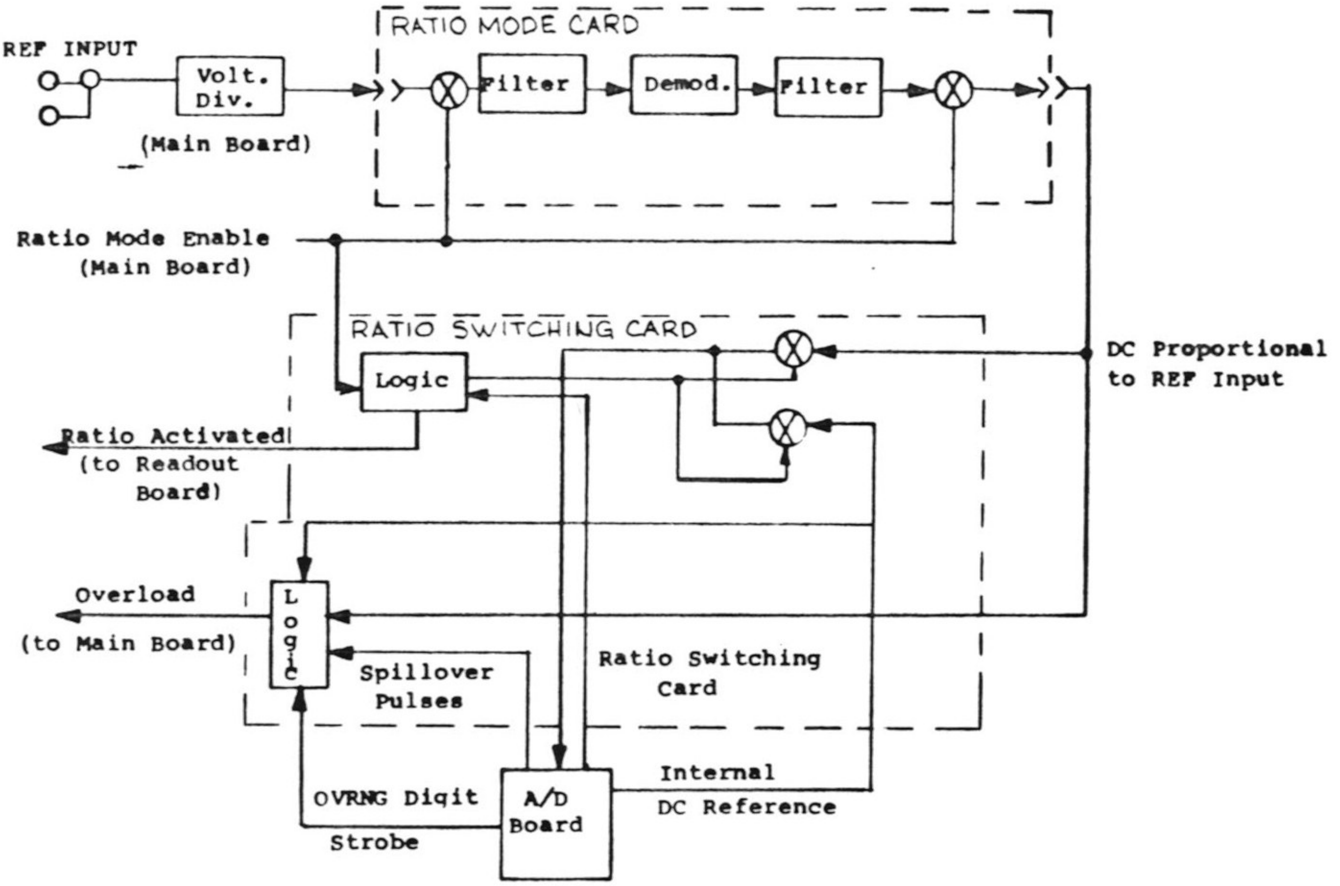


Figure D-1. Overall Block Diagram

The ratiometer signal voltage can be the Inphase, Quadrature, or Total voltage and these values are the same as in the normal mode of operation (voltmeter) producing the capability for Total, Inphase, or Quadrature ratio.

The reference input voltage (containing all harmonics and noise) is fed from reference transformer T2 to the ratio mode card. Basically, this card consists of an ac filter, a demodulator, and a dc filter. The output of this card is a dc voltage proportional to the ac reference input voltage. A block diagram of the card is shown in figure D-2.

When the ratiometer mode is selected, the analog-to-digital converter operation is altered from the normal voltmeter mode. The constand reference voltage from a zener source is disconnected and the dc voltage from the ratio card substituted by the ratiometer switching card. During a cycle of the dual slope integrator, the input of the integrator will now switch the dc voltage produced by the signal channel dc voltage which is always proportional to the signal input level. The mathematical output function of the dual slope integrator is now the ratio of two variable dc voltage External to the ratio mode card in the frequency card slot is circuitry for detecting a ratio card dc output level which would correspond to a reference input overload state greater than 126% of VR. Circuits to detect a ratio state in excess of 1.999 also exist. If either of these states is reached, the DPAV OVERLOAD flag flashes. These external circuits are located on the ratiometer switching card on the underside of the A/D converter. The overload function is performed by a calibrated comparator which detects the difference between the zener source voltage on the A/D converter and the ratio card dc output voltage

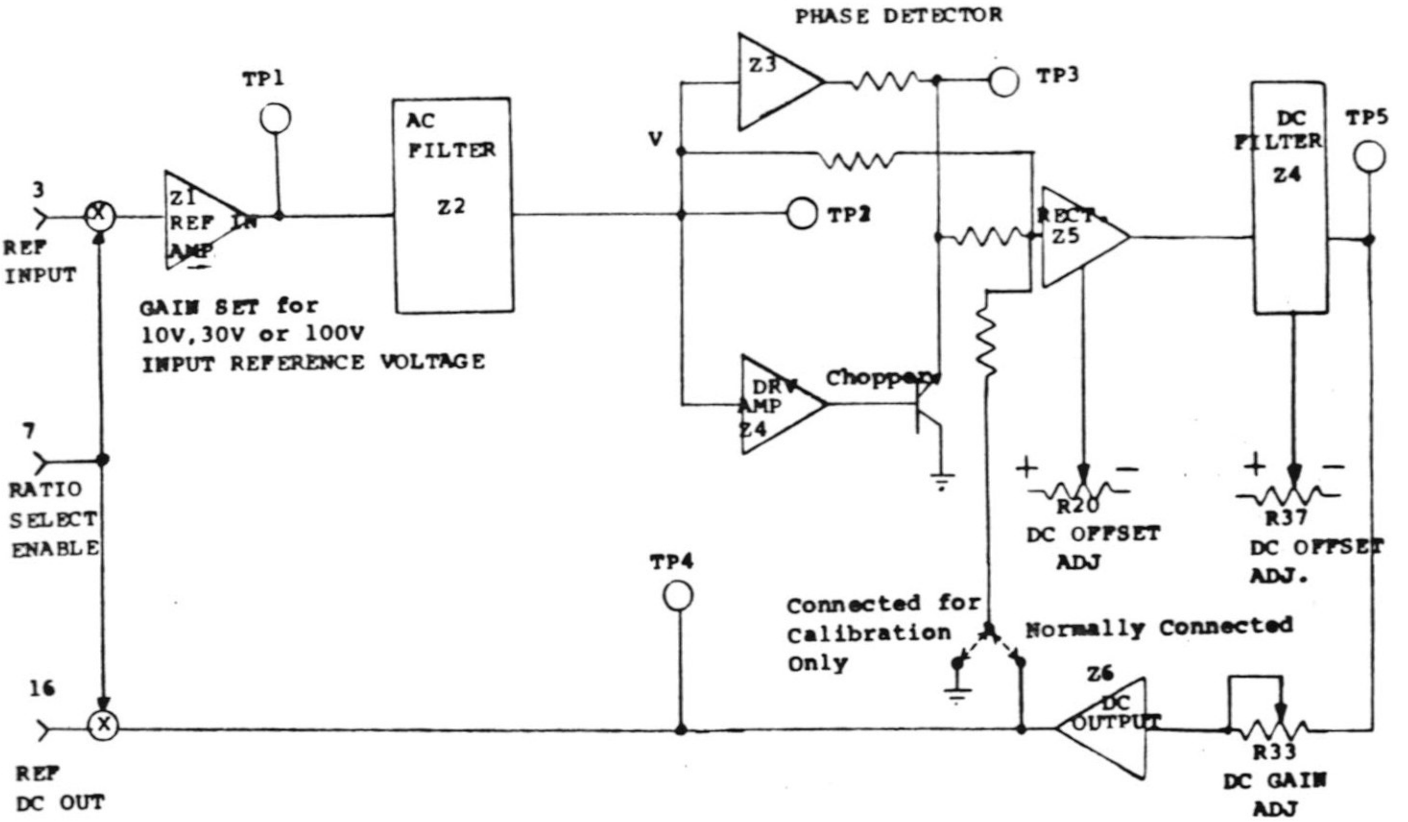


Figure D-2. Ratio Card Block Diagram

If the ratio card output dc exceeds a certain voltage, it is an indication to Z3 on the ratio switching card that the REF input is exceeding 126% of VR and the OVERLOAD lamp lights.

The excess ratio condition is detected by digital circuits which detect strobe pulses used to light the overrange digit. Circuitry Z1 and Z2 on the ratio switching card detect a state in which there are two or more overrange strobe pulses within the period of one dual slope integration cycle indicating a ratio greater than 1.999. The output of Z2 lights the OVERLOAD lamp.

The ratio switching card (figure D-3) contains a discrete logic circuit which programs both the ratio card and the readout board.

The readout board contains logic (Z15) which controls the VOLTS, MV, 10^{-2} and 10^{-5} lamps. In the ratiometer, the VOLTS and MV lamps are inhibited and 10^{-2} and 10^{-5} LED's are activated. In the normal voltage mode, 10^{-2} and 10^{-5} LED's are inhibited and VOLTS and MV lamps operate normally. For VR_{10} and 10^{-1} and 10^{-4} respectively.

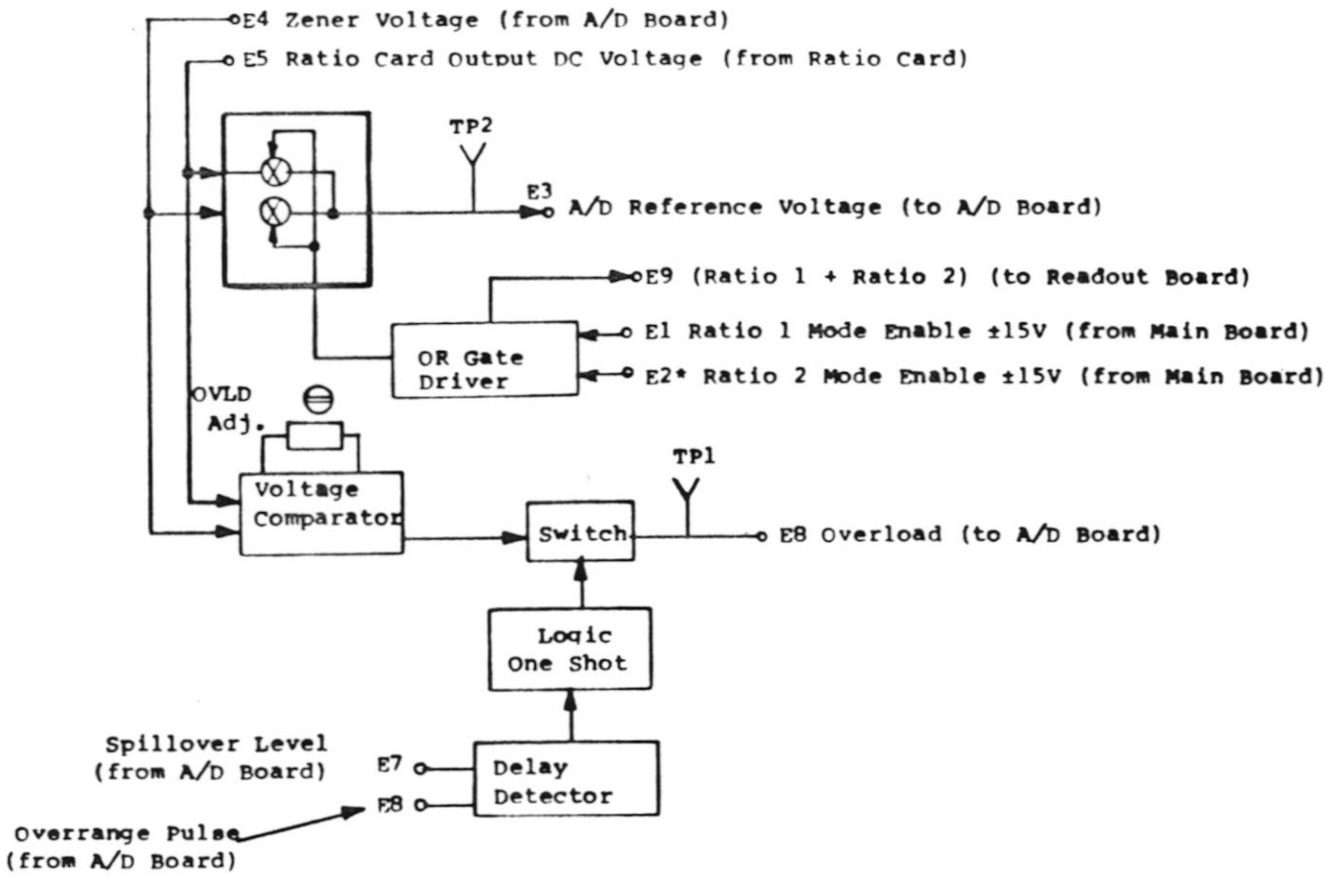
D.4 PERFORMANCE CHECKS

D.4.1 Equipment Required

- Precision Oscillator
- Power Amplifier, Krohn-Hite Model DCA-10R or equivalent
- 2 Ratio Boxes, RB504 or equivalent, or 2 Dytronics RTS 501 for frequencies greater than 5 kHz
- Ac Fluke Meter, Model 931

D.4.2 Initial Setup

a. Feed the precision oscillator into the power amplifier and set the power amplifier to the VR_{in} voltage. For a 10 V ratio mode card, this would be 10 V rms ±0.1%; for 30 V, 30 V rms ±0.1%; for 100 V, 100 V rms ±0.1%. Set the oscil-



*Used only in the case of two ratio mode capability.

Figure D-3. Ratio Switching Card Block Diagram

lator to the center frequency of operation of the ratio card frequency (±0.1%).

b. Place the power amplifier output into the inputs of two ratio boxes and label them REF and SIG. Place the SIG and REF outputs into their respective inputs of DPAV. Set both ratio boxes to 000000.

c. Place DPAV controls as follows:

Function Selector:	INPHASE
Voltage Scale:	AUTO
RATIO button:	Depressed
LOCAL:	Depressed

d. Initial Check:

(1) Note that NO SYNC lamp is lit.

(2) Increase reference ratio box setting to:

.00300 for 100 VR
.01000 for 30 VR
.03000 for 10 VR

(3) Note that NO SYNC lamp goes out.

D.4.3 Linearity Check for Offset Error

a. Set reference and signal ratio boxes to the desired voltage settings (para. D.1(Note the proper frequency range for these limits. All readings must be within the following tolerances:

VR_{100}: 100 V Ratio unit, match to VS_{100} for correct voltage levels

VR30: 30 V Ratio unit, match to VS_{30} for correct voltage levels

VR_{10}: 10 V Ratio unit, match to VS_{10} for correct voltage levels

b. Now that linearity at the center frequency of operation has been determined, bandwidth linearity must be checked. Place both Signal and Reference ratio boxes to 1.00000. Increase the input frequency by 5% above the center of operation. Note the readout values. This value must fall between the values shown in table D-1.

c. Lower input frequency by 5% below the center of operation. With ratio box settings as in b, above, note readout. The value must fall between the upper and lower limit specifications of b, above.

d. Insert VR specified (i.e., 10 V, 30 V, or 100 V) into the Signal channel and lower the reference level until the digital readout approaches 199.99. As the ratio exceeds 199.99, the OVERLOAD lamp must flash.

e. Remove Signal channel input and increase the Reference channel input to 126 V for VR_{100}, 37.8 V for VR_{30}, or 12.6 V for VR_{10}. The DPAV OVERLOAD lamp must light at this level.

D.5 ALIGNMENT AND CALIBRATION

D.5.1 Equipment Required

- Dc Fluke Meter, Model 895A or equivalent
- Precision Oscillator, Krohn-Hite Model 446R or equivalent
- Krohn-Hite Power Amplifier, Model DCA-10R or equivalent
- Two Ratio Boxes, RB504 or equivalent, or two Dytronics RTS501 for frequencies greater than 5 kHz

D.5.2 Voltage Mode Zero Offset Adjustments

a. Set oscillator at center frequency of operation of the ratio card and its corresponding voltage mode.

Set ratio boxes at 0.0000 and set up equipment per figure D-4. Set the input to the ratio boxes as shown below for the corresponding ratio card voltage:

100 V	Ratio unit:	100 V rms
30 V	Ratio unit:	30 V rms
10 V	Ratio unit:	10 V rms

b. Place DPAV in normal voltmeter mode and energize DPAV. Place DPAV in Total mode and allow one-half hour warm-up for all equipment, including DPAV, to stabilize thermally. (After warm-up period, remove DPAV top cover.)

c. Keeping DPAV in normal voltmeter mode, place it in the Inphase mode. Set the Reference input ratio box at 0.10000. NO SYNC lamp should go out.

d. Remove Signal input connection from DPAV and short the SIG HI and LO terminals together. Using dc Fluke meter, monitor A/D converter TP13 for a voltage of 0.0 V ±0.2 mV dc. If necessary, adjust TP13 voltage with main board potentiometer R93 (or R8 on an appropriate frequency card).

e. Using dc Fluke meter, monitor A/D converter TP12 for a voltage of 0.0 V ±0.2 mV dc. If necessary, adjust TP12 voltage with main board potentiometer R104 (or R18 on the appropriate frequency card).

Table D-1. Readout Values

Limit	f(26-60 Hz)	f(60-1.5k)Hz	f(>1.5k-20k)Hz	f(>20k-32k)Hz	f(>32k-54k)Hz
Upper Limit	100.26	100.18	100.42	100.55	100.91
Lower Limit	99.74	99.82	99.58	99.45	99.09

C1

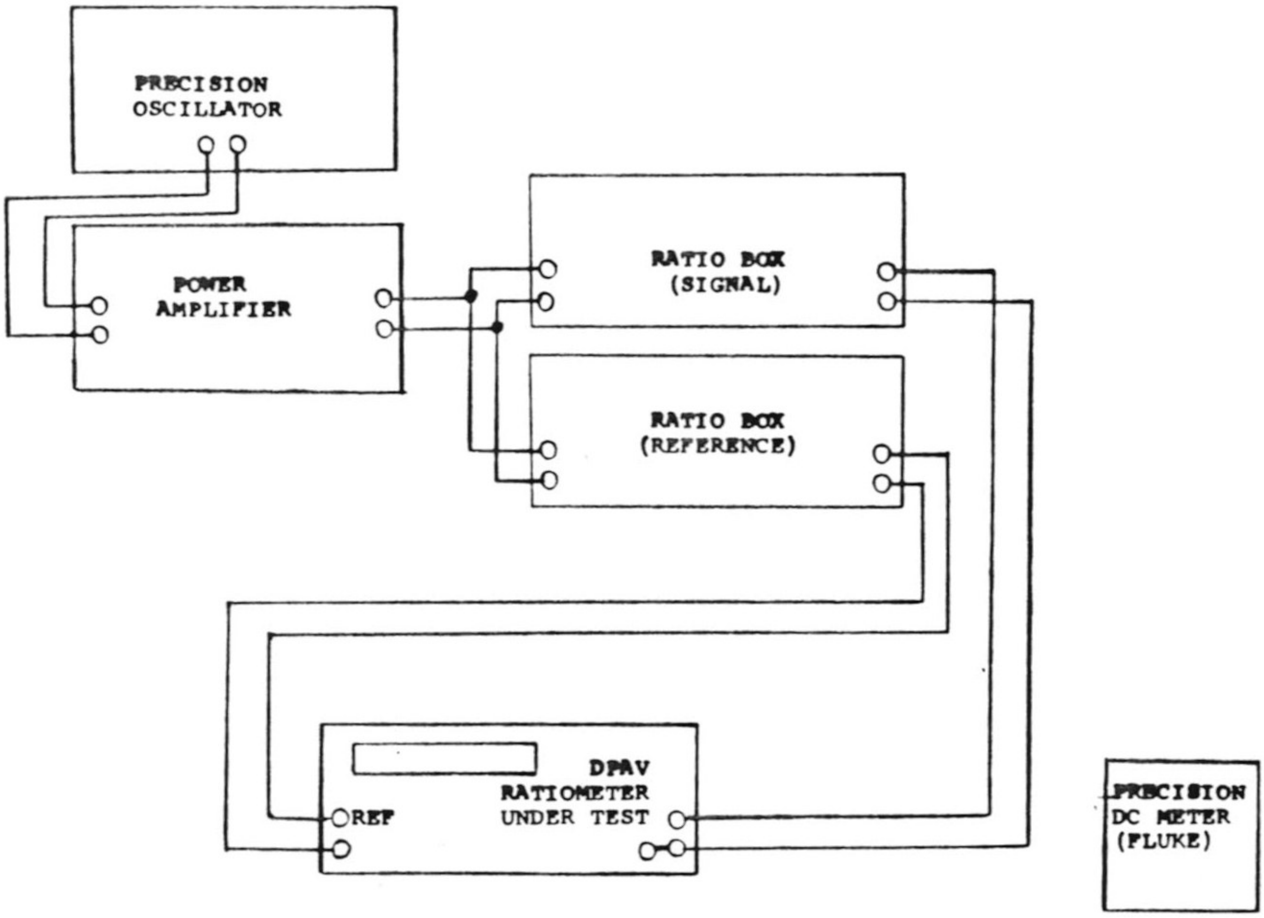


Figure D-4. Test Setup

f. Attach SIG input terminals of DPAV to its ratio box output. Using arbitrary levels, insure that DPAV operates in normal voltmeter modes (Inphase, Quadrature, Total, and Phase Angle).

D.5.3 ZERO Offset

a. Remove the REF input leads from the ratio box and short the REF input terminals of DPAV. Place DPAV in the Inphase and Ratio mode and turn the Signal input to zero.

b. Place jumper on the ratio card to ground, i.e., the calibration position.

c. Connect dc voltmeter to pin Z4-6 on the ratio card and adjust R20 for a reading of 0.0 V ±0.2 mV dc.

).5.4 Reference Gain Adjust

a. Place jumper on the ratio card into its normal operating position.

b. Set Signal and Reference ratio boxes to 1.0000 with the DPAV in AUTO and button set to ratio of 2.

c. Assure the oscillator is at center frequency of the ratio card, then adjust R38 on the ratio card for a readout of 100.00 ±0.02 on the DPAV. Use appropriate scale in ratio mode.

d. Readjust both ratio boxes to a reading of 0.5000. Observe readout and note the reading. If the reading is below 100.00 $x10^{-2}$ (for 100 or 30 V ratio reference levels) and 100.00 $x10^{-1}$ (for 10 V ratio reference levels), adjust R37 on the ratio card to above 100.00 $x10^{-2}$ by the same amount. Reset both ratio boxes to 1.00000 and adjust R38 for a readout of 100.00 ±0.02 $x10^{-2}$ (for 100 or 30 V ratio reference levels) and 100.00 ±0.02 $x10^{-1}$ (for 10 V ratio reference levels). Recheck readings as before with ratio boxes at 0.50000 and make any fine adjustments as may be necessary.

D.5.5 Overload Calibration

a. Place DPAV in Autorance, Inphase and raise the input voltage of both Signal and Reference boxes to 126 V rms ±.1%, for 100 V ratio cards; to 37.8 V rms ±.1% for 30 V ratio cards; to 12.6 V rms ±0.1% for 10 V ratio cards. Set both ratio boxes to 0.9 V.

b. Unscrew A/D converter retainers and fold up A/D converter. Locate ratio switching card attached to underside of A/D converter.

c. Set Reference input ratio box to 1.01 and rotate R4 on ratio switching card until OVERLOAD lamp goes out. Slowly rotate potentiometer R4 until OVERLOAD lamp just comes on. (R4 shown in figure D-2).

d. Return Reference input ratio box setting to 0.9. Slowly begin to reduce the Reference input while monitoring the digital readout. As the readout approaches 199.99 and proceeds to approach a theoretical 200.00, the OVERLOAD lamp must begin to light. (This function is not adjustable; if a failure exists, troubleshooting will be required.)

D.6 TROUBLESHOOTING

D.6.1 Equipment Required

- DVO 120 Weston precision oscillator or equivalent
- Krohn-Hite low power amplifier or equivalent
- Dc Fluke Model 895A or equivalent
- Ac Fluke Model 931 or equivalent
- Set of two ratio boxes

NOTE

DPAV is assumed to be operational in all modes, ranges, and phase-sensitive frequencies except for the ratiometer.

D.6.2 Initial Setup and Check

a. Place DPAV in the Inphase, ratio of 2.0 mode and apply through the ratio boxes (set at 1.00000) 10 V for a 10 V ratio unit, 30 V for a 30 V ratio unit, or 100 V for a 100 V ratio unit.

b. Remove DPAV top cover and unfasten A/D converter retainer screws. Locate ratio mode switching card attached to underside of A/D converter for future reference.

c. Monitor A/D converter TP7 with dc Fluke meter. The dc voltage at this point should be -9.50 V ±.25 V.

d. Lower the reference input ratio box setting to 0.5 in 0.1 steps. The A/D converter TP7 voltage should decrease by 0.95 V ±10 mV per step.

If the A/D converter responds correctly, the trouble is in the A/D converter and not in the ratiometer cards.

If the A/D converter TP7 voltage does not respond or is incorrect in level or change, proceed to step e.

e. Reset the Reference input ratio box to 1.0. Locate ratio card placed in one frequency card slot and monitor, with dc Fluke, TP4 (near top of card). The TP5 voltage should be -9.00 V ±.25 V dc.

D.6.3 Ratio Card Troubleshooting

a. Deenergize DPAV. Remove ratio card, and using a scope, check the J connector, in which this card was seated, for proper voltage as shown below:

Pin	Reading
7 (ENABLE)	+14.2 V ±200 mV
18	+15 V supply
10	-15 V supply
15	0 V (or approx. 0 Ω to unit ground with an ohmmeter)

b. Reinstall ratio card, energize DPAV, and reset ratio boxes to 1.00000. Set DPAV to Inphase and ratio of 2 mode.

c. Check TP1 of ratio card under test (refer to schematic) for reading of 900 mV rms. If reading is correct, check monitor TP2 for a voltage level of approximately 6.50 V rms. If reading is correct, proceed to step d.

d. Monitor Z1-12 for a square wave of the TP1 signal, switching approximately between +14 V and -14 V. Then monitor TP3, which is the chopped sine wave of TP2 (with a peak of approximately 4.7 V peak).

e. Monitor TP5 for a dc level which moves proportionately to the DPAV reference ac input. Take note of the dc voltage with the reference ratio box set at 1.00000, then set this ratio box at 0.50000 and assure the dc voltage now reads half.

f. Monitor TP4 for 9.00 V ±.25 V when the reference ratio box is set at 1.00000.

D.6.4 Ratio Switching Card Troubleshooting

a. Monitor TP2 on the ratio switching card with the dc Fluke for -9.00 V ±.25 V dc. Ripple should not exceed 1 mV. If reading is correct, the fault is in the wiring connection between the ratio switching card point E3 and the A/D converter Z29-3. If the voltage at TP2 is absent or incorrect, proceed to step b.

b. Using dc Fluke meter, monitor E5 on the ratio switching card for -9.00 V ±.25 V dc. If voltage is correct, proceed to step c. If it is absent or incorrect, there is a wiring fault between the ratio card pin 16 and the ratio switching card E5.

c. Monitor gate of Q3 with oscilloscope for +14.8 ±.2 V. If voltage is correct, Q3 and its associated components are faulty. If voltage is incorrect in polarity or level, proceed to step d.

d. Monitor collector of Q5 with oscilloscope for +150 mV ±100 mV dc. If voltage is correct, Q4 and its associated components are faulty.

For inoperative LED readouts, and with Q5 collector at a logic low (0 V ≤V ≤.25 V dc), Z13 on readout board and/or LED's are faulty.

If Q5 collector voltage is incorrect, Q5 and its associated components and/or its drive signals R1 or R1+R2 are faulty.

D.6.5 REF OVLD Fault Troubleshooting

a. Set Signal input ratio boxes to 1.0. Set the Reference input ratio box to 0.4. Use appropriate voltage levels for ratio card under test.

b. Monitor TP1 on ratio switching card (attached beneath A/D converter carriage) with oscilloscope. A pulse train should be seen between +0.1 V ±.15% to +4.5 V ±.25 V dc.

If pulse waveform is present, Q1 and its associated components are faulty; if absent, proceed to step c.

c. Monitor Z1-11 of the ratio switching card with oscilloscope. Pulses should be seen with negative excursion between +4.5 V ±.25 V dc and 0.1 V ±0.15 V dc.

If these pulses are present, Z2 is faulty; if absent, Z1 is faulty.

D.6.6 Ratio OVLD Fault Troubleshooting

a. Using power amplifier, set appropriate ratio voltage, 10 V, 30 V, or 100 V, through a ratio box set at 0.9 to the Reference terminals of DPAV. Signal channel input is unimportant.

b. Monitor anode of CR2 on ratio mode switching card with oscilloscope for -14.8 V ±.2 V dc. If a reading is correct, Q1 and its associated components are faulty. If reading is incorrect, proceed to step c.

c. While monitoring CR2 anode, ground Z3-3 with probe. CR2 anode voltage must approach +14.8 V .2 V dc. If reading is correct, R3, R4, R5 voltage divider and/or its input connections are faulty. If reading is still incorrect, Z3 is faulty.

D.7 PARTS LIST AND SCHEMATICS

Replacement Parts List: Ratio Switching Card - 783654

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C1	Capacitor, Mica 1500pf, 500V, ±5%	807363	72136	DM19FA-152J	1
C2	Capacitor, Elect. Aluminum 22μf, 16V, -0+100%	807194	24318	PCD22PB16	1
CR1	Diode	802924	07263	1N3069	5
CR2	Same as CR1				
CR3	Same as CR1				
CR4	Diode	807121	01295	1N759A	1
CR5	Same as CR1				
CR6	Same as CR1				
Q1	Transistor	806949	04713	2N4123	2
Q2	Transistor	804360	01295	2N4360	1
Q3	Transistor	803662	01295	2N3819	1
Q4	Transistor	805059	QPL	JAN 2N2906	1
Q5	Same as Q1				
R1	Resistor, Composition 5.1kΩ, 1/4W, ±5%	801397	01121	CB5125	1
R2	Resistor, Composition 43kΩ, 1/4W, ±5%	802723	01121	CB4335	1
R3	Resistor, Metal Film 14.3kΩ, 1/4W, ±5%	807475	16299	NC4 14.3K, 1/4W, 5%	1
R4	Potentiometer, 2kΩ, 20%	806910	32997	3386P-1-202	1
R5	Resistor, Metal Film 56.2kΩ, 1/8W, ±1%	807476	16299	C4 56.2K, 1/8W, 1%	1
R6	Resistor, Composition 12kΩ, 1/4W, ±5%	801721	01121	CB1235	1
R7	Resistor, Composition 10kΩ, 1/4W, ±5%	801006	01121	CB1035	1
R8	Resistor, Composition 3.9kΩ, 1/4W, ±5%	801409	01121	CB3925	1
R9	Resistor, Composition 7.5kΩ, 1/4W, ±5%	801984	01121	CB7525	2

Replacement Parts List: Ratio Switching Card - 783654 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R10	Resistor, Composition 150kΩ, 1/4W, ±5%	802757	01121	CB1545	1
R11	Resistor, Composition 51kΩ, 1/4W, ±5%	801985	01121	CB5135	3
R12	Same as R11				
R13	Same as R9				
R14	Same as R11				
R15	Resistor, Composition 160kΩ, 1/4W, ±5%	803995	01121	CB1645	1
R16	Resistor, Composition 33kΩ, 1/4W, ±5%	802259	01121	CB3335	1
XZ1,2	Socket, I.C.	807473	09922	DILB-14P-11	2
XZ3	Socket, Op Amp	805671	82110	A23-2052	1
Z1	Integrated Circuit	804883	01295	SN7400N	1
Z2	Integrated Circuit	805456	07263	9601DC	1
Z3	Operational Amplifier	806051	12040	LM741CH	1

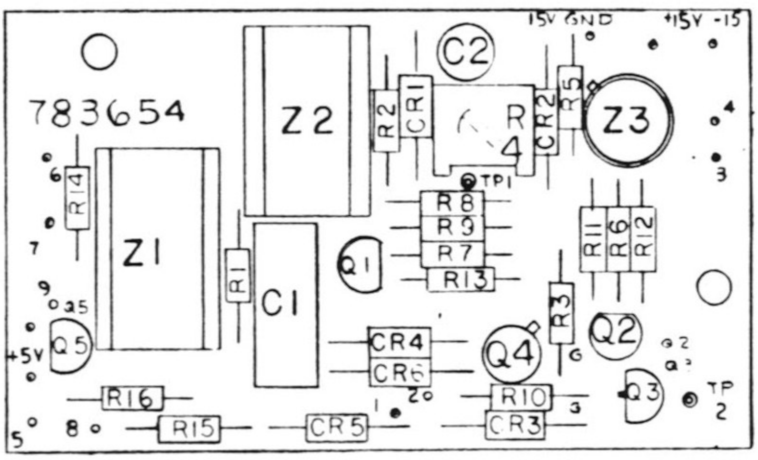


Figure D-5. Ratio Switching Card, Parts Locator

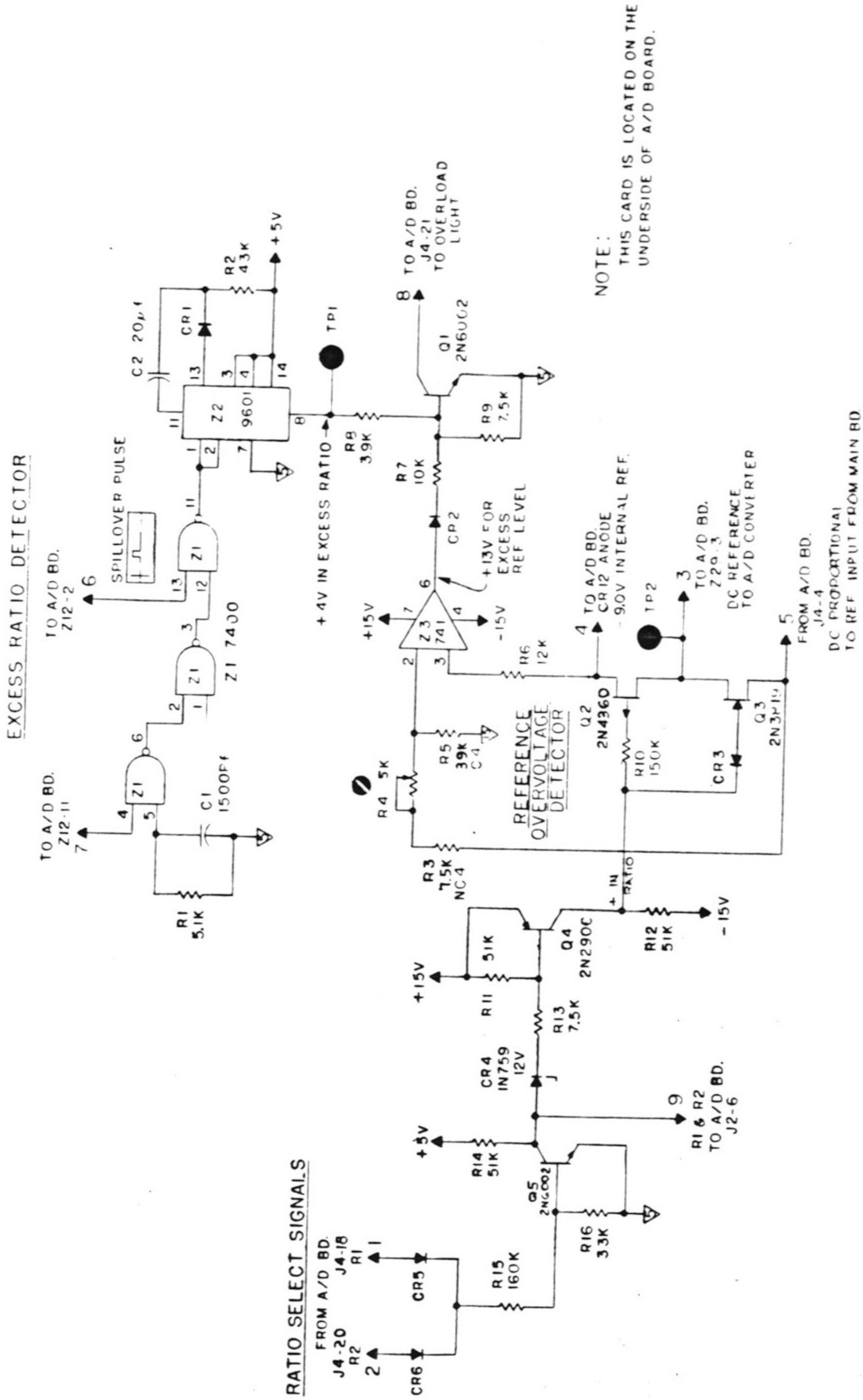


Figure D-6. Ratio Switching Card, Schematic

Replacement Parts List: Ratio Mode Reference Card (10V, 30V, 100V) - 783688, 783689, 783690

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C3	Capacitor, Ceramic .1µf, 100V, ±10%	880640		CK06BX104K	7
C5	Same as C3				
C6	Capacitor, Elect. Aluminum 10µf, 25V, -10+50%	806890	24318	PCD10PB25	2
C7	Capacitor, Ceramic 5pf, 1000V, ±.25pf	806884	72982	831-000-C0G0-509C	4
C8	Capacitor, Mica 150pf, 500V, ±5%	801365	72136	DM15-F151J	5
C11	Same as C3				
C12	Same as C3				
C13	Same as C7				
C14	Same as C8				
C15	Capacitor, Ceramic .01µf, 25V, +80-20%	880034	72982	5835-000-Y5U0103Z	4
C16	Same as C15				
C17	Same as C8				
C18	Same as C7				
C19	Same as C8				
C20	Same as C15				
C21	Same as C15				
C22	Capacitor, Polycarbonate 1µf, 50V, ±10%	806903	14752	W625B1A105K	2
C23	Capacitor, Ceramic 5000pf, 1000V, ±20%	805620	72982	811-000X5F-0201K	1
C24	Capacitor, Ceramic 200pf, 1000V, ±10%	805602	72982	831-000X5F-0201K	1
C25	Same as C22				
C26	Same as C6				
C28	Same as C3				
C29	-Same as C8				
C30	Same as C3				
C31	Same as C3				
C32	Same as C7				
CR1	Diode	802924	07263	1N3069	3
CR2	Same as CR1				

Replacement Parts List: Ratio Mode Reference Card (10V, 30V, 100V)
783688, 783689, 783690 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
CR3	Same as CR1				
CR4	Diode	806330	QPL	JAN 1N914	2
CR5	Same as CR4				
L1	Choke, 33 h	804836	76993	9230-56	2
L2	Same as L1				
Q1	Transistor	805808	01295	T1S-75	2
Q2	Same as Q1				
Q3	Transistor	808190	06001	GES6002	1
R1	Resistor, Metal Film 10kΩ, .3W, ±.1%	807176	18612	V53-1 10K, .3W, .1%	6
R2	Resistor, Composition 8.2kΩ, 1/4W, ±5%	802080	01121	CB8225	1
R3[1]	Resistor, Metal Film 210kΩ, .3W, ±.1%	808027	75042	MAR 3 210K, .3W, .1%	1
R3[2]	Resistor, Metal Film 69.8kΩ, .3W, ±.1%	808026	75042	MAR 3 69.8K, .3W, .1%	1
R3[3]	Resistor, Metal Film 21kΩ, .3W, ±.1%	808024	75042	MAR 3 21K, .3W, .1%	1
R9	Resistor, Composition 5.1kΩ, 1/4W, ±5%	801397	01121	CB5125	2
R10	Same as R1				
R11	Same as R9				
R12	Same as R1				
R13	Same as R1				
R14	Resistor, Metal Film 40kΩ, .3W, ±.1%	806933	18612	V53-1 40K, .3W, .1%	1
R15	Resistor, Metal Film 20kΩ, .3W, ±.1%	806919	75042	MAR-5 20K, .3W, .1%	3
R16	Same as R1				
R17	Same as R15				
R18	Resistor, Metal Film 100Ω, 1/4W, ±2%	803404	16299	C07 100Ω, 1/4W, 2%	1
R19	Resistor, Metal Film 150kΩ, 1/4W, ±2%	806239	16299	C07 150K, 1/4W, 2%	2

[1] 10V reference
[2] 30V reference
[3] 100V reference

Replacement Parts List: Ratio Mode Reference Card (10V, 30V, 100V)
783688, 783689, 783690 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R20	Resistor, Pot. 50kΩ	807251	32997	3299X-50K	2
R21	Resistor, Metal Film 10kΩ, 1/4W, ±2%	803386	16299	RL07 10K, 1/4W, 2%	2
R22	Resistor, Metal Film 1 MΩ, 1/4W, ±2%	805142	16299	C07 1 Meg, 1/4W, 2%	1
R23	Resistor, Metal Film 75kΩ, .3W, ±.1%	806920	18612	V53-1 75K, .3W, .1%	
R24	Resistor, Composition 10Ω, 1/4W, ±5%	803784	01121	CB1005	1
R25	Same as R23				
R26	Resistor, Metal Film 130kΩ, 1/4W, ±2%	806489	16299	C07 130K, 1/4W, 2%	1
R27	Resistor, Composition 2kΩ, 1/4W, ±5%	801094	01121	CB2025	2
R28	Resistor, Composition 1kΩ, 1/4W, ±5%	801004	01121	CB1025	1
R29	Same as R27				
R30	Resistor, Composition 10kΩ, 1/4W, ±5%	801006	01121	CB1035	2
R31	Same as R30				
R32	Resistor, Composition 1.5kΩ, 1/4W, ±5%	802232	01121	CB1525	1
R33	Resistor, Metal Film 56.2kΩ, 1/8W, ±1%	807476	16299	NC4 56.2k, 1/8W, 1%	1
R34	Same as R1				
R35	Same as R15				
R36	Same as R21				
R38	Resistor, Pot. 10kΩ	807507	32997	3299X-1-103	1
R39	Same as R23				
R40	Resistor, Metal Film 270.5kΩ, ±.1%	806197	11880	RB-71 270.5K, .1%	1
R41	Same as R19				
R42	Resistor, Metal Film 200Ω, 1/8W, ±2%	806543	16299	NC4 200Ω, 1/8W, 2%	1
R43	Resistor, Metal Film 6.2kΩ, 1/4W, ±2%	806661	16299	C07 6.2K, 1/4W, 2%	1
Z1	Operational Amplifier 301A Selected	807478			4

Replacement Parts List: Ratio Mode Reference Card (10V, 30V, 100V)
783688, 783689, 783690 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
Z2	Operational Amplifier	807428	12040	LM318H	1
Z3	Same as Z1				
Z4	Same as Z1				
Z5	Integrated Circuit	804749	04713	MC1437L	1
Z6	Same as Z1				

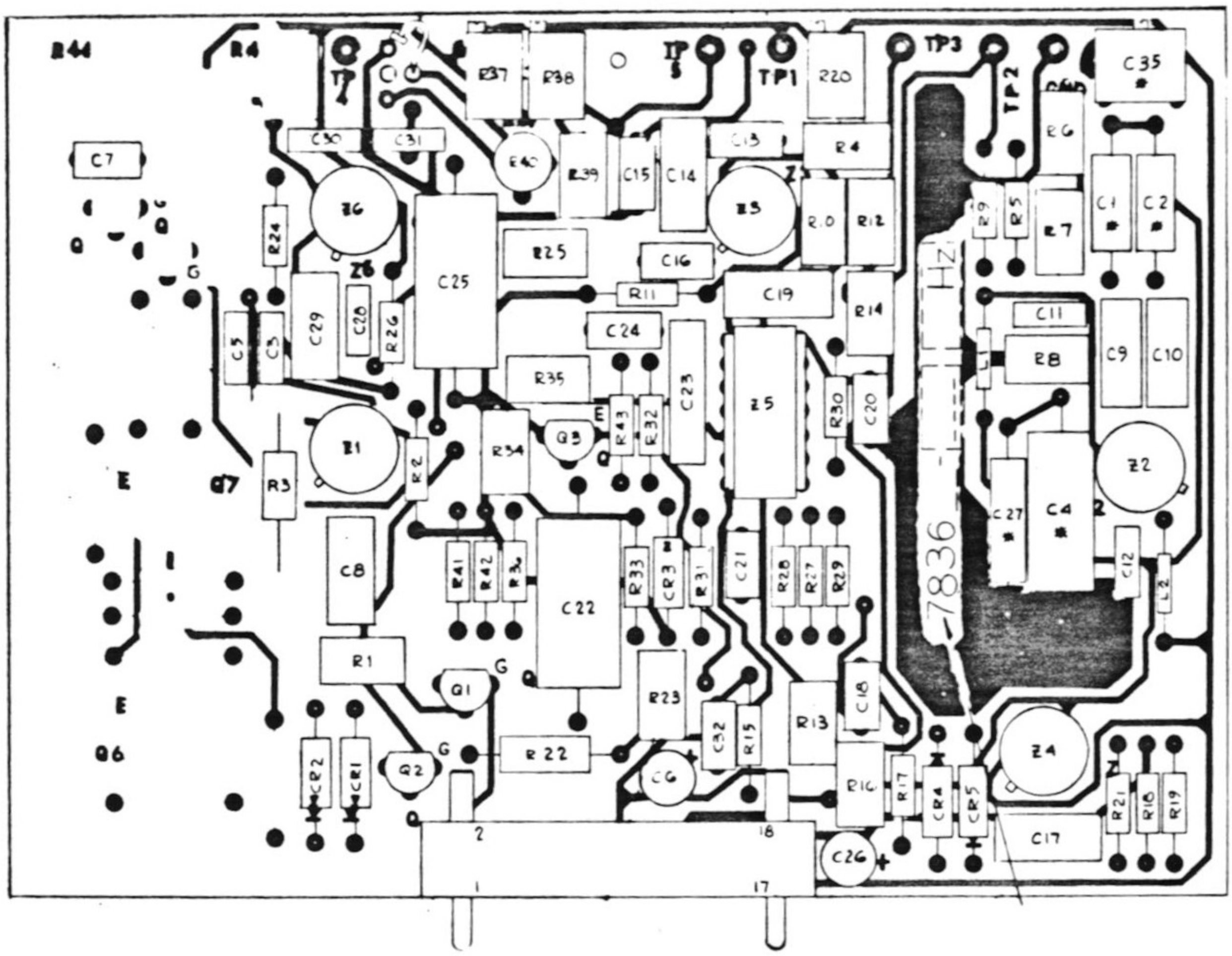
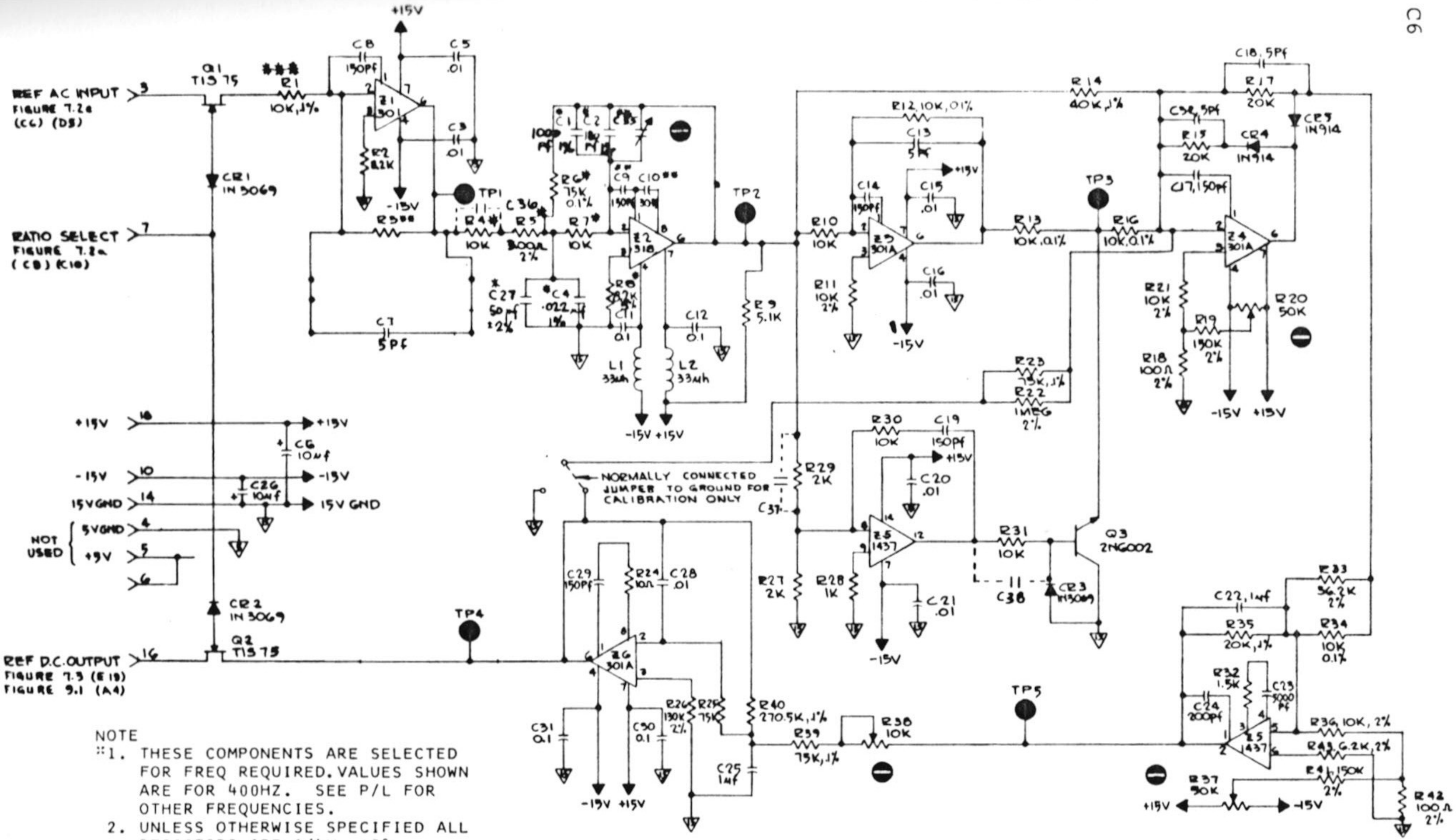


Figure D-7. Ratio Mode Reference Card, Parts Locator

Replacement Parts List: Readout Board - 783590 (Add to standard Readout Board)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R25	Resistor, Composition 200Ω, 1/4W, ±5%	802226	01121	CB2015	1
XZ15	I.C. Socket 14-pin	807473	09922	DILB-14P-11	1
Z15	Integrated Circuit	804344	07263	936DC	1



NOTE

*1. THESE COMPONENTS ARE SELECTED FOR FREQ REQUIRED. VALUES SHOWN ARE FOR 400HZ. SEE P/L FOR OTHER FREQUENCIES.

2. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/4W, ±5%.

3. ALPHA-NUMERIC DESIGNATIONS AFTER FIGURE NUMBER AND IN ( ) ARE ZONE LOCATIONS.

**4. ALL POSSIBLE COMPONENTS ARE SHOWN, SEE PARTS LIST FOR USAGE.

***5. R-1 IS EITHER SERIES OR SHUNTED WITH ANOTHER RESISTOR DURING TEST, TO GIVE A 9.50 VOLT D.C. LEVEL AT TP4 WITH R38 AT ITS MIDPOINT.

Figure D-8. Ratio Mode Reference Card, Schematic

APPENDIX E

REAR SIGNAL AND REFERENCE CONNECTORS (MS)

Signal and reference input terminals are connected in parallel to pins A and C of connectors on rear panel. Use of the jumper on front terminals will duplicate connections of rear connector. The rear connector is MS3102A-10SL-3P. (Its' mating connector is MS3106A-10SL-3S.) Connections are as follows:

Signal

Front Terminal	Rear Connector
Hi	A
Lo	C
Gnd	B

Reference

Front Terminal	Rear Connector
Hi	A
Lo	C

APPENDIX F

VARIABLE SCALE ADJUST (VSA)

F.1 THEORY OF OPERATION

The variable scale adjust option permits the operator to vary the signal channel level (8.75 V dc going to the A/D converter) when operating the unit in the Inphase mode. When operating the DPAV in the Quadrature mode, the variable scale adjust has no affect.

The VSA is enabled in the local mode by push button switch S1. The resulting logic 1 (thru Z2 and Z3 gating) at pin 6 of Z3 enables the VSA. A logic 0 at this point disables the VSA. This logic level is fed into Z1A op amp which is configured as a basic differential input comparator. When the input is at logic 1, the op amp goes into positive saturation and when it is logic 0 it goes into negative saturation. When the VSA is enabled (push button depressed) and Z1A is at positive saturation, Q2 FET switch conducts and Q1 FET switch is open; thereby actuating R6 variable potentiometer located on the front panel. This potentiometer varies the signal channel dc voltage going into Z1B op amp. Z1B is configured as a voltage follower and the resultant output is a dc level proportional to the potentiometer setting when the VSA is disabled (push button OUT depressed). Z1A goes into negative saturation, thereby causing FET switch Q1 to conduct and FET switch Q2 to shut off. The voltage follower output is the same as the input because R6 potentiometer is out of the circuit.

The VSA is disabled in Total, Fundamental, and Phase Angle modes. This is accomplished thru Z3. If any of the above modes are selected, Z3 output goes to a logic 0, thereby disabling the VSA.

When in the Remote mode the VSA enable and disable can be programmed externally through the remote control digital output board J1-10. Potentiometer R6, located on the front panel, must always be manually operated. IEEE VSA control lines are designated J1-1 and J1-2 on the VSA PC board.

F.2 TEST AND ADJUSTMENT

a. Use the DPAV in the main board frequency VM mode with its signal input connected to an inverting ratio box (NAI Model 504, or equivalent).

b. Place the DPAV in the Inphase mode, 1 V scale and set the ratio box output to 0 V rms. Check and readjust, if necessary, R93 on main board for 0 V ±0.2 mV at TP8. Set VSA IN/OUT switch to OUT. Turn VSA front panel control fully cw, being careful not to force it past its internal end stops. Connect test lead to A/D converter TP13 or TP1 on VSA board (use main board TP9 GND for VSA TP1) and adjust R3 on VSA for 0 V ±0.2 mV dc. Set VSA IN/OUT switch to IN and check that the previou[s] adjustment has not changed more than 0.2 mV dc. Set VSA IN/OUT switch to OUT.

c. With the DPAV in the Inphase mode, 1 V range, and + and -1.18 V applied, note the readings. Set the VSA IN/OUT switc[h] to IN and VSA front panel control fully clockwise. The readings should be the same respectively ±2 LSD. Check that the reading can be adjusted to within 25 LSD's at the 25, 50, and 75% of full scale points with ±1 V applied.

d. The VSA is disabled in Total, Fundamental, and Phase Angle modes. To check this, apply +1 V rms to the signal channel in the Inphase mode. Set the VSA IN/OUT switch to IN and adjust the front panel control to read 0.5 V inphase. Check that the readout returns to its proper full scale reading in Total and Fundamental mode. Set VSA IN/OUT switch to OUT and place unit in Phase Angle mode. Set REF OFFSET switc[h] to IN and adjust variable offset contro[l] for a reading of 45.0°. Set VSA IN/OUT switch to IN. Reading should stay at 45° for Phase Angle and 315.0° for Ref Phase. Return unit to Inphase, VSA out, and REF OFFSET out.

e. If Remote Control (Option 03) is included, repeat step c except progra VSA externally by grounding pin 10 J1 on the remote control board.

F.3 PARTS LIST AND SCHEMATIC

Replacement Parts List: Variable Scale Adjust - 786707

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Tc Q
C1	Capacitor, Mica 100pf, 500V, ±5%	801264	72136	DM15-E101J	
C2	Same as C1				
C3	Capacitor, Ceramic 0.1µf, 25V, +80-20%	806086	72982	5815-000Y5U0-104Z	
C4	Same as C3				
C5	Same as C3				
CR1	Diode	802924	07263	1N3069	:
CR2	Same as CR1				
Q1	Transistor	884661	04713	2N5465	1
Q2	Transistor	807505	01295	TIS 75	1
R1	Resistor, Composition 5.6kΩ, 1/4W, ±5%	801983	01121	CB5625	1
R2	Resistor, Composition 51kΩ, 1/4W, ±5%	801985	01121	CB5135	1
R3	Potentiometer, Trim. 50kΩ	806911	32997	3299W503	1
R4	Resistor, Composition 10kΩ, 1/4W, ±5%	801006	01121	CB1035	2
R5	Same as R4				
R6	Potentiometer, Wirewound 10K	884880	02111	162-284	1
S1	Switch	807203	07342	807203	1
XZ1	Socket, I.C.	807473	09922	DILB-14F-11	3
XZ2	Same as XZ1				
XZ3	Same as XZ1				
Z1	Integrated Circuit, Linear	807754	04713	MC1747CL	1
Z2	Integrated Circuit, TTL	804883	01295	SN7400N	1
Z3	Integrated Circuit, DTL	805807	07263	962DC	1

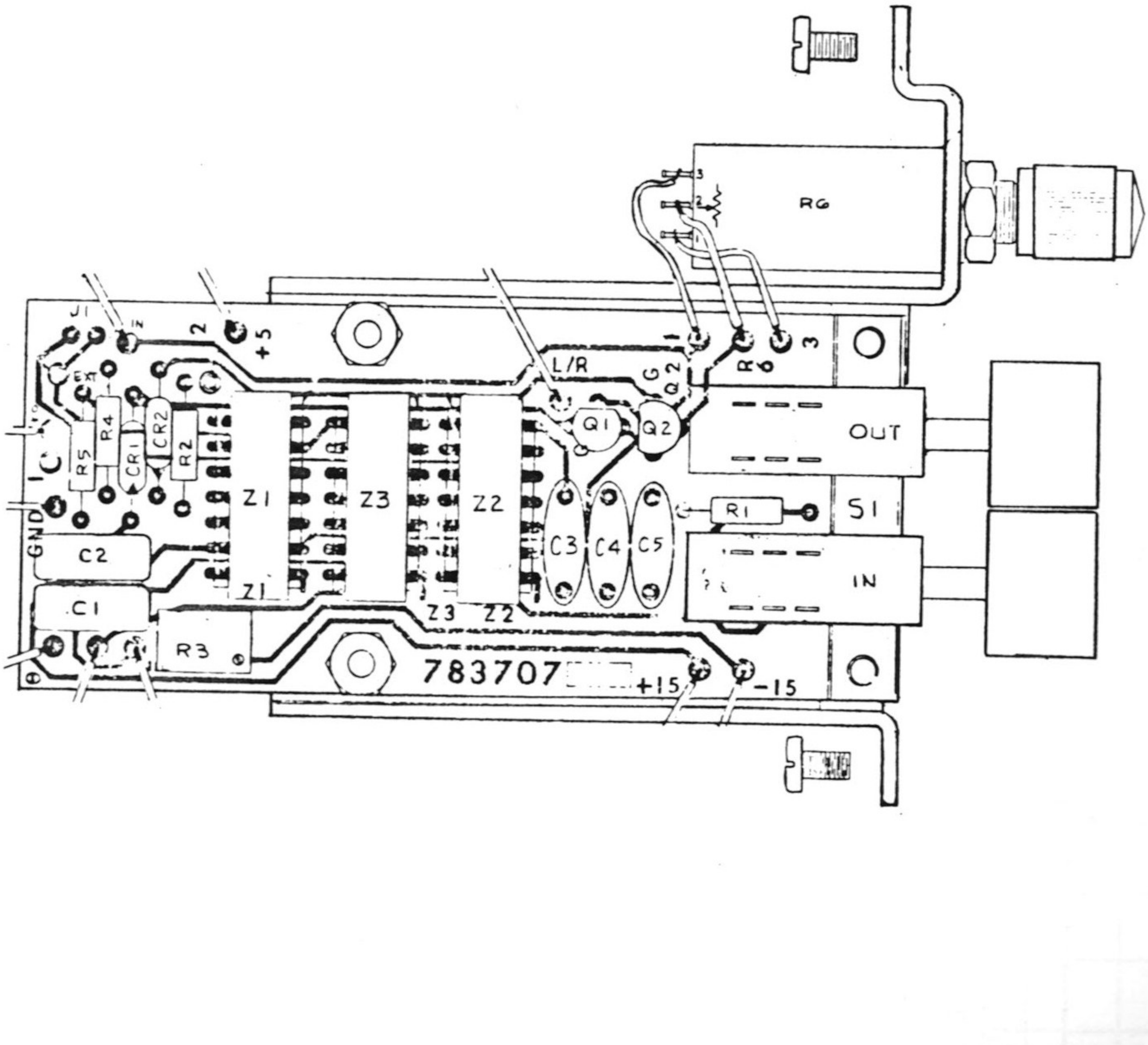


Figure F-1. Variable Scale Adjust, Parts Locator

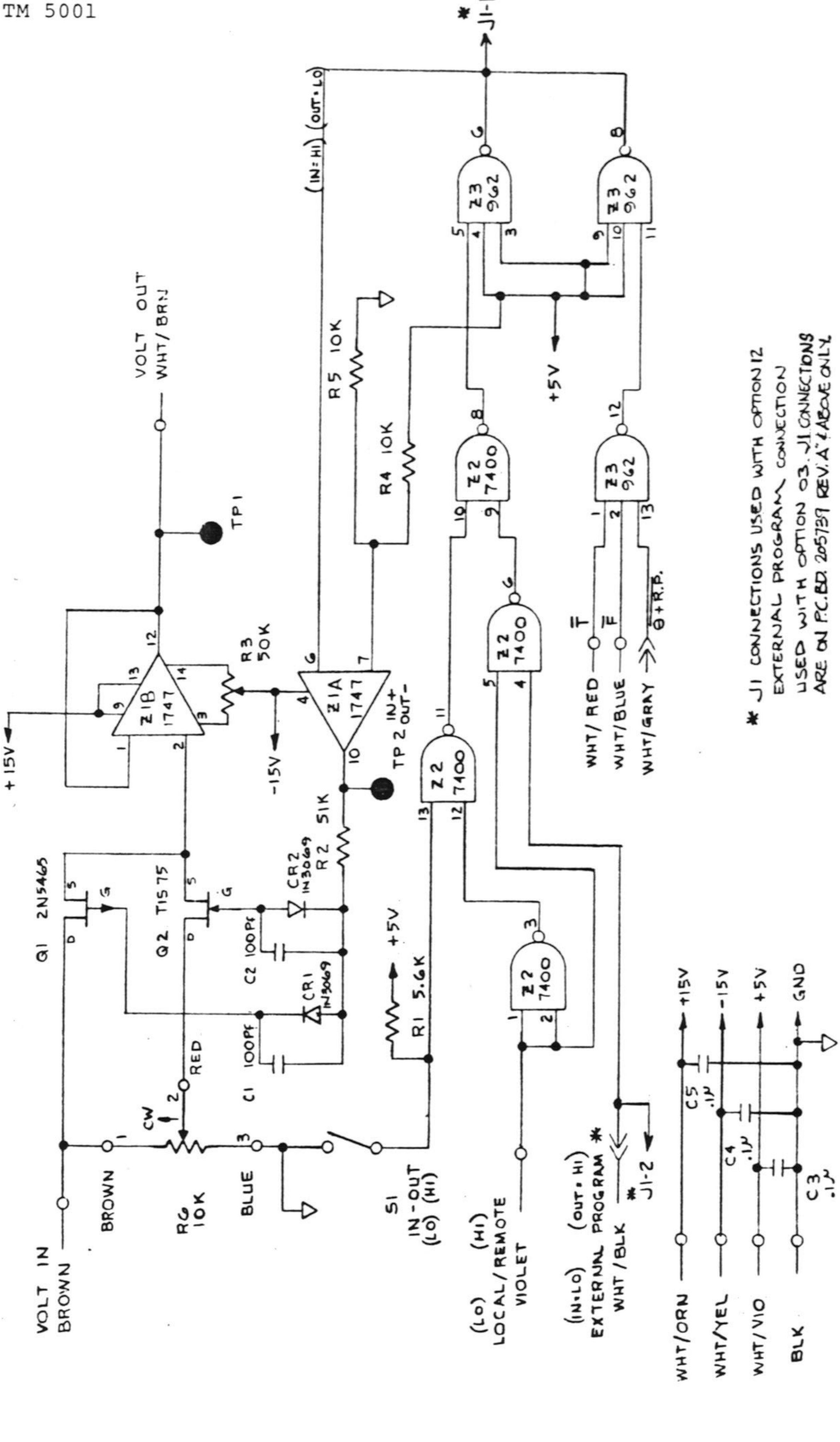


Figure F-2. Variable Scale Adjust, Schematic

APPENDIX G

MANUAL CHANGE DATA

G.1 INTRODUCTION

This appendix contains information necessary to backdate the manual to conform with earlier assembly configurations. To identify the configuration of the assembly used in your unit, refer to the revision letter on the solder side of each assembly. Table G-1 defines the assembly revision levels documented in this manual with an X.

G.2 NEWER UNITS

As changes and improvements are made to the unit they are identified by incrementing the revision letter or number marked on the affected assembly. These changes are documented on a Product Revision Sheet which, when applicable, is inserted at the front of the manual.

G.3 OLDER UNITS

To backdate this manual to conform with earlier assembly revision levels, perform the changes indicated in table G-1 in descending order.

Table G-1. Manual Status and Backdating Information

Assembly Name	NAI Part No.	To adapt manual to earlier rev configurations perform change numbers in descending order (by no.), ending with change under desired rev letter.															
		A	B	B1	C	E	F	G	J	K	KT	KT2	L	L1	T	U	W2
Main Board	500869										6	X					1
Readout Board	783590					4										X	
A/D Converter	783591						X										
Reference Isolation	783601-2									X							
Signal Broadband Isolation	783602-2							X									
Null Meter	783672	X															
Frequency Board	783599												5	X			
Remote Control/ Digital Output	783603				2										X		
IEEE Interface (Prime Board)	783777-03		3	X													
IEEE Interface (Expansion Board)	783778								X								
Ratio Switching	783654		X														
	783688				X												
Ratio Mode Ref.	783689					X											
	783690					X											
Variable Scale Adj.	783707		X														

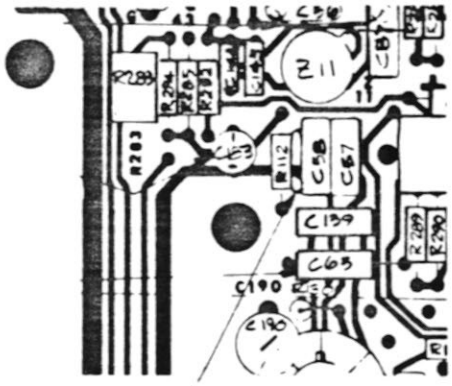
X = the assembly revision levels documented in this manual.
Numbers represent changes described in the following pages.

CHANGE 1 - MAIN BOARD (PCR 21699)

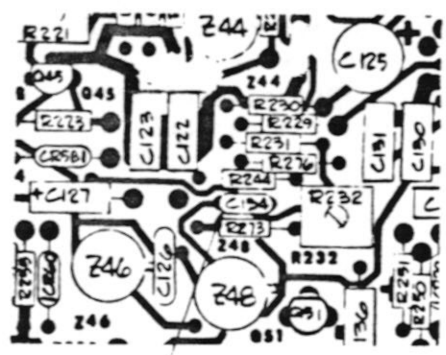
1. Remove C193 (NAI P/N 807459) from the main board parts list.

2. Change Z48 from NAI P/N 808145 to NAI P/N 804069.

3. Remove C193 from figure 7-1 (sh 1 of 4) and reorient C134 in figure 7-1 (sh 3 of 4)

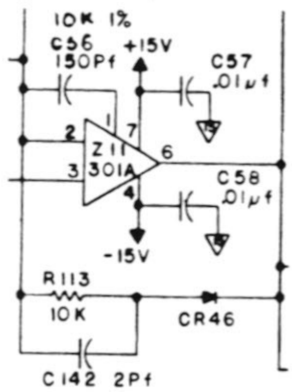


C193 (REMOVE)

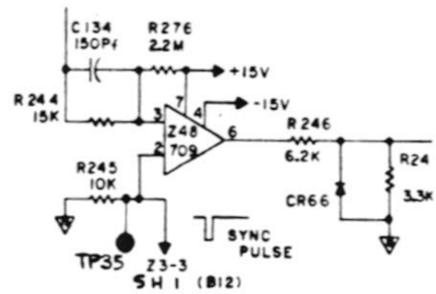


C134

4. Change figure 8-2, sheet 2 of 7 and sheet 5 of 7 to the configurations shown below:



SH 2 OF 7



SH 5 OF 7

CHANGE 2 - REMOTE CONTROL DIGITAL BOARD 783603 (PCR 22283)

In the remote control digital board parts list (Appendix B) change Q1 and Q2 from NAI P/N 808190 to NAI P/N 806949.

CHANGE 3 - IEEE INTERFACE 783777-03 (PCR 22470)

1. In the IEEE interface board parts list, change U23 from NAI P/N 885068-1 to NAI P/N 884781 and U24 from NAI P/N 885068-2 to NAI P/N 884782.

2. Delete the following note from figure C-7.

NOTE

WHEN REPLACING U23 or U24, INSTALL PROM MARKED 885068-1 INTO U23 POSITION AND 885068-2 INTO U24 POSITION.

CHANGE 4 - READOUT BOARD 783590 (PCR 22497)

In the readout board parts list, change XZ1 through XZ12 from NAI P/N 808197 to NAI P/N 807474.

CHANGE 5 - FREQUENCY BOARD 783599 (PCR 22552)

1. In the frequency board parts list, change Q12 from NAI P/N 882779 to NAI P/N 884661 (2N5465).

2. In figure 7-7, change orientation and shape of Q12 to 

3. In figure 8-4, change Q12 from 2N5116 to 2N5465.

CHANGE 6 - MAIN BOARD 500869 (PCR 22551)

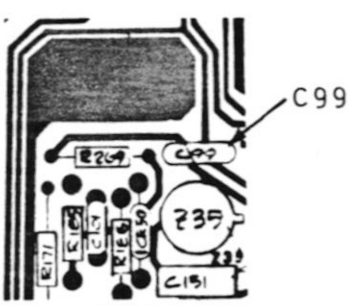
1. Add the following components to the main board parts list.

Ref. Des.	Description	NAI P/N	Code	MFR P/N
C99	Capacitor, Ceramic 150pf, 1000V, ±10%	806883	72982	831-000X5F0151K
Q20	Transistor	808190	06001	GES 6002
R270	Resistor, Composition 15kΩ, 1/4W, ±5%	801988	01121	CB1535
R278	Resistor, Composition 150kΩ, 1/4W, ±5%	802757	01121	CB1545

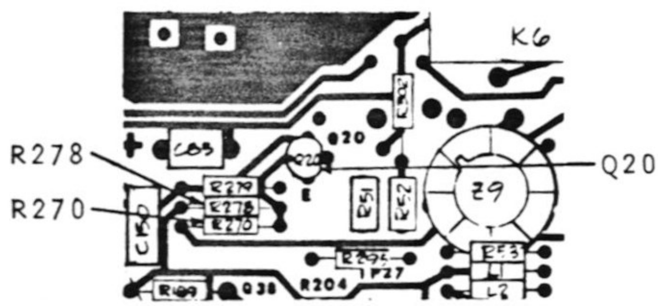
2. On the main board parts list, change the following components:

Ref.	New NAI P/N	Old NAI P/N
Z62	808145 (LF357H)	885101
Z35	806347 (LM301AH)	885122
R279	801636 (20KΩ)	803784
R187	802193 (75KΩ)	801636
R308	805916 (86.6KΩ)	805911
Q34	884661 (2N5465)	882779

3. Add C99 to figure 7-1, sheet 1 and R270, R278 and Q20 to figure 7-1, sheet 2.



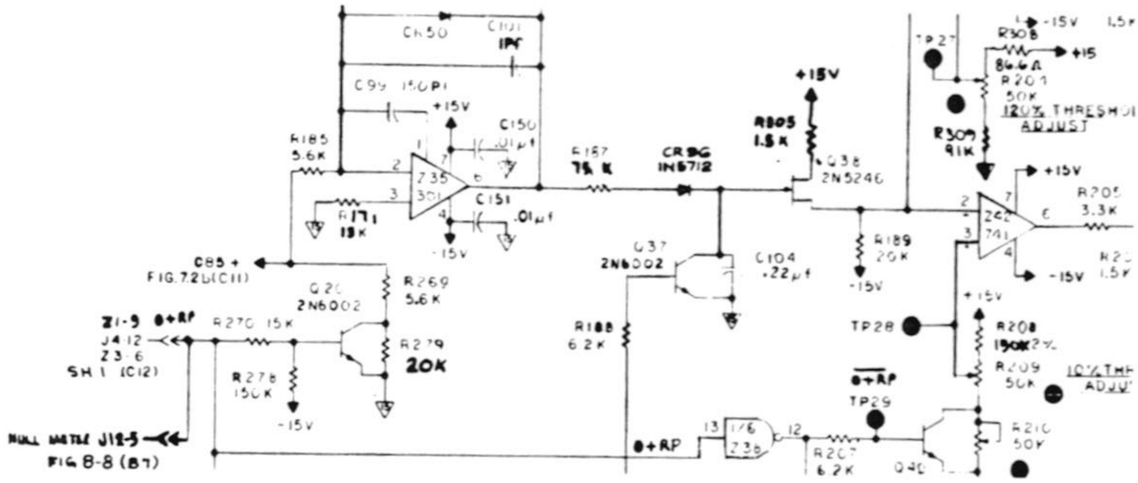
SH 1



SH2

4. In figure 8-2 (sheet 2), change Z62 to LF357H.

5. In figure 8-2 (sheet 4), add Q20, C99, R270, and R278. Also change Z35, R187, and R308 as shown below:



6. In figure 8-2 (sheet 5), change Q34 to 2N5116.

7. Change the 5th line in paragrpah 5.8.9.2 from 0.333Vrms to 0.3Vrms.

WARRANTY

A. The Seller warrants Products against defects in material and workmanship for one year from the date of original shipment. The Seller's liability is limited to the repair or replacement of Products which prove to be defective during the Warranty period. There is no charge under the Warranty except for transportation charges. The Purchaser shall be responsible for Products shipped until received by the Seller.

B. The Seller specifically excludes from the Warranty 1) calibration, 2) fuses, and 3) normal mechanical wear, e.g.; end-of-life on assemblies such as switches, relays, gear trains, etc. is dependent upon number of operations or hours of use, and end-of-life may occur within the Warranty period.

C. The Seller is not liable for consequential damages or for any injury or damage to persons or property resulting from the operation or application of Products.

D. The Warranty is voided if there is evidence that Products have been operated beyond their design range, improperly installed, improperly maintained or physically mistreated.

E. The Seller reserves the right to make changes and improvements to Products without any liability for incorporating such changes or improvements in any Products previously sold, or for any notification to the Purchaser prior to shipment. In the event the Purchaser should require subsequently manufactured lots to be identical to those covered by this Quotation, the Seller will, upon written request, provide a quotation upon a change control program.

F. No other Warranty expressed or implied is offered by the Seller other than the foregoing.

CLAIMS FOR DAMAGE IN SHIPMENT

The purchaser should inspect and functionally test the Product(s) in accordance with the instruction manual as soon as it is received. If the product is damaged in any way, including concealed damage, a claim should be filed immediately with the carrier, or if insured separately, with the purchaser's insurance company.

SHIPPING

On products to be returned under warranty, await receipt of shipping instructions, then forward the instrument prepaid to the destination indicated. The original shipping containers with their appropriate blocking and isolating material is the preferred method of packaging. Any other suitably strong container may be used providing the product is wrapped in a sealed plastic bag and surrounded with at least four inches of shock absorbing material to cushion firmly, preventing movement inside the container.

RESOLVER/SYNCHRO SIMULATORS & BRIDGES

Model 5310
Programmable Resolver/Synchro Simulator

The Model 5310 can be used as a bench-top Resolver/Synchro Simulator or as a completely programmable device for ATE systems. Designed to drive control-type synchros and resolvers, typical applications include production testing, simulation systems and general purpose automatic synchro/resolver testing. The 5310 replaces the previous series 538 Digital to Resolver/Synchro Converters.

Contained within the same compact package size as our popular series 8310 and 8810 Angle Position Indicators, the 5310 features fully isolated inputs and outputs and is protected against accidental short circuits and overloads on the output and overvoltage and transients on the power line input.

Standard features include full remote programmability for line-to-line level, reference levels, synchro or resolver mode and output angle. Remote control is parallel BCD or binary bussable tri-state; IEEE-488-1978 GPIB is available. The 5310 also has full front-panel controls for manual operation.

The 5310 has been designed using state-of-the-art technology with reliability and maintainability as major considerations. Serviceability is enhanced by the wide use of IC sockets.

Featuring 18 bit resolution, 3.0 VA output and 36 arc-second accuracy, the 5310 is ideally suited for many commercial and military applications.

Model 540/10
Resolver/Synchro Bridge

This bridge permits direct measurement of resolver and synchro transmitters. It features a constant null gradient output voltage, isolated input and output, and input impedance over 500K. The Model 540/10 features 2 arc-second accuracy at 400Hz and is useful up to 10kHz.

Model 540/20
Broadband Resolver/Synchro Bridge

The Model 540/20 features 10 arc-second accuracy over most of the frequency band from 55Hz to 10kHz. Also featured is a constant null gradient voltage which permits deviation measurements by using a Phase Angle Voltmeter as the null detector.

Series 530
Resolver/Synchro Simulator

This simulator provides the ideal outputs for driving resolvers and synchros at 11.8, 26, 90 and 115V line-line voltages. These line-line voltages are all available with either 26V or 115V, 400Hz excitation, and feature isolated input and output. Accuracy is 2 arc-seconds. Resolution is .0001°, with standard units 3½″ full rack panel.

Model 530/20
Broadband Resolver/Synchro Simulator

The Model 530/20 features 10 arc-second accuracy at 60Hz, 400Hz, and 800Hz, and 20 arc-second accuracy at 10kHz. It is useable over the entire frequency band from 50Hz to 10kHz. This broadband frequency characteristic makes it an ideal instrument for test facilities desiring the maximum capability in each instrument.

Model 532
Low-Cost Synchro Simulator

Model 532 is a miniature synchro simulator offering precision performance in a small panel-mounted unit suitable for production test, ground support and similar systems. Direct simulation of 11.8V 400Hz line-line synchro transmitters (CX) is provided, with dial reading in 30° segments plus 5° increments selectable by sealed thumbwheel switches and accurate to 30 arc-seconds.

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NO. 121 ANGLE-SENSING TRANSDUCERS FOR SHAFT-TO-DIGITAL CONVERSION

SALES OFFICES

North Atlantic Sales Engineering Representatives are located in principal cities throughout the world. These representatives are available for consultation, can provide engineering data on any of the North Atlantic products, or prepare technical and cost proposals for special requirements on computer interface equipment, phase sensitive instrumentation, resolver/synchro instrumentation and automatic test equipment. To locate the Sales Engineering Representative serving your area, please consult the current editions of EEM (Electronic Engineers Master), or contact our Sales Department.

SERVICE CENTERS

Factory service is available at authorized Service Centers in:

LOS ANGELES, CA
MINNEAPOLIS, MN
HAUPPAUGE, NY
LONDON, ENGLAND
MUNICH, GERMANY
PARIS, FRANCE
TEL AVIV, ISRAEL
TOKYO, JAPAN

north atlantic
INSTRUMENT DIVISION
60 Plant Avenue, Hauppauge, NY 11788-3890
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