Serial No. _____

INSTRUCTION MANUAL

MODEL 750
PHASE METER

WAVETEK
Box 651, San Diego, Calif., 714-279-2200

4R-1/74

WARRANTY

All Wavetek instruments are warranteed against defects in material and workmanship for a period of one year after date of manufacture. Wavetek agrees to repair or replace any assembly or component (except batteries) found to be defective, under normal use, during this period. Wavetek's obligation under this warranty is limited solely to repairing any such instrument which in Wavetek's sole opinion proves to be defective within the scope of the warranty when returned to the factory or to an authorized service center. Transportation to the factory or service center is to be prepaid by purchaser. Shipment should not be made without prior authorization by Wavetek.

This warranty does not apply to any products repaired or altered by persons not authorized by Wavetek, or not in accordance with instructions furnished by Wavetek. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, repairs will be billed at cost.

Wavetek assumes no responsibility for its product being used in a hazardous or dangerous manner either alone or in conjunction with other equipment. High voltage used in some instruments may be dangerous if misused. Special disclaimers apply to these instruments. Wavetek assumes no liability for secondary charges or consequential damages and, in any event, Wavetek's liability for breach of warranty under any contract or otherwise, shall not exceed the purchase price of the specific instrument shipped and against which a claim is made.

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Figure i. Model 750 Phase Meter

SCOPE OF THIS MANUAL

This manual provides descriptive material and instructions for the installation, operation, maintenance, and repair of the WAVETEK Model 750 Phase Meter.

Product Improvement Notice

Wavetek maintains a continuing program to make improvements to their instruments that will take advantage of the latest electronic developments in circuitry and components.

Due to the time required to document and print instruction manuals, it is not always possible to incorporate these changes in the manual.

Wavetek has manufactured your instrument, using metal film 1% tolerance resistors in place of 5% carbon resistors, wherever practical. This results in a substantial improvement in the overall performance of your instrument. Therefore, there may exist a discrepancy between the resistor used to manufacture your instrument and the resistor called out in the Parts List and Schematic Diagrams in this manual.

If field replacement of an affected resistor does become necessary, replacement may be made in accordance with the manual call outs. Wavetek, however, recommends replacement with the same type of resistor used in the manufacture of your instrument, whenever possible.

SECTION 1
INTRODUCTION

1.1 PURPOSE OF THE EQUIPMENT

The Wavetek Model 750 Phase Meter has been designed to accurately measure the phase angle between any two ac signals (with amplitudes between 1 mV and 300 V) within the 10 Hz to 2 MHz range. A precision wide band bench instrument, the Model 750 uses a unique circuit design which permits accurate phase angle measurements with input signals having high even harmonic distortion. A four-digit readout is used to display, in degrees and tenths of degrees, the phase angle being measured.

Two ranges, 0°/360° and −180°/+180°, assure continuous phase data without discontinuity at 0 and 180 degrees. High impedance differential inputs are used; and a dc OUTPUT −10 mV/DEG is provided for use in recording phase angle measurements, or as a control signal for phase lock loops or servo systems.

The automatic operation of this instrument eliminates the need for amplitude matching, frequency tuning, and output filtering, resulting in true hands-off operation.

1.2 GENERAL PHYSICAL DESCRIPTION

Weighing approximately 9 pounds (4.1 kg) net and 13 pounds (5.9 kg) when shipped, the Model 750 is 8½ inches (21.6 cm) wide, 5¼ inches (13.7 cm) high, and 11 inches (27.9 cm) deep. Housed in a compact, ruggedized, portable case, the Model 750 is normally shipped with a 10-foot, 3-wire, detachable line cord and one copy of this instruction manual.

1.3 SPECIFICATIONS

1.3.1 Power Requirements

105-130 Vac or 200-250 Vac, 50-400 Hz, less than 25 W, single phase.

1.3.2 Input Signals

Frequency Range . . . . . 10 Hz to 2 MHz

OVERVOLTAGE LIMITS

Amplitude Ranges	AC Limit	Maximum Peak (AC + DC Limit)
.001-2 VOLTS RMS . .	50 V RMS . . .	100 VOLTS
.300-300 VOLTS RMS .	330 V RMS . . .	500 VOLTS

Input Impedance

Single-Ended Inputs . . . . . 1 MΩ, shunted by 30 pF
Differential Inputs . . . . . 2 MΩ, shunted by 20 pF

Common Mode Rejection

10 Hz to 100 kHz . . . . . Greater than 50 dB
100 kHz to 2 MHz . . . . . Greater than 40 dB

1.3.3 Output Signals

OUTPUT −10 mV/DEG (Standard)

Amplitude, 0°/360° Range . . . . . 0 Vdc to −3.600 Vdc
Amplitude, −180°/+180° Range . . +1.8 Vdc to −1.8 Vdc
Output Impedance . . . . . 1 kΩ

1.3.4 Accuracy

Absolute Calibration Accuracy

20 Hz to 20 kHz square wave, 100 mV to 5 V p-p . . . ±0.1°

Frequency Effect on Accuracy (100% of Range Sine Wave Inputs)

20 Hz to 20 kHz . . . . . Calibration Accuracy ±.2°
Zero Offset, 10 Hz to 10 kHz . . . . . Less than 0.1°
Zero Offset, 10 kHz to 100 kHz . . Less than 0.1°/10 kHz
Relative Accuracy, 100 kHz to 2 MHz . . . . Better than 2°

NOTE

The term relative accuracy means the accuracy of difference in phase reading from one condition to another. For example, it is the accuracy of 1) repeatability, 2) comparison of readings among unknown signals with respect to a given signal, 3) phase deviation of input without regard to zero offset.

Amplitude Effect on Accuracy (Equal Level Inputs)

Less than 1.5° for 60 dB change on both inputs.
NOTE: Minimum sensitivity below 20 Hz and above 50 kHz is 1% of amplitude range.

Phase Angle Resolution . . . . . 0.1°

Phase Angle Drift . . . . . Less than .3° for 100 hrs.

Response Time (Full Scale Change) . . Less than 4 seconds

NOTES

1. *Phase angle measurements within 2° of the RANGE limits should be avoided; allow ±5° for frequencies below 50 Hz.*
2. *For frequencies above 20 kHz, both VOLTS RMS switches should be set to the same range to eliminate attenuator phase delay.*
3. *For operation at higher voltages, the instrument is designed for use with Tektronix or Hewlett Packard 10X probes.*

1.3.5 Mechanical Characteristics

Dimensions and Weight

Width	8-½ inches (21.6 cm)
Height	5-¼ inches (13.7 cm)
Depth	11 inches (27.9 cm)
Weight (Net)	9 pounds (4.1 kg)
Weight (Shipping)	13 pounds (5.9 kg)

Connector Types

Inputs . . . . . 3 Binding Posts, 3/4-inch spacing
Outputs . . . . . 2 Binding Posts, 3/4-inch spacing

1.3.6 Environmental Characteristics

Recommended Warmup 1/2-hour

Operating Temperature Range . . . . . 25°C (±5°C)

1.4 ACCESSORIES AND ASSOCIATED EQUIPMENT

The Model 750 is normally shipped with a 10-foot, 3-wire, detachable line cord and a copy of this instruction manual. The items listed below are compatible accessories and associated equipment which may be helpful in the user's installation.

Rack Adapter Kit . . . . . Wavetek No. 130-602
Attenuators, 10 to 1 . . . . . Dual Banana Jack Output
Single BNC Output
Adapters, Dual Banana . . . . . Dual Banana to BNC Plug
Dual Banana to BNC Receptacle
Shielded Test Leads, 36-inch . . Dual Banana to Dual Banana
Dual Banana to Alligator
Dual Banana to BNC

All phase angle measurements are dependent on type of waveform, amplitude, and frequency. The diagrams below show the absolute accuracy, taking into account all sources of error.

The term relative accuracy means the accuracy of difference in phase reading from one condition to another. For example, it is the accuracy of 1) repeatability, 2) comparison of readings among unknown signals with respect to a given signal, 3) phase deviation of input without regard to zero offset.

ABSOLUTE ACCURACY

ALL ACCURACIES STATED ARE ± DEGREES

CHANNEL A AMPLITUDE PERCENT OF FULL SCALE	.1%	1%	10%	100%
100%	2.4	1.5	0.7	0.4
10%	1.5	0.7	0.6	0.7
1%	0.7	1.0	0.7	1.5
.1%	1.5	0.7	1.5	2.4

CHANNEL B AMPLITUDE PERCENT OF FULL SCALE

MULTIPLICATION FACTOR AS A FUNCTION OF FREQUENCY

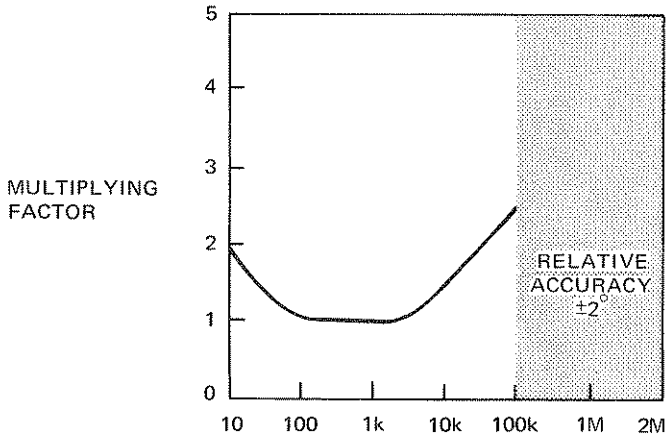


Figure 1-1. Instrument Accuracy Diagrams

SECTION 2
INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect the external parts for damage to knobs, indicators, connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packing material should be saved in case reshipment is required.

No mechanical installation is required when the instrument is to be used as a portable bench unit. If a rack mounting configuration, or a Rack Adapter Kit (see paragraph 1.4), is provided; the unit may be mounted in a standard 19-inch equipment rack. Instructions for attaching the Rack Adapter Kit are provided with the kit.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

Connect the ac line cord to the mating connector at the rear of the unit and the ac line supply. Check that the proper type of fuse is installed for the line supply being used.

NOTE

Unless otherwise specified at the time of purchase, the Model 750 is shipped from the factory with the power transformer connected for operation on a nominal 115-volt ac line supply. Conversion for 230-volt operation requires resetting a switch at the rear of the unit. To reset the 115/230 conversion switch (concealed by the rear panel) remove the rear panel, set the switch to 230 using a thin-bladed screwdriver, and replace the panel. Install a 1/8-ampere fuse in place of the normal 1/4-ampere fuse.

2.2.2 Input Connections

Connect the desired input signals to their respective connectors using shielded cable equipped with dual banana connectors. Connect single-ended inputs between ground and the appropriate polarity terminal, with the shorting link connected between ground and the opposite polarity terminal. Connect differential inputs between the "+" and "—" terminals, and disconnect the shorting link. See Table 2-1 for input connections and their requirements.

Table 2-1. ELECTRICAL INSTALLATION GUIDE

Symbol	Name	Function
J1	(Line Cord)	Connector for 3-wire line cord.
J2	INPUT A "+"	Connectors for single-ended or differential input signal. The shorting link is used only with single-ended inputs, between a polarized terminal and ground. Observe amplitude specifications and limits of paragraph 1.3.2.
J3	INPUT A "—"	
J4	INPUT A "⏚"	
J5	INPUT B "+"	Connectors for single-ended or differential input signal. The shorting link is used only with single-ended inputs, between a polarized terminal and ground. Use shielded cables with dual banana connectors for these connections.
J6	INPUT B "—"	
J7	INPUT B "⏚"	
J8	OUTPUT —10mV/DEG	Standard output connector.
J9	(Output "⏚")	

2.2.3 Output Connections

Connect the OUTPUT −10 mV/DEG to the desired point. Since the OUTPUT −10 mV/DEG has an output impedance of 1 kΩ the loading of this output should be considered. This output is short circuit proof and shorting it will not inhibit normal operation. See Table 2-1.

2.3 INSTALLATION CHECKS

This paragraph outlines a quick checkout procedure for determining proper operation of the instrument. Field calibration and checkout instructions are given in Section 4 for determining if the unit is within all electrical specifications. See Table 2-2 for a description of the functions of the operating controls. No special test equipment is required to perform a checkout of the instrument as outlined below.

1. Connect the line cord to the instrument and the line supply, depress POWER pushbutton, and allow a 20-minute warmup period for the unit to reach a stable operating temperature.
2. Depress RANGE 0°/360° pushbutton and hold CALIBRATE switch (on the rear panel) in the +360.0/+180.0 position. The four-digit readout should display "+360.0".
3. Hold CALIBRATE switch in the 000.0/−180.0 position. The four-digit readout should display "+000.0", ±000.1.
4. Depress RANGE −180/+180 pushbutton and hold CALIBRATE switch in the +360.0/+180.0 position. The four-digit readout should display "+180.0", ±000.1.
5. Hold CALIBRATE switch in the 000.0/−180.0 position. The readout should display "−180.0", ±000.1.

Table 2-2. OPERATING CONTROL FUNCTIONS

Symbol	Name	Function
SW1	POWER	Connects ac line voltage to the instrument.
SW2	115/230	Selector for 115-volt or 230-volt operation.
SW3	CALIBRATE	Used for quick check of offset (if any) in phase reading.
SW1	VOLTS RMS .001-2 (INPUT A)	When depressed, selects the 0.001 to 2 V rms input signal amplitude range for the A input. Interlocked with SW2 below.
SW2	VOLTS RMS .3-300 (INPUT A)	When depressed, selects the 0.3 to 300 V rms input signal amplitude range for the A input. Interlocked with SW1 above.
SW3	RANGE 0°/360° (A and B)	When depressed, the phase angle display range will be 0° to 360°, with slight discontinuity between 358° and 2°. Interlocked with SW4 below.
SW4	RANGE −180°/+180° (A and B)	When depressed, the phase angle display range is −180° to +180°, with slight discontinuity between 178° and 182°. Interlocked with SW3 above.
SW5	VOLTS RMS .001-2 (INPUT B)	When depressed, selects the 0.001 to 2 V rms input signal amplitude range for the B input. Interlocked with SW6 below.
SW6	VOLTS RMS .3-300 (INPUT B)	When depressed, selects the 0.3 to 300 V rms input signal amplitude range for the B input. Interlocked with SW5 above.

If, after sufficient warmup, the proper readings are not observed, refer to the Calibration Instructions given in paragraph 4.2 of this manual.

2.4 OPERATING CONTROLS

The operating controls and the functions they perform are given in Table 2-2. Additional adjustments, and the functions they perform, are described as they appear in the text of Section 3 and Section 4 of this manual. Do not disturb any control settings, with the exception of operating controls, unless absolutely necessary; and then only if suitable equipment is available for recalibration.

If the equipment appears to operate abnormally, refer to the Calibration Instructions (paragraph 4.2) and the Corrective Maintenance (paragraph 4.3) instructions.

2.5 OPERATING PROCEDURE

No preparation for operation is required beyond completion of the initial Installation Checks given in paragraph 2.3 of this manual.

C A U T I O N

If single-ended ac inputs are used, the shorting link must be connected between the negative and ground terminals. If differential ac inputs are used, the shorting link must be removed and the input signal must be connected between the positive and negative (+ and −) terminals.

C A U T I O N

To measure the phase angle between any two ac signals (with an amplitude ratio as great as 300,000 to 1) within the specified frequency range, proceed as follows:

1. Depress the appropriate VOLTS RMS pushbutton for each input signal.
2. Depress the appropriate RANGE pushbutton to select the range (0/360 or −180/+180) that provides the closest center of range indication, or use both ranges for continuous phase angle measurements.
3. Connect one ac signal to INPUT A terminals and the other signal to INPUT B terminals observing the CAUTION notice above.

N O T I C E

If the readout jumps or scatters occasionally with low input amplitude and/or frequency, it is probably caused by noise spikes riding on the input signal or a high signal to noise ratio. To eliminate or reduce this effect connect a 0.1 μF capacitor (or matched filters) across input terminals.

N O T I C E

4. Read phase angle (phase difference) directly on digital display panel. If the readout polarity is positive, INPUT B leads INPUT A by the measured number of degrees. If the readout polarity is negative, INPUT B lags INPUT A by the measured amount.
5. OUTPUT −10mV/DEG provides the same data, electronically, for use as a control signal or for general recording applications.

SECTION 3
CIRCUIT DESCRIPTION

3.1 SIMPLIFIED BLOCK DIAGRAM

As shown in Figure 3-1, the Model 750 Phase Meter consists of two similar input channels (only the A channel has the RANGE selector switch) and a common output channel. Paragraph 3.2 provides further descriptions of the functions of each basic circuit comprising this instrument. This paragraph describes, briefly, the major circuit elements and their relationship to one another.

The Frequency Compensated Attenuator in each input channel is used to reduce high amplitude inputs to a level

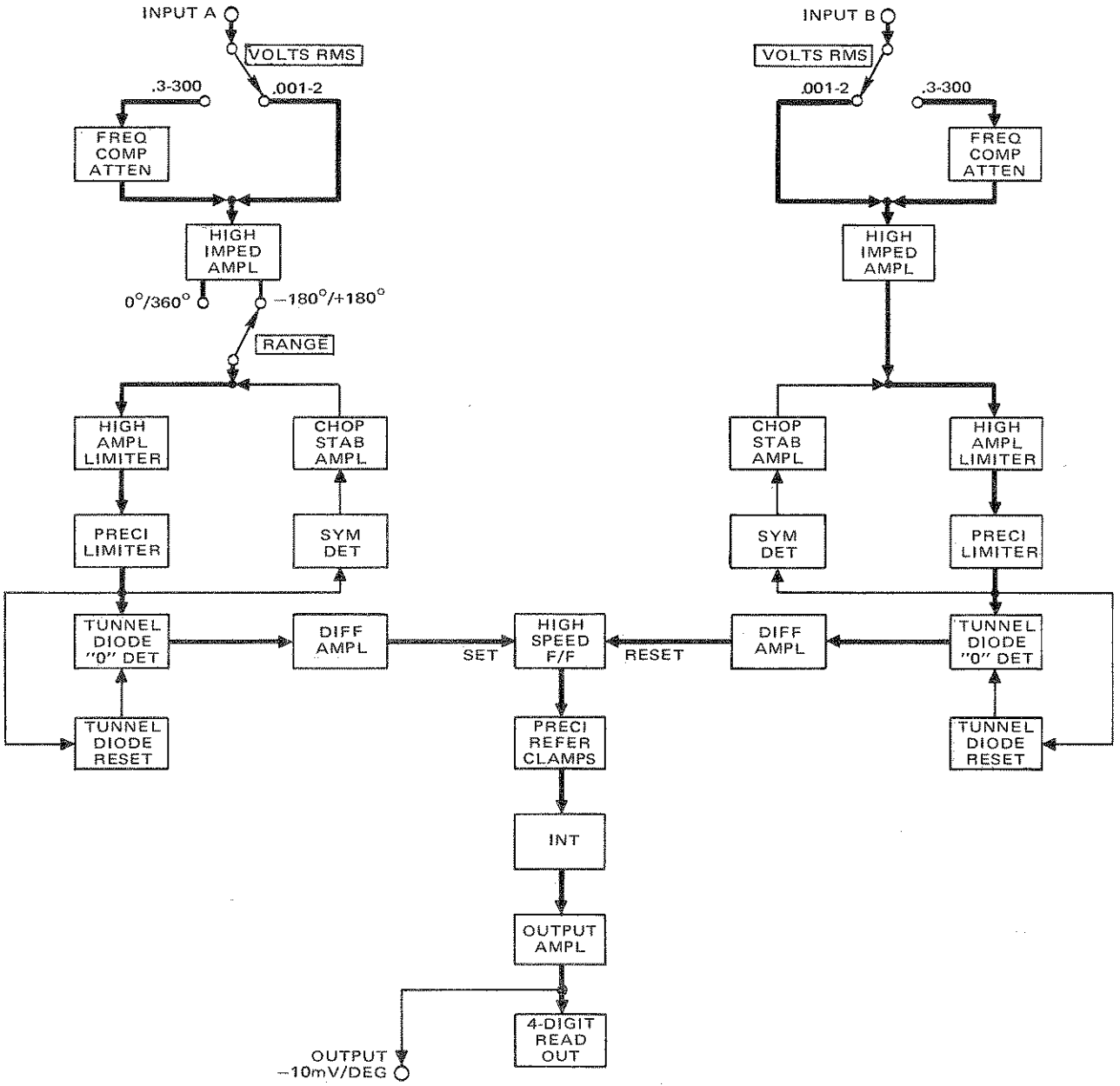


Figure 3-1. Simplified Block Diagram

suitable for the remaining circuitry. The attenuator is in the circuit when the .3-300 VOLTS RMS input range is selected, and it is out of the circuit when the .001-2 VOLTS RMS range is selected.

The selected input signal is applied, through the VOLTS RMS switch, to a High Impedance Amplifier stage. In the A channel, the RANGE switches (0°/360° or −180°/+180°) select the appropriate phase out of the differential amplifier. The B channel does not employ a 180° phase shifter, as only one is needed in the instrument. Another function of the High Impedance Amplifier is to isolate the plus and minus inputs and provide high common mode rejection.

Next, the signal is high-amplitude-limited to prevent overdriving in the Precision Limiter stage. The Precision Limiter is a nonlinear feedback, wideband amplifier which limits the input signal at ±100 μV. The limited output signal is applied to a Symmetry Detector which integrates the waveform and produces a dc voltage that is proportional to the symmetry of the clipped waveform. This dc output represents an error in the zero-crossing system or an error due to the distortion of the input signal. The dc level is amplified and inverted in a Chopper Stabilized Amplifier and summed at the input to the first limiter stage. The closed-loop circuitry provides long-term, stable phase detection and automatically balances the limiters to correct for drift or offset voltages in the system due to temperature variations or component aging. Errors due to even-harmonic distortion are essentially eliminated by this self-balancing zero-crossing technique.

Following the limiters, the waveform zero-crossing is detected in a wideband Tunnel Diode Zero Detector. The Tunnel Diode Reset supplies the reset signal to the detector and provides system noise immunity. The detected zero-crossing output is then applied to the High Speed Flip-Flop through a Differentiating Amplifier. The output of Channel A is applied to the "set" input, and the output of Channel B is applied to the "reset" input of the flip-flop.

The flip-flop output is applied to a Precision Reference Clamp stage which provides a signal having an amplitude defined by the reference voltage and a duty cycle proportional to the phase difference between the two input signals. This output is integrated into a dc voltage proportional to the phase difference and is applied to the Output Amplifier for full scale and zero adjustment, before being applied to the digital display readout and output connectors.

3.2 FUNCTIONAL BLOCK DIAGRAM ANALYSIS

As each functional circuit is described, refer to the appropriate block diagram and, if necessary, the appropriate portions of the schematic diagrams at the rear of this manual.

3.2.1 Zero Crossing Circuit (Figure 3-2 and 3-3)

Both input channels employ similar Zero Crossing Circuits; the only difference being the RANGE switch in Channel A. In view of this, only the functions of Channel A are described, realizing that there are counterparts in Channel B. Figure 3-2 is a functional block diagram of the Zero Crossing Circuit, Figure 3-3 shows key waveforms within this circuit.

When .001-2 VOLTS RMS is selected as the input amplitude range, the input signal is capacitively coupled to the High Impedance Differential Amplifier Q1-Q2. When the .3-300 VOLTS RMS range is chosen, the input signal is passed through the Frequency Compensated Attenuator before being applied to Q1-Q2. When the latter range has been selected, the plus and minus inputs are symmetrically attenuated in the ac/dc attenuator which is adjusted for a flat frequency response by trimmer capacitors C1 and C5.

The input source currents for the High Impedance Differential Amplifier stage are balanced by trimmer adjust R187 to yield best common mode rejection. The output of Q1-Q2 is applied, through the selected RANGE switch, to either the positive or the negative input of Input Amplifier IC1.

Trimmer capacitors C10 and C11 adjust the phase shift of the negative and positive inputs to IC1 to match those of IC4 in Channel B for best high frequency performance. IC1 provides either a 180° or a 0° phase shift, depending on the setting of the RANGE selector switches. With either range the gain of IC1 is unity, and its output is applied to the summing junction at the gate of Q3. FET Q3 and transistor Q4 provide a high input impedance to the summing point, as well as temperature compensation. The output from Q3-Q4 is applied to the symmetrical Amplitude Limiter CR1-CR4. R21 is used to balance this four-diode limiter.

The output from CR1-CR4 is coupled to Precision Limiting Amplifier IC2, a 50 MHz amplifier with nonlinear feedback. R28 is a dc balance adjustment, C22 is a phase matching trimmer. The output of IC2 is a clipped waveform having an amplified volts/second relationship at the zero crossing of the input waveform.

For high accuracy, the output of the final limiting amplifier of a zero crossing system must be symmetrical for a sine wave input. To ensure this, the output waveshape must be sampled periodically and the result fed back to the input of the first limiter to correct any unbalance or dissymmetry. The Integrator (comprised of R37-R40 and C26 and C30)

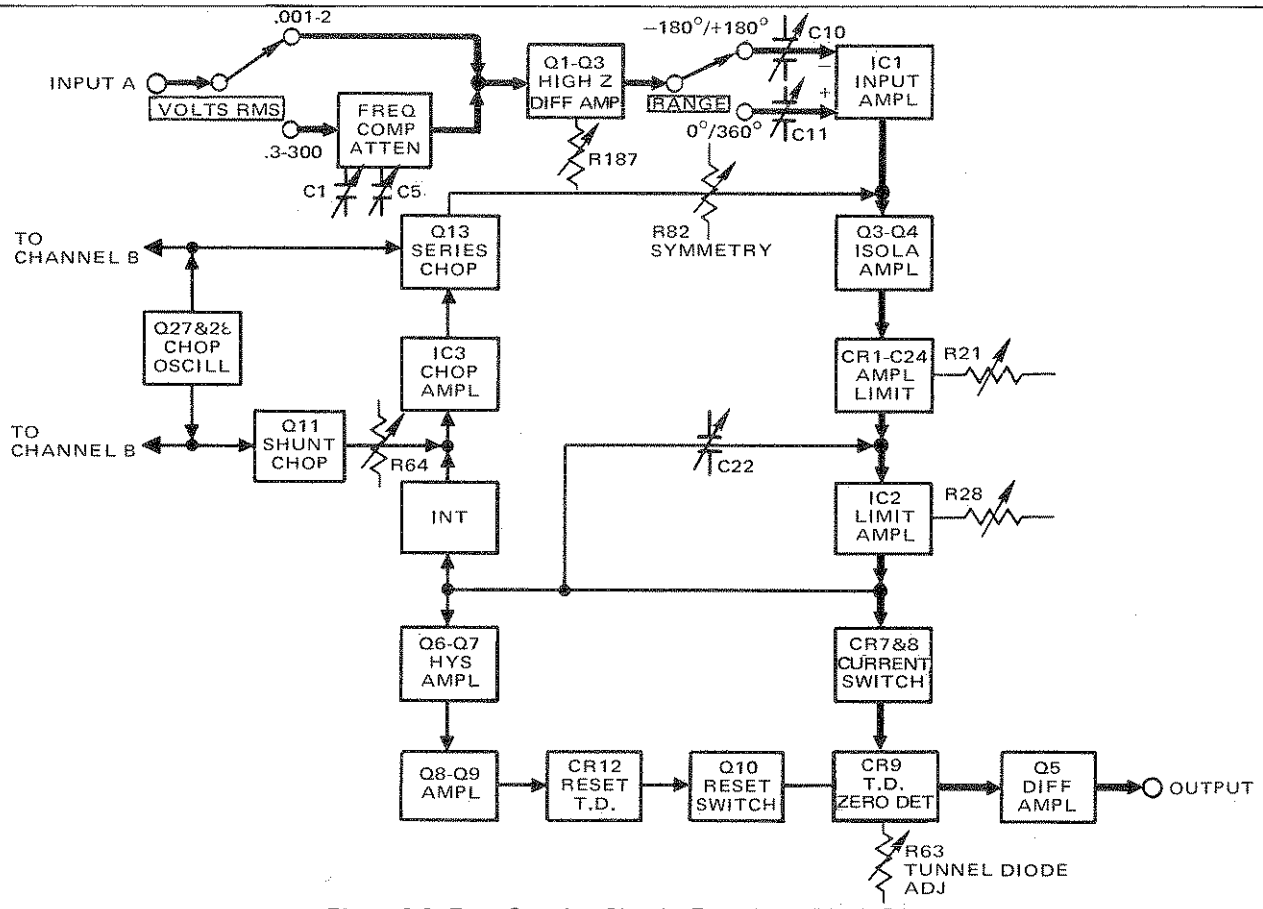
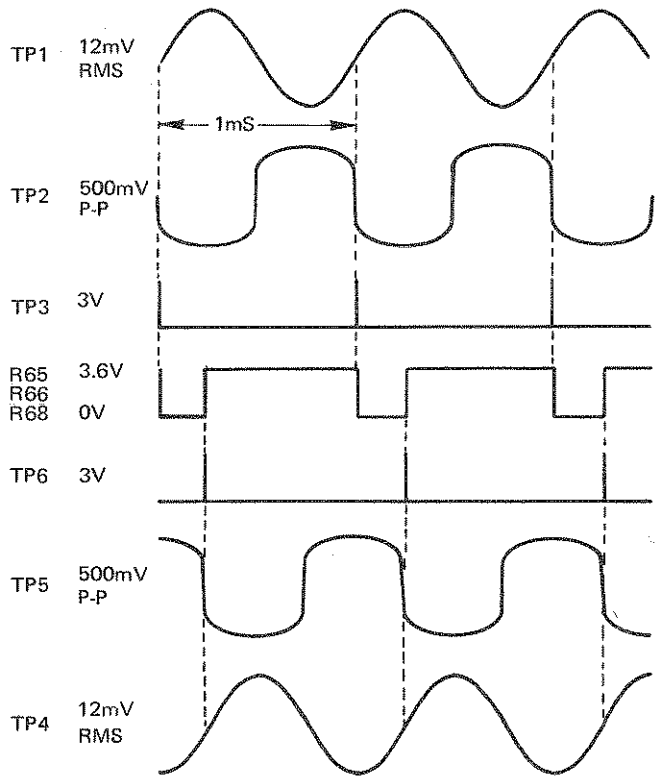


Figure 3-2. Zero Crossing Circuit, Functional Block Diagram



NOTES

A and B VOLTS RMS	.001-2V
PHASE RANGE	0°/360°
INPUTS	10mV RMS

CHANNEL B LAGS BY 90°

Figure 3-3.
Timing Diagram, Zero Crossing, and Logic Circuit

supplies a dc voltage proportional to the symmetry of the output of IC2 to the input of Chopper Amplifier IC3. Shunt Chopper Q11 converts the dc output of the Integrator to an ac signal. R64 is the chopper balance adjust.

This ac signal is then amplified in IC3, and the output is demodulated in Series Chopper Q13. The voltage developed across capacitor C59 is an amplified error signal proportional to the nonsymmetry of the output of IC2. This error signal is applied, through R23, to the summing point at the gate of Q3. R82 is a symmetry adjustment which controls the amount of error signal in the feedback loop. This chopper-stabilized symmetry-detection system also eliminates the effects of even harmonic distortion with the limits of the chopper loop.

The symmetrical output of IC2 is then applied to Current Switch CR7-CR8 which supplies a small amount of current, at the actual zero crossing point, to trigger Tunnel Diode Zero Detector CR9. Tunnel Diode Adjust R63 sets the firing point of CR9 to be at the zero crossing point.

Differentiating Amplifier Q5 then supplies a pulse output which occurs at the true zero crossing point of the input waveform.

The reset circuitry for CR9 consists of transistors Q6 through Q10. Hysteresis Amplifier Q6-Q7 amplifies the output of IC2 and provides the necessary hysteresis to prevent double triggering. The output from Q6-Q7 is applied, through Amplifier Q8-Q9, to reset Tunnel Diode CR12. When CR12 fires, the resultant waveform is differentiated and drives Reset Switch Q10 to saturation which, in turn, resets the Tunnel Diode Zero Detector CR9 to its original state.

Chopper Oscillator Q27-Q28 is the circuitry common to both channels of the Zero Crossing Circuit. This oscillator supplies the chopper pulse which drives the gates of field-effect-transistors Q11 and Q13 at the proper sample rate.

3.2.2 Logic Circuit (Figure 3-3 and 3-4)

The Logic Circuit converts the pulse information generated by the Zero Crossing Circuit into a precision, linear dc voltage whose value is a direct function of the phase difference between inputs A and B.

The two pulses generated by the Zero Crossing Circuit are applied to the inputs of a fast rise and fall time Set-Reset Toggle IC4. This stage is a dual transistor gate connected as an RS toggle with hot carrier diodes CR13 and CR14 providing nonsaturated, high speed operation. This stage

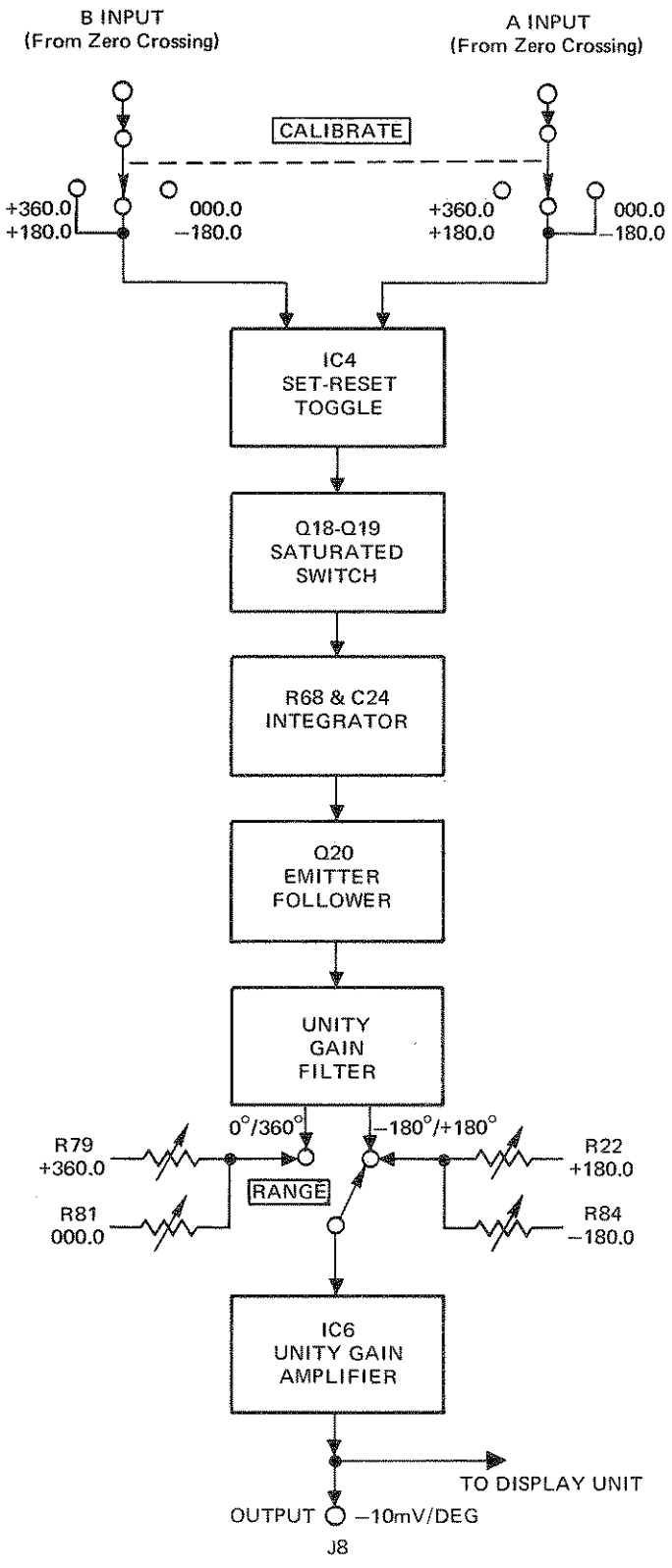


Figure 3-4. Logic Circuit, Functional Block Diagram

converts the pulse information into a rectangular waveform that drives Saturated Switch Q18-Q19.

When the CALIBRATE switch is actuated, it inhibits either the "A" or "B" input from the Zero Crossing Circuit. With one input inhibited, the Set-Reset Toggle IC4 will go to a single state and remain. One state of IC4 corresponds to 0°, the other state corresponds to 360°. Therefore, when CALIBRATE switch SW3 is actuated, all dc calibrations may be checked.

Q18-Q19 operates as a pair of saturated switches between ground and a precision +3.6 Vdc. The resulting output, at the junction of R65 and R66, is integrated in Integrator R68/C24 and then filtered by an active Unity Gain Filter comprised of IC5, R69, R70, C25, and C26. Q20 functions as an Emitter Follower input to the Unity Gain Filter.

The integrated and filtered signal, representing the phase angle between INPUT A and INPUT B, is then conditioned in the Unity Gain Amplifier IC6. The final dc voltage out of IC6 has a −10 mV/degree relationship to the measured phase angle, and is provided (at J8) as an output as well as the input to the Digital Display Circuit.

RANGE calibration is accomplished by four potentiometers at the rear of the unit. When the 0°/360° RANGE is selected, the +360.0 and 000.0 limits may be calibrated using R79 and R81 respectively. When the −180°/+180° RANGE is selected, the +180.0 and the −180.0 limits may be calibrated using R22 and R84 respectively.

The reference voltage at the integrator input is the same voltage used as the voltmeter reference. The result is a ratio measurement that is independent of power supply drift.

3.2.3 Digital Display Circuits (Figure 3-5 and 3-6)

The Digital Display Circuit is a four-digit, automatic-polarity-indicating, dual-slope-integrating, digital voltmeter (DVM). As this circuit is described, refer to the timing diagram (Figure 3-6) as well as the block diagram and schematic at the rear of this manual.

The −10 mV/degree dc output from the Logic Circuit is applied to the input of the Digital Display Circuit. This input is switched into an integrator for a precise time interval, causing the integrator to "ramp" to some voltage. At the end of the input time interval, a reference voltage is switched into the integrator causing it to ramp back to zero. The time between the start of the reference ramp and the time the reference ramp passes through zero is converted to a timing pulse by logic circuitry. The width of this pulse is directly related to the amplitude of the dc voltage input applied to the DVM, and thus, the phase relationship (phase angle) of INPUT A to INPUT B. This pulse is used to gate a counter so that, for each 1 mV of input voltage, one count is displayed, yielding .1° phase resolution on the digital readout.

The entire DVM is synchronized from a master clock, Oscillator IC7-Q17, which is scaled down in the four 10^N Decade Counters, to provide the DVM time base. This time base controls the input to the Integrator, IC1, and sequences logic decisions used to generate the counter gating pulse.

The Integrator, IC1 and C2, has four inputs. The input voltage is switched in by Q1 and Q2. Depending on the input voltage polarity, either the +3.6 V reference is switched in by Q3 and Q4, or the −3.6 V reference is switched in by Q5 and Q6. Zero adjustment is made by R11 (ZERO OFFSET ADJ) which compensates for the input switch and integrator offset voltages.

It should be noted here that the +3.6 V used as the DVM reference is also the +3.6 V used to power the circuitry generating the dc output from the Logic Circuit. Thus, if the +3.6 V should change, there will be virtually no variation in the DVM output since a ratio relationship exists between the generating source and the measuring system.

The output of IC1 is detected in Comparator IC2 and the Amplifier comprised of Q8-Q10. IC3A and IC4A provide additional drive for the comparator input at zero, through Q7 and Q11, to prevent multiple comparator outputs. The amplified comparator output steers JK Flip-Flop IC5A which, upon receipt of the 10^{-3}8 clock signal from IC5B, determines the polarity of the DVM input voltage. Once the polarity has been determined, either IC3B or IC4C changes state to switch in the appropriate reference voltage for ramping the integrator back to zero. As the reference voltage is switched in, IC3C is gated positive, producing the start of the output pulse. When the Integrator reaches zero, the Comparator changes state. This change in state causes IC3B or IC4C to gate IC3C negative, generating the end of the output pulse.

The analog board converts the dc output of the phase meter to a positive pulse whose width is proportional to the phase shift at the input to the instrument. This pulse is then applied to pin 4 of the Digital Readout Board.

The positive pulse is fed through R3 to the base of Q2, an inverter, causing the collector of Q2 to go negative for the same duration. The first negative transition of the pulse at the collector of Q2, coupled through C1, causes the output of IC2 to go positive. This positive output is applied to the reset pins of IC5, IC8, IC11, and IC14—the counter portion of the digital readout

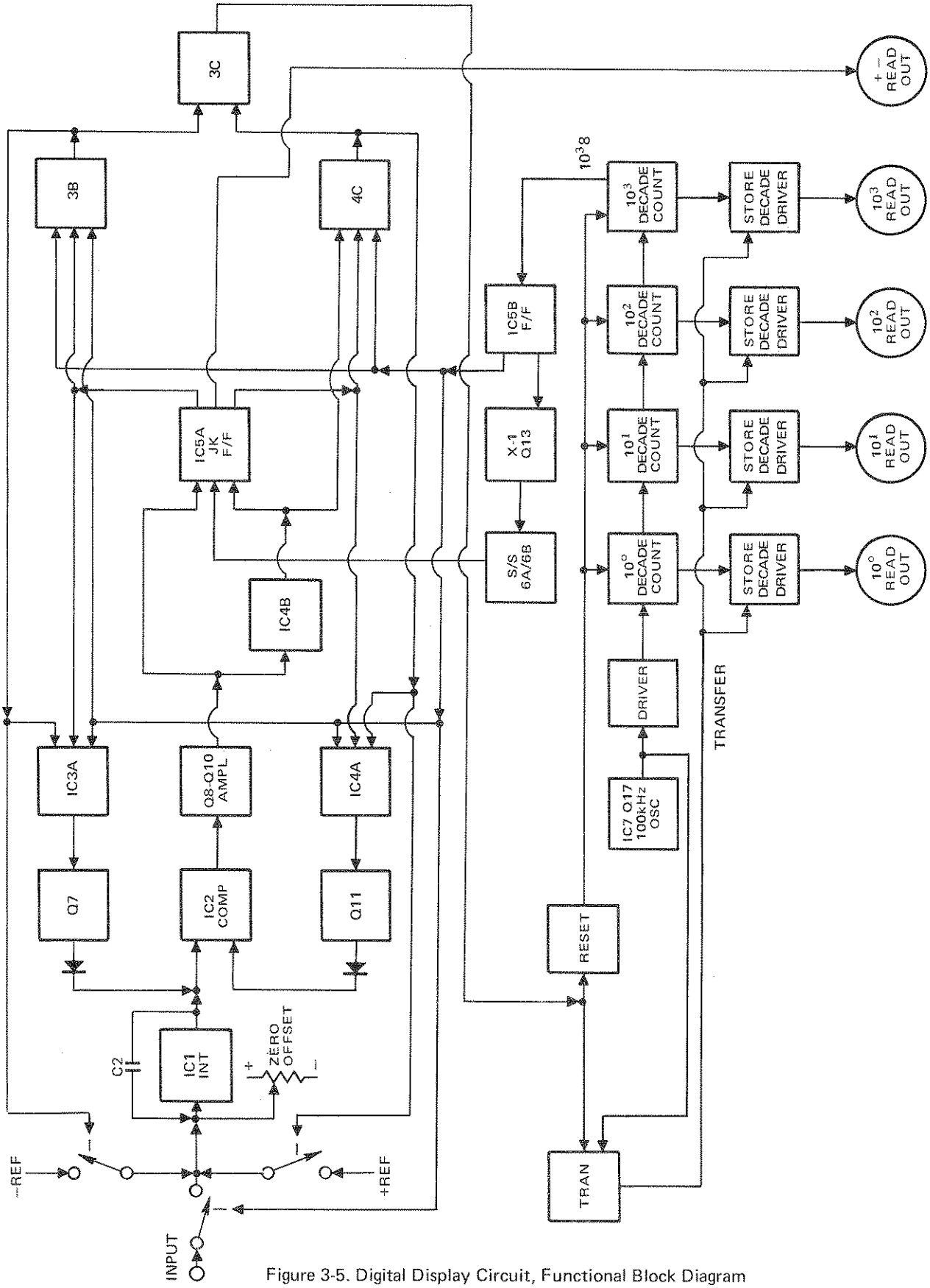


Figure 3-5. Digital Display Circuit, Functional Block Diagram

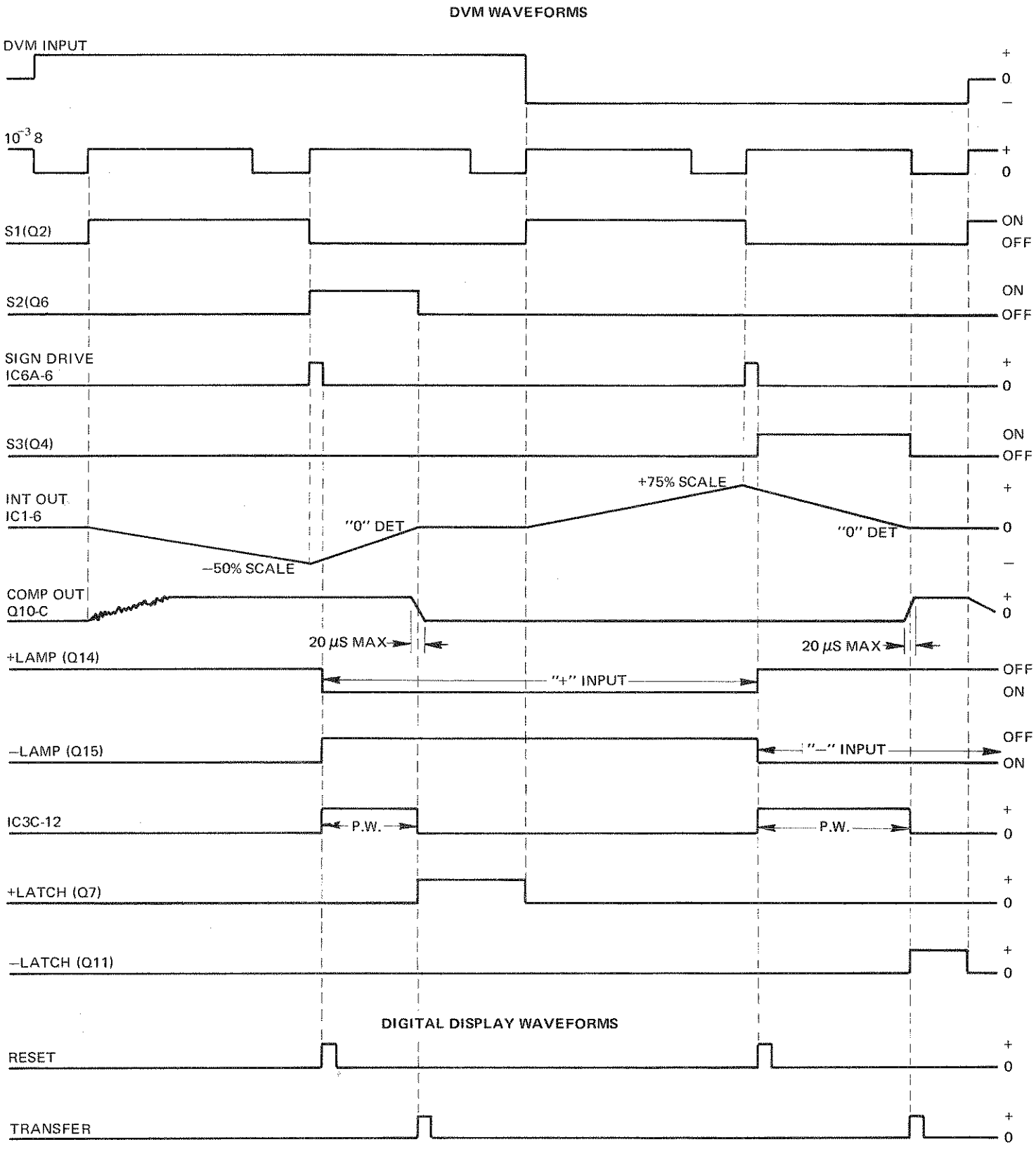


Figure 3-6. Digital Display Circuit, Timing Diagram

system. Thus, the negative transition of the pulse at the collector of Q2 causes a zero state to be set into the counter.

The clock input, a frequency of approximately 25 kHz, is applied through Q1 to pin 14 of IC5, the first decade of the decade counter stages. This frequency is then counted until a positive transition of Q2 is coupled through C2 causing IC2 to go negative. The single-shot configuration of IC2 provides a positive pulse at pin 8. This also drives pin 1 of IC1 to a positive condition which (if pins 8 and 11 of IC1 are in the reset condition) allows the pulse to get through to pin 3 of IC1 and pin 6 of IC1 to go negative. This action strobes the information from the clock decade counters into the latch circuits of IC4, IC7, IC10, and IC13, and also strobes the Print Command output circuit.

When the new information is updated into the quad latch circuitry, decoder drivers IC3, IC6, and IC9, and IC12 then decode the information and present it to the digital display tubes V1, V2, V3, and V4.

Transistors Q3 and Q4 are the plus and minus sign drivers for the digital display tubes.

Due to the cycle time of the dual slope integrator; the maximum waiting period, from input of an external read command to output of a print command and the data presented to the digital readout is approximately 1 second.

3.2.4 DC Power Supplies (Figure 3-7)

Regulated operating voltages for the Model 750 Phase Meter include +15 V, −15 V, +3.6 V, −3.6 V, +5 V, and

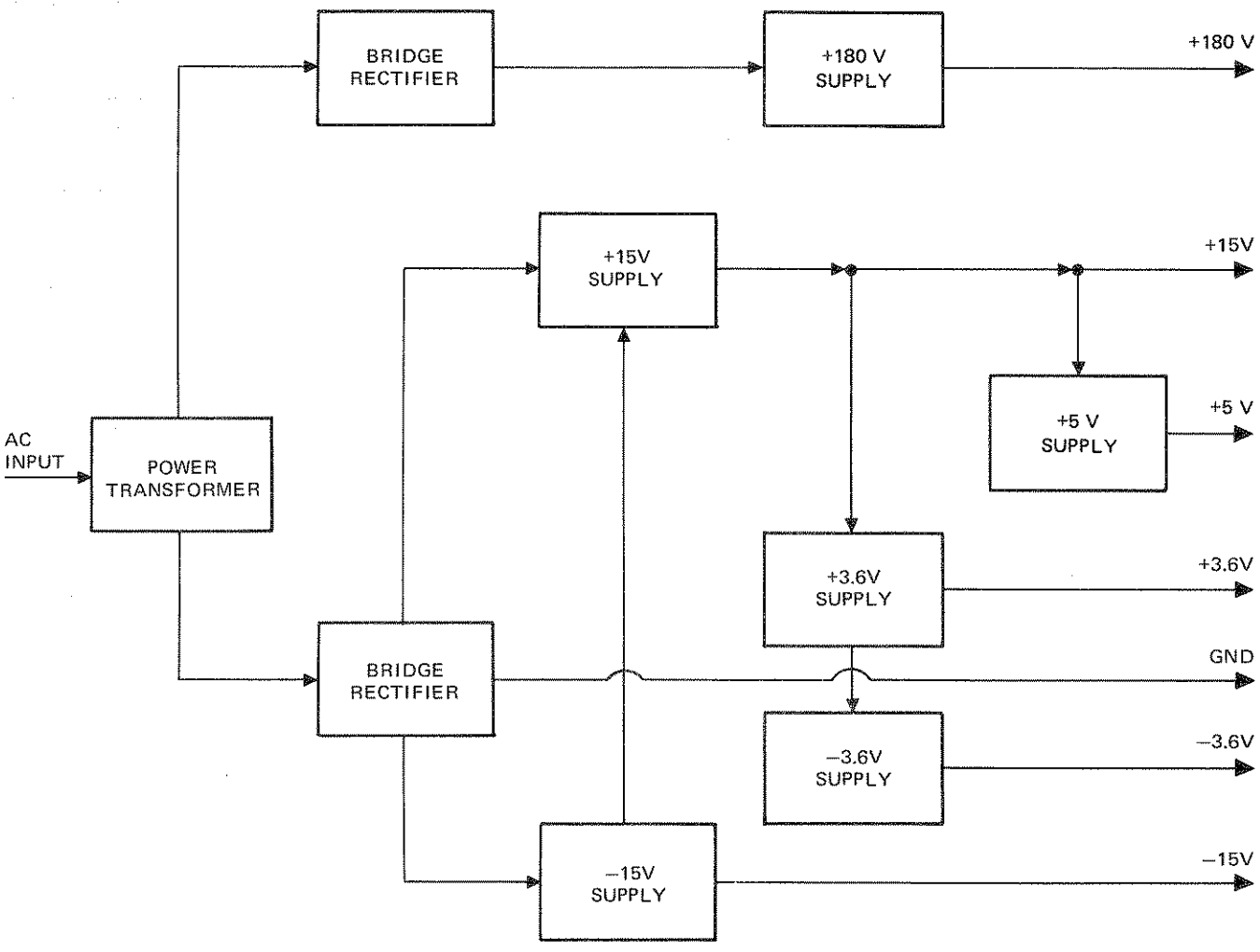


Figure 3-7. DC Power Supplies, Functional Block Diagram

+180 V. AC line voltage is connected through the line cord to the POWER switch on the front panel. A slo-blo fuse is installed on the line side of the switch, and a 115/230 power selector switch connects the primary winding of the power transformer for the appropriate line voltage.

AC voltage is coupled from the transformer secondary to the Bridge Rectifier CR1-CR4. Filtering is provided by C3 and C11. Q12 is operated as a Zener diode reference voltage for the −15 V supply. IC3 is a comparator differential amplifier. The Comparator drives a Darlington-connected Series Pass transistor pair, Q9 and Q11, used for added current gain. Q8 is also connected to operate as a Zener diode reference to provide a voltage level shift for the output of IC3. R36, −15 V ADJ, adjusts the minus input of IC3 with respect to the plus input which has a Zener voltage of approximately 7 volts. If the −15 V tries to increase due to a change in line voltage or load current, the collector of Q12 stays approximately at the same voltage. Thus, the minus input to IC3 becomes more positive than the plus input, and the IC3 output draws more current. The output moves less positive, and this change is coupled to the base of Q9 and Q11 through Q8, returning the supply to −15 volts.

IC1 is a Comparator Differential Amplifier in the +15 V supply. The plus input of IC1 is returned to ground through R9. Voltage Divider R7-R8, between the plus and minus 15-volt supplies, sets the minus input of IC1 precisely at ground. An increase in the −15 volts, due to line voltage variation or load current change, results in the minus input of IC1 moving positive, and the output of IC1 moving negative. This change is coupled to the bases of Q1 and Q2 through Q4. Q1 and Q2 form a Darlington-connected Series Pass pair for added current gain. The negative-going change returns the output to +15 volts.

Q3, in conjunction with R2 through R4, comprises a foldback current limiter for the +15 V regulator. Normally, the base of Q3 is turned off. Thus, the base of Q2 moves freely as the output from IC1 changes. When the +15 volt output is overloaded, heavy current flows through R2 and creates a potential drop across the resistor. When the potential drop overcomes the drop across R3, Q3 begins to conduct, starting to short the base of Q2 to the +15 volt output. In this condition, the output can be shorted indefinitely at a lower than maximum power dissipation of Q1. When the overload condition is removed from the +15 V output, the base of Q2 starts to rise. As the emitter of Q1 rises toward +15 volts, Voltage Divider R3-R4 has more effect on the base of Q3 and eventually turns Q3 off completely. When Q3 turns off, the normal condition is restored. Q10 with R28, R29, and R30, form a foldback current limiter for the −15 volt regulator.

The +3.6 volt supply is provided by Q5 and Q6 operating as a Comparator Differential Amplifier controlling the Series Pass transistor Q7. The error signal is obtained from the wiper of R20, in a Voltage Divider comprised of R18, R20, and R21 between +3.6 volts and −15 volts (the −15 volts here acts as a reference voltage) and R2 is used as the +3.6 volt adjustment.

The −3.6 volt supply is provided by IC2 operating as a Unity Gain Operational Amplifier with R22 providing gain control and the −3.6 volt adjustment.

For the +5 volt supply, ac voltage is coupled from the transformer secondary to Bridge Rectifier CR8-CR11. Filtering is provided by C14. Q14, Q15, and Q16 form a Comparator Differential Amplifier controlling Series Pass transistor Q13. The error signal is sensed directly on the +5 volts and is applied to the base of Q16. The Voltage Divider R38-R44, between +15 volts and ground, provides the reference voltage for the base of Q15. Q17, R40, R41, R42, and R43 form a foldback current limiter for the +3.7 volt regulator.

For the +180 volt supply, ac voltage is coupled from the transformer secondary to Rectifier CR12. Current limiting is provided by R48 and filtering is provided by C17. R49 is a bleeder resistor for C17, to prevent a sustained high voltage after power is turned off.

3.3 SUPPLEMENTAL CIRCUITS

There are no unique or supplemental circuits within the Model 750 to be separately described as "Supplemental Circuits". The preceding circuit descriptions adequately describe the complete circuitry of the Model 750 to the degree required by a competent technician.

For Performance Check, Use Specifications before Adjustment! 8-22-95

SECTION 4
MAINTENANCE

4.1 ACCESS INSTRUCTIONS

Removal of the dust cover affords quick access to the majority of components within the unit. However, it may be necessary to remove the Digital Readout Assembly or the Zero Crossing Board in order to gain access to those components not exposed by removing the dust cover. Instructions for all three are given below.

4.1.1 Removing the Dust Cover

To remove the dust cover (case) from the Model 750 Phase Meter, the following procedure should be followed.

1. Unplug the power cord.
2. Unscrew two captive screws on rear panel.
3. Remove rear casting.
4. Set instrument face down and, watching clearance between bottom printed circuit board and cover, lift cover off slowly making sure bolts on the cover do not hit any adjustments.
5. Reverse this procedure when replacing dust cover. Tighten the captive screws only finger-tight.

4.1.2 Removing the Digital Readout Assembly

To remove the Digital Readout Assembly from the Model 750 Phase Meter, proceed as follows:

1. Remove the two Phillips screws on top of the Digital Readout Assembly closest to the front panel.
2. Remove the two Phillips screws holding the two bars extending from the assembly to the rear panel.
3. The assembly can now be removed and placed on the POWER switch side of the instrument. The unit may be turned on and operated while in this stage of disassembly.
4. The assembly may be completely removed by lifting up on the AMP pins connecting the assembly to the Logic and Power Supply board.

4.1.3 Removing the Zero Crossing Board

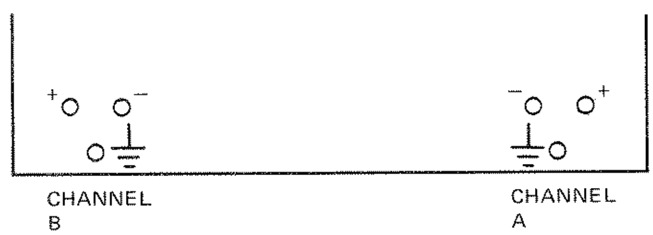
To remove the Zero Crossing Board from the Model 750 Phase Meter, proceed as follows:

1. Set instrument on its side and disconnect the AMP pins of the two sets of three input connectors. These are located near the front of the bottom board.
2. Remove the three bottom screws on both sides of the instrument holding the Zero Crossing Board to the side plates.
3. Slide Zero Crossing Board back until front switches clear the front panel.
4. Swing the Zero Crossing Board out from the front and replace the screws at the rear of the board. This allows the user to get at both sides of the Zero Crossing Board while the instrument is operating.

NOTE

The inputs are now available at the AMP pins on the front of the Zero Crossing Board.

5. To replace the Zero Crossing Board, reverse the above procedure. When reconnecting the input AMP pins, follow the diagram below.



Component Side of Zero Crossing Board

4.2 CALIBRATION INSTRUCTIONS

This paragraph provides complete sequential calibration instructions for the Model 750 Phase Meter. The instructions are concise and are written for the experienced electronics technician or field engineer having a working knowledge of this type of instrumentation.

WAVETEK maintains a factory repair department for those customers not possessing the necessary test equipment or personnel to maintain this type of instrument. If an instrument is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached. This will hasten turnaround time.

Test point and control locations necessary for calibration are given within this section unless a foldout illustration is required. In the latter instance, the foldout illustration will be found at the rear of the manual.

4.2.1 Recommended Test Equipment

The following test equipment (or equivalent) is recommended for this calibration procedure.

VCG/VCA Generator . . . . . Wavetek Model 136
Voltmeter . . . . . 1mV Resolution
Oscilloscope . . . . . Tektronix Model 454
Flat-bladed screwdriver 1/8-inch

4.2.2 Preliminary Procedures

Before attempting to recalibrate this instrument, the user should read and understand the entire calibration procedure. The four major segments of this procedure should be performed in the sequence given, as should the steps within each segment.

1. Connect the Model 750 Phase Meter in the test set up illustrated in Figure 4-1[A].
2. Set POWER switch to ON, set RANGE selector for 0°/360°, and set both VOLTS RMS selectors for .001-2.

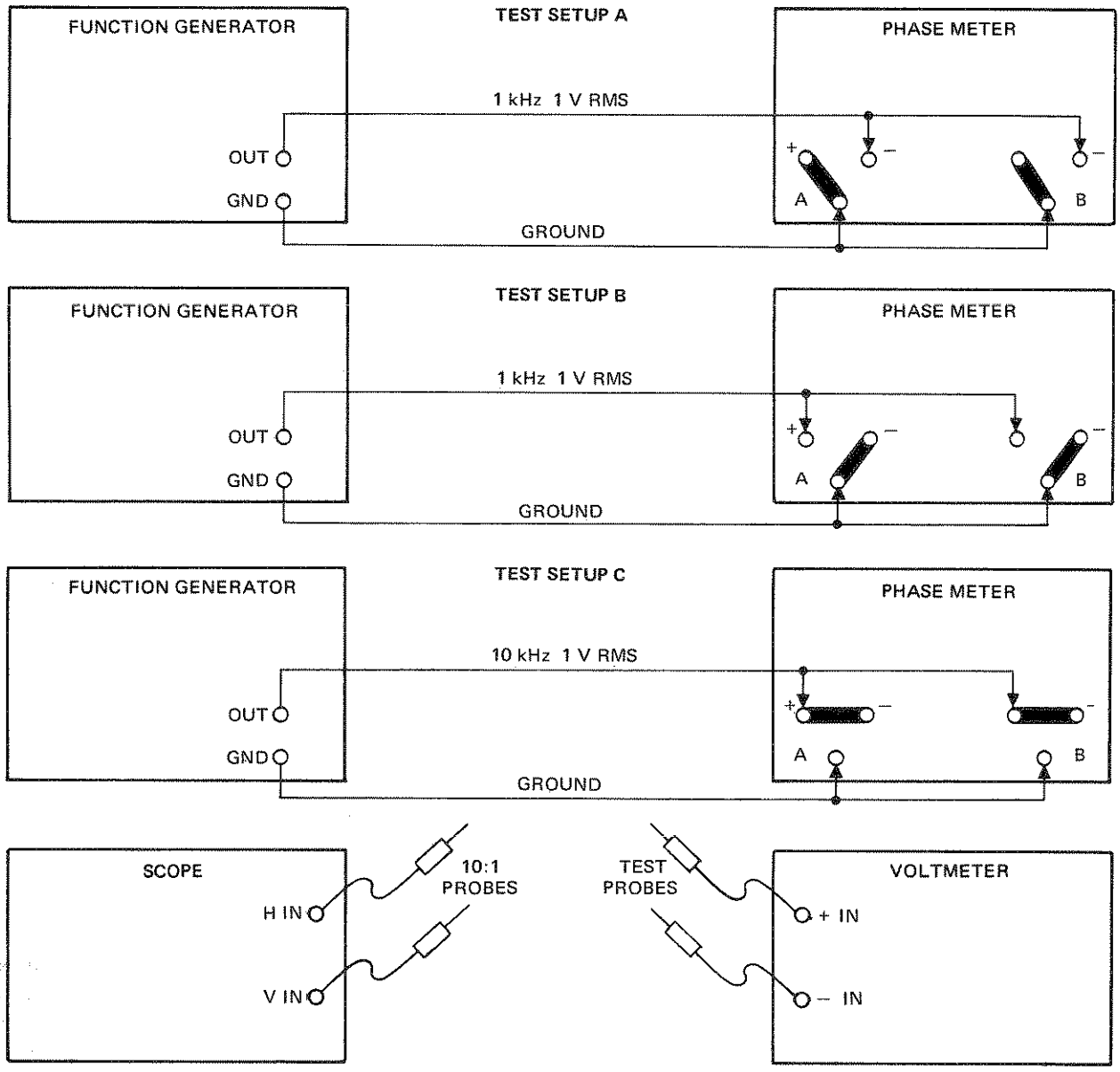


Figure 4-1. Calibration Set-Up

3. Allow a 30-minute warmup period before attempting to calibrate this instrument.

4.2.3 Full Scale Calibration Procedure

4. With equipment connected as shown in Figure 4-1[A]; hold CALIBRATE switch down (000.0/−180.0) and adjust 000.0 ADJ R81 for 000.0 plus or minus 1/2-count.

NOTE

One-half count (1/20th of a degree) can be determined by interpolation of alternate readings. If display alternates between ±000.0 and +000.1, the indication may be averaged to give +000.05. Careful adjustment should yield a display of ±000.0 (±.1) after equipment warmup.

5. Hold CALIBRATE switch up (+360.0/+180.0) and adjust +360.0 ADJ R79 for a display centered between +359.9 and +360.0.
6. Set RANGE selector for −180°/+180°.
7. Hold CALIBRATE switch down (000.0/−180.0) and adjust −180.0 ADJ R84 for a display centered between −179.9 and −180.0.
8. Hold CALIBRATE switch up (+360.0/+180.0) and adjust +180.0 ADJ R22 for a display centered between +179.9 and +180.0.
9. Repeat steps 4 through 8 for best indications. If all four calibrations are not within the specified limits, refer to the Logic Board Calibration Procedure given in paragraph 4.2.4.

4.2.4 Logic Board Calibration Procedure

10. Remove the dust cover and the display unit from the Model 750 Phase Meter following the procedures outlined in paragraphs 4.1.1 and 4.1.2.
11. Connect the positive probe of the voltmeter to test point TP2, and the negative probe to TP1, of the Logic Board (Figure 4-2).
12. Set POWER switch to ON and allow a 30-minute warmup period.
13. Set RANGE selector to 0°/360°, and set +3.6 V ADJ R20 to the center of its adjustable range.
14. Adjust −15 V ADJ R36 to obtain +3.600 V (±2 mV) between TP1 and TP2 (+3.6 V supply).
15. Connect the voltmeter to the OUTPUT −10mV/DEG and GROUND dual-banana terminals (J8 and J9) at the rear of the instrument.

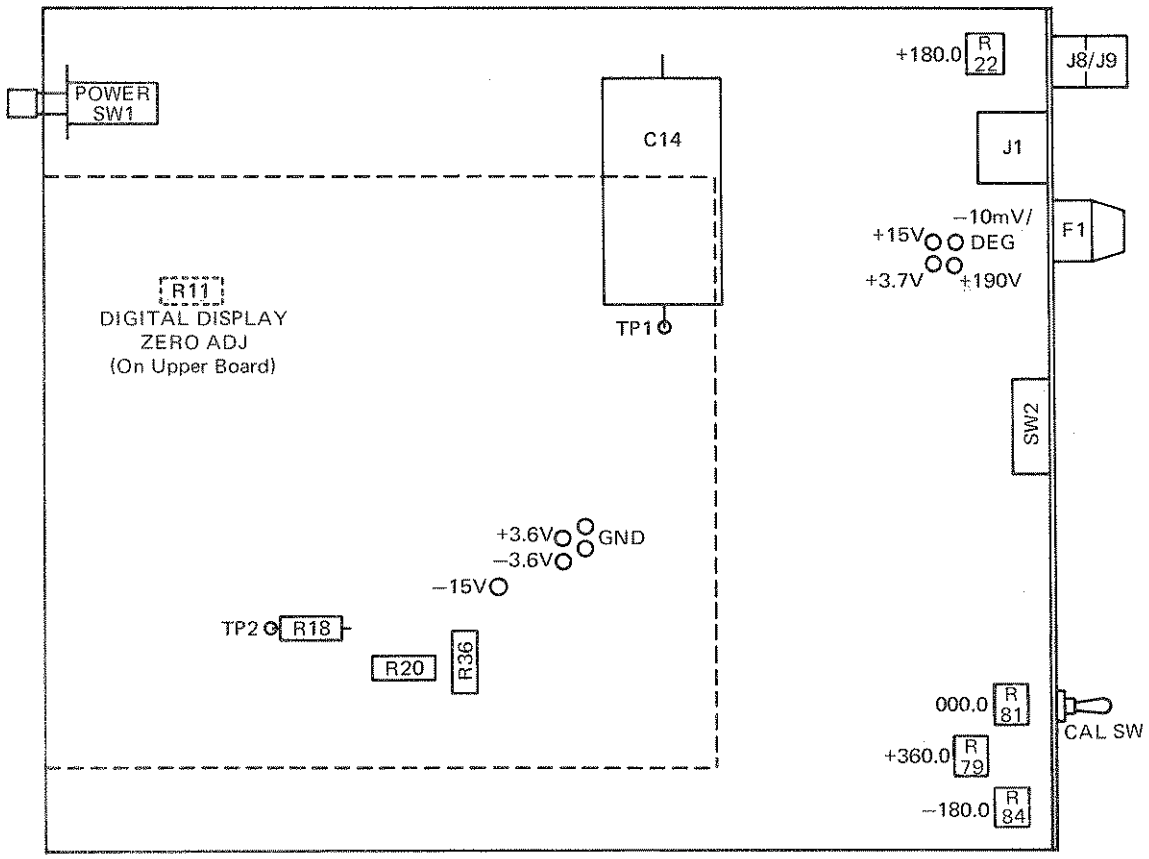


Figure 4-2. Logic Board Adjustment Locations

16. Hold CALIBRATE switch down (000.0/−180.0) and adjust 000.0 ADJ R81 for 0.000 V (±.3 mV) on the voltmeter.
17. Hold CALIBRATE switch down (000.0/−180.0) and adjust DIGITAL DISPLAY ZERO control R11 (accessible from the left side of the top printed circuit board of the Digital Display assembly) for a display of 000.0 plus or minus 1/2-count.
18. Hold CALIBRATE switch up (+360.0/+180.0) and adjust +360.0 ADJ R79 for a display centered between +359.9 and +360.0.
19. Hold CALIBRATE switch up (+360.0/+180.0) and adjust +3.6 V ADJ R20 for −3.600 V (±.3 mV) on the voltmeter.
20. Set RANGE selector to −180°/+180°.
21. Hold CALIBRATE switch down (000.0/−180.0) and adjust −180.0 ADJ R84 for a display of −180.0 plus or minus 1/2-count. Voltmeter should read +1.800 V ±2 mV.
22. Hold CALIBRATE switch up (+360.0/+180.0) and adjust +180.0 ADJ R22 for a display of +180.0 plus or minus 1/2-count. Voltmeter should read −1.800 V ±2 mV.
23. If readings are within ±2 mV, turn power off and reinstall display.
24. If steps 16 through 22 are out more than ±2 mV on the voltmeter, repeat steps 14 through 22 again. If voltmeter still indicates readings outside the specified limits, refer to the Corrective Maintenance instructions in paragraph 4.3.

4.2.5 Zero-Crossing Mid-Frequency Procedure

25. Turn power on, set both VOLTS RMS selectors to .001-2, and set RANGE selector to −180°/+180°.
26. Connect a 1 kHz sine wave, 10 mV rms (28 mV p-p), into each input (Figure 4-1[A]).
27. Check 10:1 oscilloscope probe for dc zero, by connecting it to the GROUND banana jack, and center trace on horizontal centerline of CRT. Set scope gain to 10 mV/centimeter, and sweep speed to 0.1 ms/centimeter.
28. Connect the scope probe to Channel A test point TP2 (Figure 4-3) of the Zero Crossing Board. The oscilloscope should display a waveform similar to the one shown in Figure 4-4[A].
29. Adjust DC BALANCE ADJ R28 so that V1 (Figure 4-4[A]) is equal to V2 (±10 mV).
30. Adjust CHOPPER BALANCE ADJ R64 so that t_1 (Figure 4-4[A] is equal to t_2 (±1 μS).
31. Alternately perform steps 29 and 30 until the closest to optimum results are obtained.
32. Adjust TD ADJ R63 until top of tunnel diode trigger is at zero volts dc (±1 mV) as shown in Figure 4-4[B].
33. Connect scope probe to test point TP5 adjust DC BALANCE ADJ R119, CHOPPER BALANCE R155, and TD ADJUST R154 and perform steps 296 through 32 for Channel B. Recheck oscilloscope for dc drift by connecting the scope probe to the phase meter ground and adjusting scope controls to reposition trace on horizontal center line.
34. If steps 25 through 33 have been followed correctly, the digital readout should indicate one half of plus and minus full scale (CALIBRATE switch up and down readings). This reading is called "out of case zero" in the rest of the manual.

Examples:

Calibrate "Up"	Calibrate "Down"	"Out of Case Zero"
+180.0	−180.0	000.0 (±.1°)
+180.2	−179.8	+000.2 (±.1°)
+180.2	−179.4	+000.4 (±.1°)

N O T I C E

Do not be alarmed if the full scale values are not precise, the instrument is out of the case and will return to proper readings when case is replaced. It is important, however, that the "out of case zero" be displaced equally from the range extremes.

DO NOT READJUST
FULL SCALE VALUES AT THIS POINT

If "out of case zero" is not equally displaced repeat steps 25 through 33 and step 35 below. Go on to the Zero Crossing High Frequency Procedure; three or four tenths of a degree error could be caused by high frequency misalignment.

N O T I C E

35. Increase the input signal amplitude to both channels to 1 V rms (2.8 V p-p). If reading changes more than ±0.1°, adjust PK-PK ADJ R21 and R112 for accurate time symmetry at test points 2 and 5, as shown in Figure 4-4[C].

4.2.6 Zero-Crossing High-Frequency Procedure

36. Set both VOLTS RMS selectors to .001-2, and RANGE selector to −180°/+180° and remove all scope probes.
37. Apply a 10 mV rms sine wave, 80 kHz, into both channels, using the test configuration shown in Figure 4-1[A].
38. Adjust C22 until digital readout is equally displaced from range extremes for "out of case zero" (±0.2).

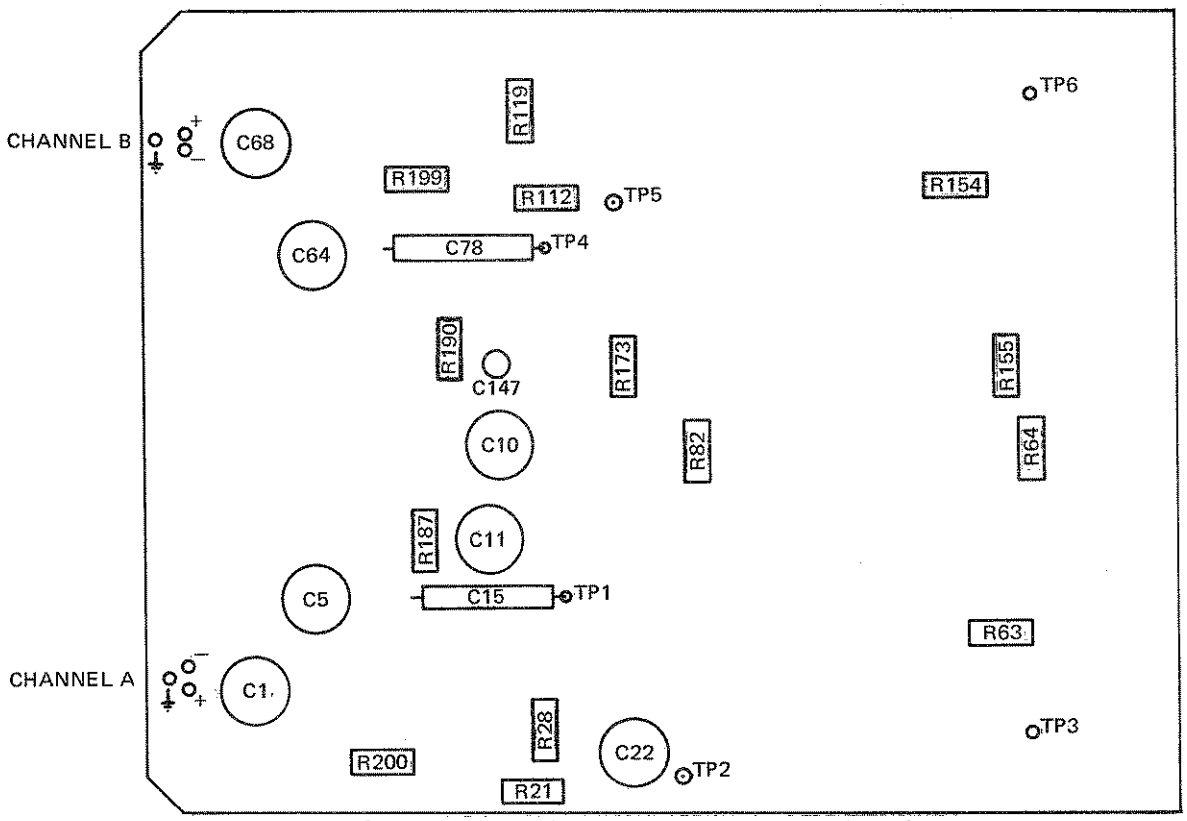


Figure 4-3. Zero Crossing Board Adjustment Locations

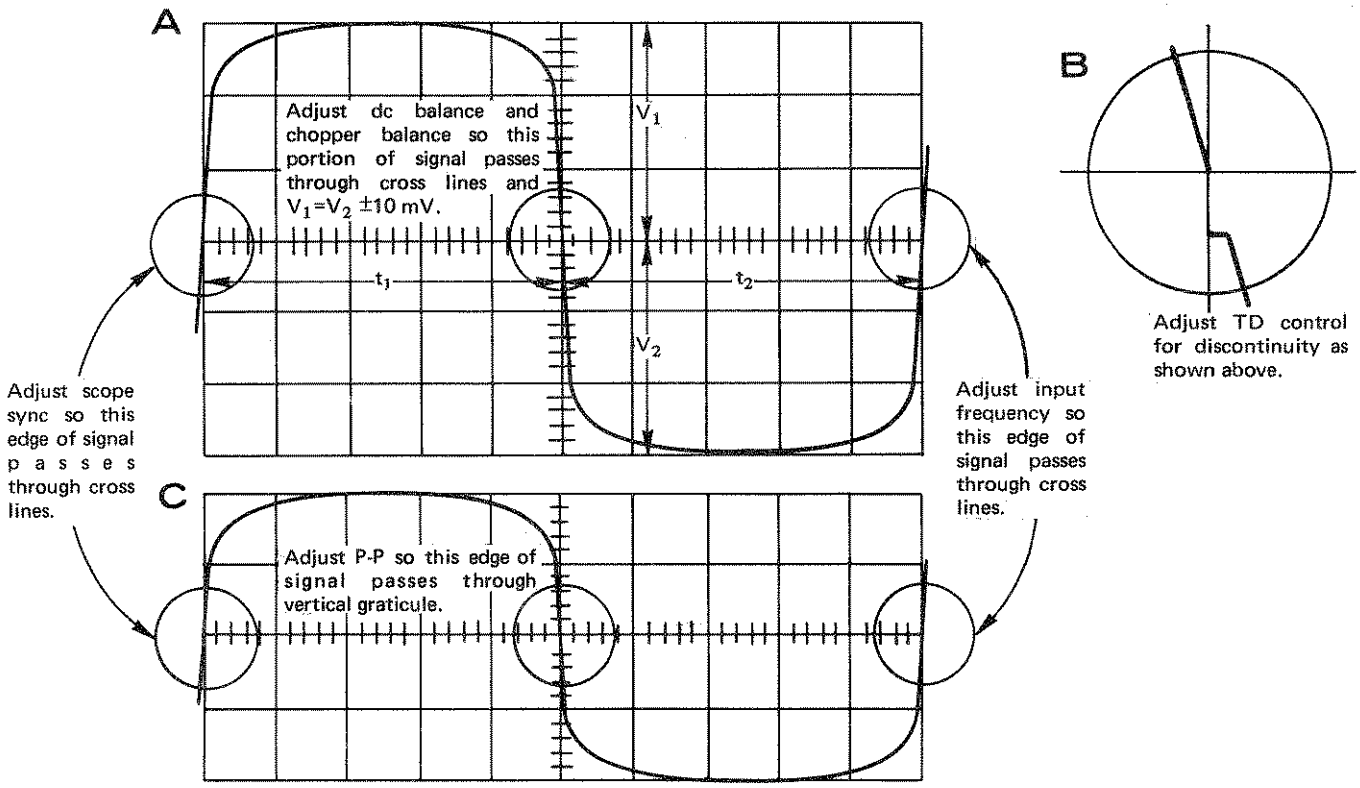


Figure 4-4. Oscilloscope Calibration Displays

39. Increase input amplitude to 100 mV rms, increase input frequency to 800 kHz, and adjust C10 until the digital readout equals "out of case zero" (±.4°).
40. Since steps 38 and 39 interact, they must be alternately performed until both readings, when going from one condition to the other, are within limits. Recheck steps 28 through 33 and, if necessary, readjust controls for proper indications.
41. Apply a 1 mV rms sine wave to both inputs, using the configuration shown in Figure 4-1[A] and, while watching the digital readout, vary the frequency from 1 kHz to 10 kHz. Record the reading at 1 kHz and the reading at 10 kHz. Determine the difference between the two readings, taking into account the polarities indicated, and record this as the "error span".

Examples:

1 kHz Readings	10 kHz Readings	Error Span
−000.2	+001.0	1.2°
+000.2	+001.1	.9°
−000.2	−000.8	.6°

42. Set input frequency back to 1 kHz at 1 mV rms and equally adjust Channel A Tunnel Diode ADJ R63 and Channel B Tunnel Diode ADJ R154 so that the digital display readout indicates one-third of the Error Span with a minus sign. (This would be −000.4° in the first example shown in step 41.)
43. Set input frequency to 10 kHz at 1 mV rms and display readout should indicate two-thirds of the Error Span with a plus sign. If the Error Span is not distributed one-third and two-thirds at 1 kHz and 10 kHz respectively, repeat steps 41 and 42.

4.2.6.1 ATTENUATOR FREQUENCY ADJUSTMENT

NOTE

Make sure the oscilloscope probes are properly compensated for lissajous operation. Check each probe with the scope calibrate signal, then connect both probes to the same signal and vary the frequency from 10 Hz to 1 MHz and make final adjustment for closed lissajous.

44. Set both VOLTS RMS selectors to .3-300, and apply a 1 kHz 7 V rms sine wave to the positive input terminals as shown in Figure 4-1[B]. Connect the probes of a dual channel scope, with lissajous capability, between the plus input terminal and test point TP1 of Channel A.
45. While varying the input frequency from 1 kHz to 10 kHz, adjust C1 for a closed lissajous.
46. Connect the scope probes from TP1 to TP4 of Channel B. Adjust C64 for a closed lissajous. The digital readout should now read within ±.2° of reading obtained with 100 Hz input (switch to 100 Hz without changing amplitude and check). If it doesn't, repeat steps 45 and 46 until the readout is within this limit.

4.2.6.2 COMMON MODE REJECTION CALIBRATION

47. Apply a 10 kHz, 10 mV rms, sine wave to both inputs as shown in Figure 4-1[C]; and set VOLTS RMS selectors to .001-2.
48. Connect scope probe to test point TP2, and alternately adjust R187 and C11 for minimum signal. Increase input to 1 V rms and adjust for double input frequency at TP2.
49. Connect scope probe to test point TP5, and alternately adjust R190 and C147 for minimum signal with 10 mV input. Increase amplitude to 1 V rms and adjust for double input frequency at TP5.
50. Repeat steps 47 through 49 using a 100 kHz input. Adjust only variable capacitors for minimum signals at test points.

4.2.6.3 ATTENUATOR COMMON MODE REJECTION ADJUSTMENT

51. Set both VOLTS RMS selectors to .3-300, and apply a 7 V rms 25 Hz sine wave to both inputs as shown in Figure 4-1[C].
52. Connect scope probe to test point TP2, and adjust R200 for minimum signal.
53. Increase input frequency to 25 kHz, and adjust C5 for minimum amplitude at TP2.
54. Connect scope probe to test point TP5, decrease input frequency to 25 Hz, and adjust R199 for minimum signal.
55. Increase input frequency to 25 kHz, and adjust C68 for minimum amplitude at TP5.

NOTE

Above 30 kHz, it is advisable to keep both channels on the same input range (VOLTS RMS) to minimize phase offset differences in the attenuators. If different ranges are used, note offset at 0° and subtract this from the phase reading.

56. Repeat steps 51 through 55 if needed.
57. Replace the dust cover by following the instructions in paragraph 4.1.1; apply POWER, and allow 20 minutes for the unit to reach a stable operating temperature.
58. Check plus and minus full scale calibration on both RANGE selections by applying the same sine wave, 1 kHz at 1 V rms, to both inputs as shown in Figure 4-1[A].

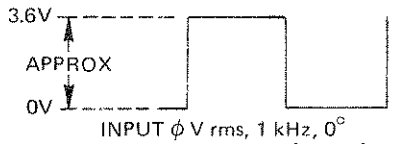
4.3 CORRECTIVE MAINTENANCE

If the Model 750 Phase Meter appears to be operating abnormally, and an investigation of input/output connections, as well as a calibration check, do not cure the problem; follow the trouble-shooting procedure outlined below.

Trouble	Check
1. Readout jumping around when no input signal is applied.	Normal operation, the high sensitivity of the input picks up external 60 Hz noise.
2. Readout scattering occasionally with low input amplitude and/or frequency.	Noise spikes are riding on input signal or signal-to-noise ratio is too high. Put 0.1 μF capacitors, or matched filters, across inputs.
3. Readout scattering randomly with input signal applied.	a. Check that phase angle is not within 2° of RANGE extreme. Use other RANGE setting. b. Reduce ground loops, and use differential inputs isolating grounds.
4. Erroneous phase reading.	a. Check both VOLTS RMS settings. Overdrive causes phase errors. b. Quick check CALIBRATE limits. c. If "a" and "b" do not help, apply same input to both channels, select −180°/+180° RANGE and, if reading is not 000.0, recalibrate Zero Crossing board.
5. Display not lighted when POWER is set to ON.	Check fuse. Check +180 V, ±15 V, ±3.6V, and +5 V power supplies.
6. Two digits light in same lamp.	Defective display lamp.
7. Display locked on maximum or minimum full scale regardless of inputs.	a. If locked on maximum, Channel A Zero Crossing has no output. b. If locked on minimum, Channel B Zero Crossing has no output. c. If not "a" or "b" check IC4 on the Logic and Power Supply board.
8. Input loading circuit being measured due to low input impedance.	Input FET Q1, Q2, Q14, or Q15 has been damaged. Replace with MPF104 or 2N5458 or equivalent.

If the instrument is not operating properly, and the above steps do not solve the problem, recalibrate the instrument as described in paragraph 4.2. If recalibration does not solve the problem, follow the procedure outlined below.

1. First check all power supplies for proper operation. If any are malfunctioning, refer to the Circuit Description as well as the schematic when trouble shooting the supply.
2. With 1 kHz 1 V rms sine waves applied to both inputs, look at Zero Crossing test points TP3 and TP6. If 1 V pulses at 1 kHz are not observed, read Circuit Description and refer to the schematic for trouble shooting.
3. If the proper pulses are seen in step 2 above, look at the junction of R65, R66, and R68. This point should show a waveform like that pictured below.



INPUT ϕ V rms, 1 kHz, 0°
RANGE set to −180°/+180°

4. If the dc OUTPUT −10mV/DEG is correct but the digital display is incorrect, recheck +180 V, +5 V, and ±3.6 V supplies. Refer to the timing diagram (Figure 3-6) and Circuit Description given in paragraph 3.2.3.

SECTION 5
NOTES AND ADDENDUMS

5.1 ADDENDUMS

WAVETEK'S product improvement program incorporates the latest electronic development into it's instruments as rapidly as development and testing permit. Due to the time required to document and print instruction manuals, it is not always possible to include the change information in the final printing. When this occurs, change pages or addendum sheets are prepared for insertion immediately behind the title page. If no such pages exist, the manual is correct as printed.

5.2 NOTES

The space below may be used to record pertinent data relating to a specific unit, or general information helpful to user. When minor "special" features are requested in the purchase order, WAVETEK will summarize these features below.