KROHN-HITE

MODEL 6600
OPERATING and MAINTENANCE MANUAL

10Hz to 10MHz

PRECISION PHASEMETER

SERVICE AND WARRANTY

KROHN-HITE Instruments are designed and manufactured in accordance with sound engineering practices and should give long trouble-free service under normal operating conditions. If your Instrument fails to provide satisfactory service and you are unable to locate the source of trouble, contact our Representative if there is one in your area or write to our Service Department giving all the information available concerning the failure.

Do not return the instrument without our written authorization for, in most cases, we will be able to supply you with the information necessary to repair the instrument and thus avoid the transportation problems and costs. When it becomes necessary to return the instrument to our Factory, kindly pack it carefully and ship it to us prepaid.

All KROHN-HITE products are warranted against defective materials and workmanship. This warranty applies for a period of one year from the date of delivery to the original purchaser. Any instrument that is found within the one year period not to meet these standards, will be repaired or replaced. This warranty does not apply to electron tubes, fuses, or batteries. No other warranty is expressed or implied.

KROHN-HITE CORPORATION reserves the right to make design changes at any time without incurring any obligation to incorporate these changes in instruments previously purchased.

Modifications to this instrument must not be made without the written consent of an authorized employee of KROHN-HITE CORPORATION.

1Hz TO 10MHz

PRECISION PHASEMETER

MODEL 6600

Serial No. __________

OPERATING AND MAINTENANCE MANUAL

KROHN-HITE CORPORATION

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SECTION 1
GENERAL DESCRIPTION

1.1 INTRODUCTION

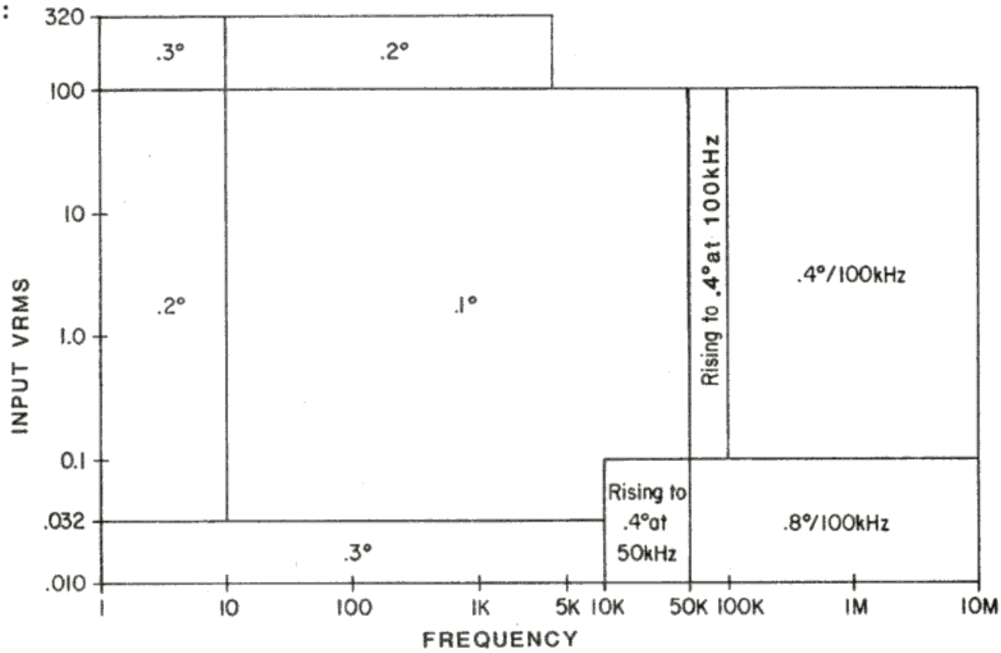
The Model 6600 Precision Phasemeter measures the phase angle between two waveforms of coincident frequency, over a range of 10Hz to 10MHz with a typical accuracy of 0.1° and 0.1° resolution. It will accept a wide range of input signal levels automatically without range switching from 10 millivolts to 320 volts rms, and input waveforms of sine, square, triangle, and pulses of >50ns. A 4 digit, LED display provides continuous direct read-out of phase angles between 0.0° and 360.0°. An analog output provides a dc voltage equal to 10mV/° for use with an external meter or recorder.

The Model 6600 is carefully inspected, aged, and adjusted before shipment, and ready for operation when unpacked. If it has been damaged in shipment, make a claim with the carrier and notify Krohn-Hite immediately.

1.2 SPECIFICATIONS

FREQUENCY RANGE: 10Hz to 10MHz (1Hz Optional)
ACCURACY

Sine Wave:



Square Wave: Double the sine wave specification.

INPUT

Signal Amplitude: Auto ranging from 0.01V to 320Vrms.

Waveforms: Sine, triangle, square and >50ns pulse. (The phasemeter is triggered on the positive going transition of the input waveform. A sine-wave on the reference input and a square wave on the signal input is allowed).

Impedance: 1 Megohm in parallel with a 50pf.

MAXIMUM DC COMPONENT: ±200 volts.

RESPONSE

Time Constant: >10Hz, less than 500msec; <10Hz, less than 5sec.

Settling Time: To within specified accuracy, within 1 to 8 seconds, dependent on input amplitude and frequency (>10Hz).

DRIFT

Vs. Time: (30 days without CALIBRATE reset) Sine Wave, ±0.025° from 20Hz to 100kHz; ±0.1° at 10Hz; ±0.1° per 100kHz above 100kHz. Square Wave, ±0.025° from 10Hz to 5kHz; ±0.05° to 100kHz; ±0.1° per 100kHz above 100kHz.

Vs. Temperature: (Without CALIBRATE reset) ±0.01°/°C, 10Hz to 100kHz; ±0.05°/°C to 1MHz; ±0.05°/°C per MHz above 1MHz.

ANALOG OUTPUT: (for use with an external meter or recorder) 0-3.6 volts DC, 10mV DC/degree phase, impedance 50 ohms.

DISPLAY: 0.5", 7 segment, green LED.

DISPLAY RANGES: 0.0° to 360.0°.

RESOLUTION: 0.1°.

REPEATABILITY: Better than 0.1°.

POWER CABLE: 7 feet, removable.

DIMENSIONS: 3.5"/(9cm) high, 16.5"/(41.9cm) wide, 16"/(40.6cm) deep.

WEIGHTS: Net 15 lbs/(6.75kg), Shipping 18 lbs/(8.1kg).

AMBIENT TEMPERATURE RANGE: 0°C to 50°C.

FRONT PANEL CONTROLS: POWER, Reference Waveform, Signal Waveform, CALIBRATE (0° and 360°), phase adjust (0° and 360°).

POWER REQUIREMENTS: 90-132V or 198-264V, single phase, 50-400Hz, 40W.

OPTIONS

- **RK-316:** Rack Mount Kit for a standard 19" rack spacing.
- **Option 001:** BCD Output.
- **Option 002:** 1Hz operation.
- **Option 003:** Rear panel BNC connectors for REFERENCE and SIGNAL inputs.

Specifications are subject to change without notice.

1.3 TYPICAL PERFORMANCE

Typical performance of the Model 6600 is shown in Figure 1.1 with matched inputs. The graph with interrupted lines is the specified response with unmatched inputs over the input range of 0.1 to 100V.

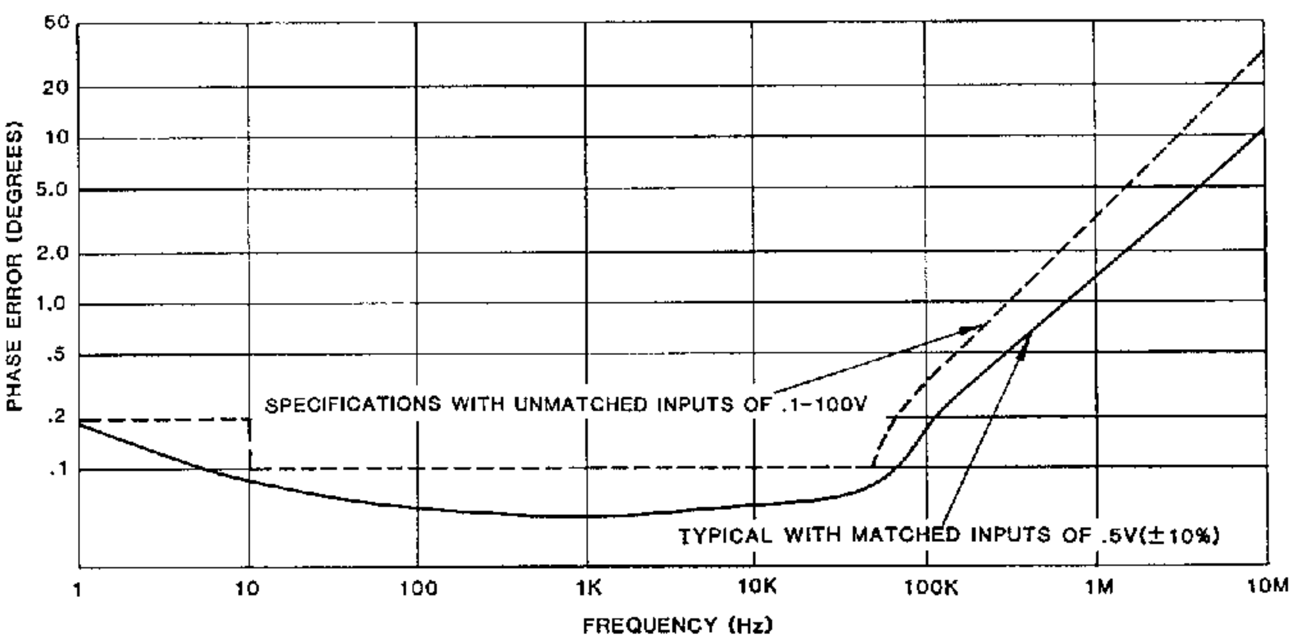


Figure 1.1 Typical Performance

1.4 FACTORS AFFECTING PHASEMETER ACCURACY

1.4.1 Inconsistencies In Meter Reading Near 0° and 360°

A problem affecting a phasemeter's accuracy is the inability of the phasemeter circuit to detect relatively small phase angles, resulting in meter fluctuations or inconsistencies in meter readings. The 6600 overcomes this inconsistency (or ambiguity as it is sometimes referred to) by using a specially designed network that permits measurements as small as 0.1° to be made without meter fluctuations or repeatability errors, and eliminates the need for multiple meter ranges, or shifting of the meter scale.

1.4.2 Noise Present On The Input Signals

Another problem affecting phase accuracy is random noise. If there is a sufficient noise level on either or both inputs, false triggering will occur and a phase error is introduced. The 6600 uses special circuits plus filtering to minimize the effects of noise on the phase accuracy. Typically, any broadband noise present on both inputs 40dB down from the input signals will produce only a 0.1° error. Figure 1.2 gives a typical curve for phase error versus input frequency, for a signal to noise ratio of 10:1 on both inputs.

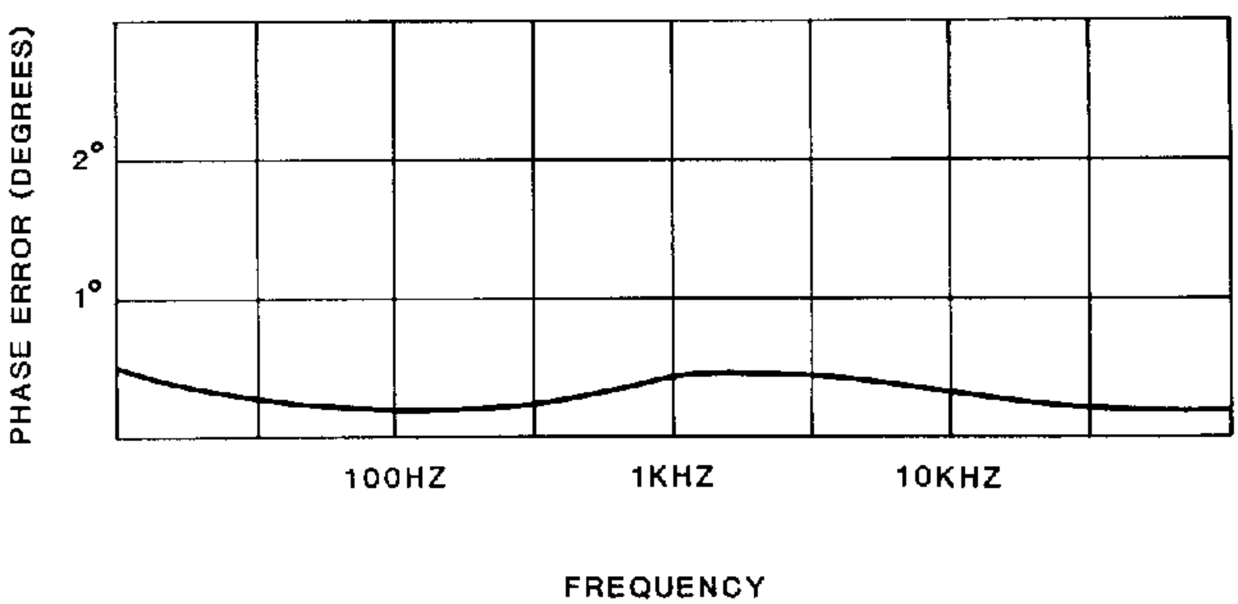


Figure 1.2 Phase Error for a 10:1 Signal-to-Noise Ratio

1.4.3 Distortion Present On The Input Signal

If there is distortion present on one of the input signals, a phase error may be introduced, depending upon the relationship between the fundamental and its harmonics. If the amplitude of all the odd or even harmonics add up to zero at the positive zero crossing of the fundamental, then the harmonics will produce no phase error. If the resultant of the amplitudes is not zero, however, it will cause a shift in the zero crossing of the input waveform. Worst case would occur when the maximum of the harmonic coincides with the positive zero crossing of the fundamental. The effect of an even harmonic will not only shift the zero crossing of the waveform, but also alter the symmetry of the comparator or detector output. If a symmetry control loop is added to the phasemeter circuit, the effect of the even harmonic on accuracy can be minimized. The 6600 uses the type of symmetry loop mentioned above.

The effect of an odd order harmonic is not as easily corrected. An odd order harmonic simply shifts the phase of the output of the comparator or detector loop. Since the symmetry is not affected, there is no way to detect any phase error. Figure 1.3 shows the maximum phase error introduced versus the percentage of harmonic distortion present on each input channel.

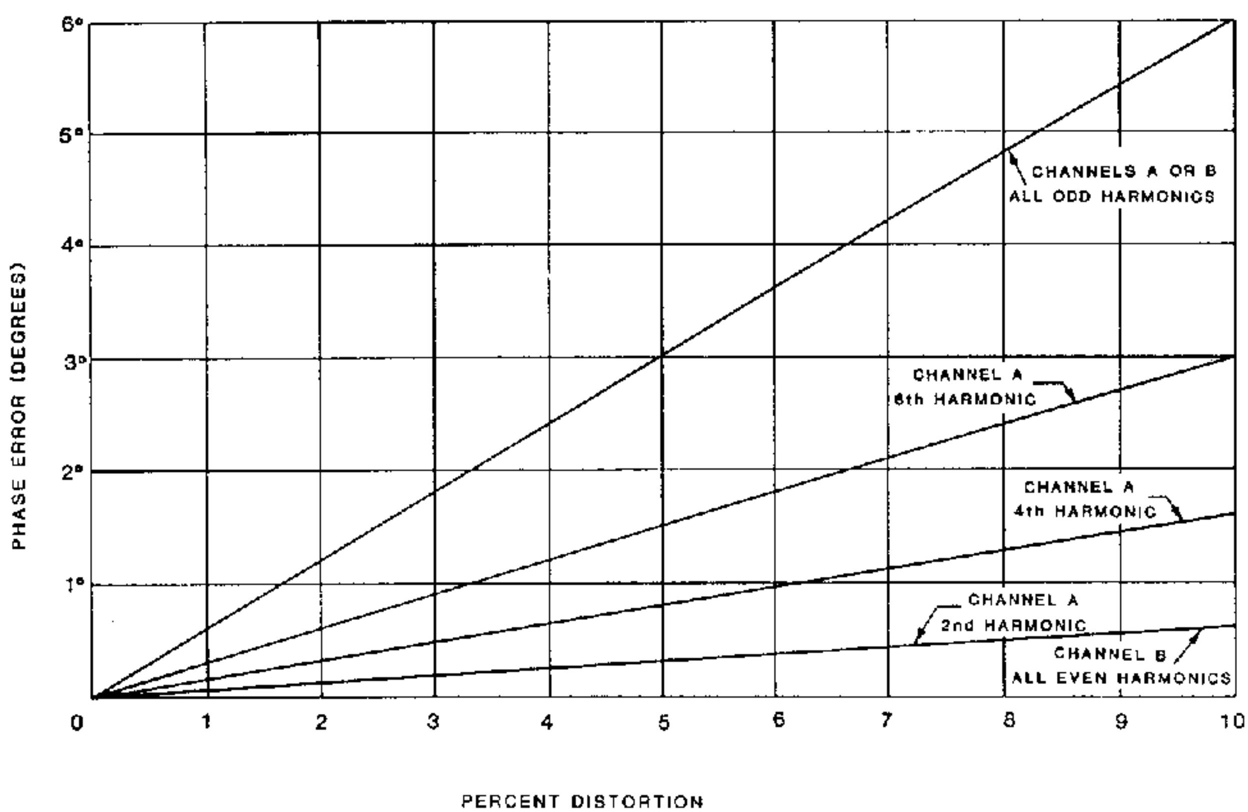


Figure 1.3 Maximum Phase Error vs. % Harmonic Distortion

SECTION 2
OPERATION

2.1 INTRODUCTION

This section describes the basic operation of the Model 6600. It includes the proper ac power requirements, the recommended turn-on procedure and a detailed explanation of all operating controls and modes of operation.

2.2 POWER REQUIREMENTS

The Model 6600 is designed to operate from a single phase, 50-400Hz ac power source of 90-110, 108-132, 198-244 or 216-264 volts. Line switches on the rear panel allow it to be powered from one of the above 4 voltage ranges. The ac power receptacle, on the rear panel, is a standard 3-pin connector and complies with the European I.E.C. standard. The fuse receptacle contains a 3/4 ampere slo-blow fuse for 120V operation and a 3/8 ampere slo-blow fuse for 240V operation. A detachable line cord is provided with the instrument.

2.3 TURN-ON PROCEDURE

1. Set the line switches for the correct voltage range and check to see that a fuse with the correct rating is in the fuse receptacle.

   For 90-110 volts, set the 120V/240V switch to 120V and the NORM/LO switch to LO. The fuse should be 3/4 amp.

   For 108-132 volts, set the 120V/240V switch to 120V and the NORM/LO switch to NORM. The fuse should be 3/4 amp.

   For 198-244 volts, set the 120V/240V switch to 240V and the NORM/LO switch to LO. The fuse should be 3/8 amp.

   For 216-264 volts, set the 120V/240V switch to 240V and the NORM/LO switch to NORM. The fuse should be 3/8 amp.

2. Make sure that the POWER switch is in the OFF position.
3. Plug the line cord into the unit and into an ac outlet.
4. Turn the power on and allow it to warm-up for several minutes.

CAUTION

For safety purposes, the line cord must be connected to a grounded 3 terminal ac outlet. Because of potentially dangerous voltages that exist within the unit, the cover should be removed by qualified personnel only.

2.4 FRONT PANEL CONTROLS, CONNECTORS AND INDICATORS

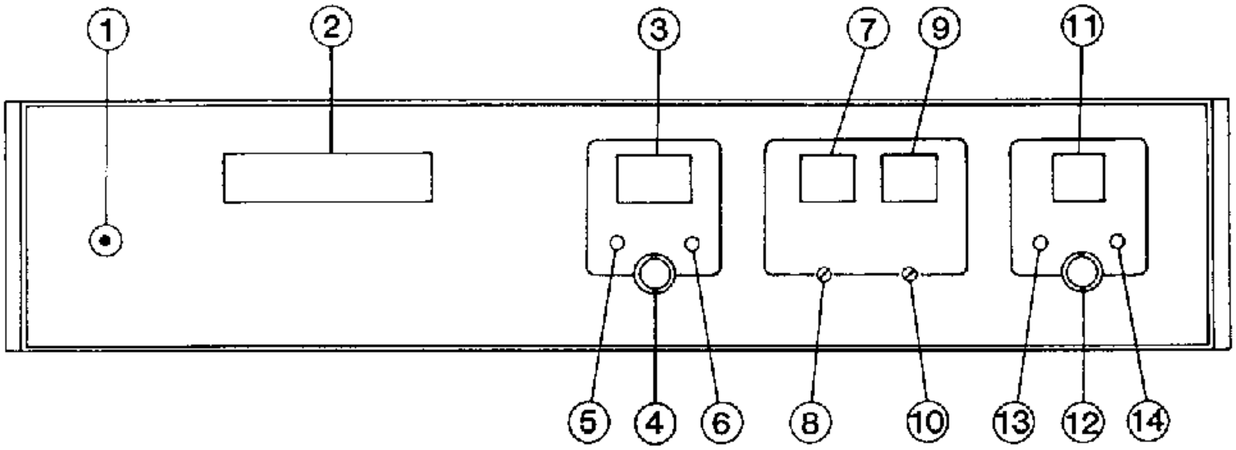


Figure 2.1 Front Panel Controls, Connectors and Indicators

1.	POWER	On/Off toggle switch.
2.	DISPLAY	5 digit, green LED, 0.55" high.
3.	WAVEFORM	Selects desired waveform applied to REFERENCE input.
4.	REFERENCE INPUT	BNC, 10mV to 320Vrms.
5.	LED INDICATOR	Indicates REFERENCE input is <10mVrms.
6.	LED INDICATOR	Indicates REFERENCE input is >320Vrms.
7.	CALIBRATE	Meter calibration at 0.0°. Press and hold while adjusting control below key.
8.	CONTROL	Adjustment for 0.0°.
9.	CALIBRATE	Meter calibration at 360°. Press and hold while adjusting control below key.
10	CONTROL	Adjustment for 360.0°.
11.	WAVEFORM	Selects desired waveform applied to SIGNAL input.
12.	SIGNAL INPUT	BNC, 10mV to 320Vrms.
13.	LED INDICATOR	Indicates SIGNAL input is <10mVrms.
14.	LED INDICATOR	Indicates SIGNAL input is >320Vrms.

2.5 REAR PANEL CONTROLS AND CONNECTORS

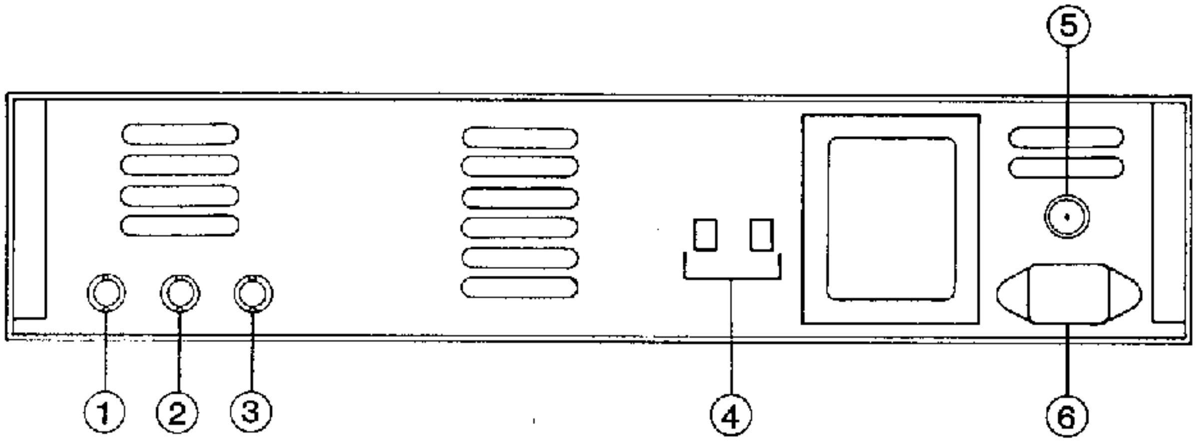


Figure 2.2 Rear Panel Control and Connectors

1.	SIGNAL INPUT	BNC (optional), 10mV to 320Vrms.
2.	REFERENCE INPUT	BNC (optional), 10mV to 320Vrms.
3.	ANALOG OUTPUT	BNC, 0 to 3.6Vdc, 10mV/°. Impedance 50 ohms.
4.	LINE	Slide switches to select 120V or 240V operation, and NORMAL or LOW ac line.
5.	FUSE RECEPTACLE	3/4 amp for 120V operation, 3/8 amp for 240V operation.
6.	AC POWER RECEPTACLE	Standard 3 Pin Receptacle.

2.6 OPERATION

To operate the Model 6600 proceed as follows:

1. Make the appropriate power connections to the unit. Turn the power on and let the unit warm up for at least 30 minutes to achieve the rated accuracy and eliminate any drift that may be caused due to temperature variation.

2. Press and <u>hold</u> the [0] key in the CALIBRATE section and adjust the screwdriver control below the key so display reads 0.0°.

   Press and <u>hold</u> the [360] key in the CALIBRATE section and adjust the screwdriver control below the key so display reads 360.0°.

> **NOTE**
>
> The 0° and 360° keys are momentary switches. They must be held down when adjusting the display.

After the unit has warmed up and the initial calibration was done to the phasemeter, connect the reference signal to the REFERENCE INPUT and the signal to be measured to the SIGNAL INPUT.

NOTE

It is recommended that matched, equal length, coaxial cables be used, as a difference in length may affect the phasemeter accuracy, especially at higher frequencies. As an example, two cables of the same type (approximately 30pf/ft), but differing in length by one foot will create an error at 100kHz of about 0.06°.

When the input cables are connected to the proper inputs, press the WAVEFORM key on each channel to select the desired input waveform. If the [sine] is selected, the phasemeter will measure phase angles between sine waves, a sine and triangle wave, or triangle waves. If the [square] is selected, the phasemeter will measure squarewaves and/or pulses. Pulse width must be >50ns. It is recommended, however, that when a [sine] is selected with a [square], that the sine wave, which will be the cleanest signal, be connected to the REFERENCE INPUT. If a sinewave is used when [square] is selected, an error of several degrees can be expected.

After selecting the proper WAVEFORM, check to see that the LED above the REFERENCE and SIGNAL inputs are off. When the input voltage is less than 10mV rms (<.01V) or greater than 320V rms (>320V), the appropriate LED will light to indicate the too low/high condition. If either LED is on, adjust the input voltage level until the LED turns off.

SECTION 3
DIGITAL INTERFACE

3.1 BCD OPTION

The Model 6600 with the BCD option is equipped with a digital data connector (Amp type 206604-1), mounted on the rear panel, that provides an equivalent BCD output of the front panel display, including polarity. A total of 15 data lines, 4 control lines, plus 5 lines of ground return are provided.

A total of 14 lines are used to provide the BCD equivalent output of the 4 digit, front panel display. Each digit, with the exception of the 100's digit, is represented by 4 output lines, and is binary-coded in a 1-2-4-8 format. The 100's digit is represented by 2 lines, coded in a 1-2 format.

3.2 OUTPUT CONNECTOR PIN CONNECTIONS

Pin #	Function	Description
1	Chassis Ground	
2	Digital Ground	
3	Digit 1 Disable (LSD)	
4	Digit 2 Disable	
5	Digit 3 Disable	
6	Digit 4 Disable (MSD)	
7	Digit Ground	
8	000.1	
9	000.2	
10	000.4	
11	000.8	
12	Digital Ground	
13	Digital Ground	
14	001.0	
15	002.0	
16	004.0	
17	008.0	
18	010.0	
19	020.0	
20	040.0	
21	080.0	
22	100.0	
23	200.0	
24	Polarity (+/-)	"High" for positive angle. "Low" for negative angle.
25	No Connection	

The logic levels for all OUTPUT lines are 0V < Low > 0.5V; Isink = 10ma.
2.4V < High > 5.0V; Isource = .5ma.

SECTION 4
INCOMING ACCEPTANCE

4.1 INTRODUCTION

The following procedure should be used to verify that the Model 6600 phasemeter is operating within specifications. These tests may be used for incoming acceptance and periodic performance checks. The procedure should be followed in sequence, with the covers in place, and the phasemeter operating for ½ hour to reach thermal equilibrium.

Before testing, follow the operating procedure in Section 2 of this manual. If not operating within specifications, refer to Section 5, Calibration, before attempting any detailed maintenance.

NOTE

As an alternate to the following procedure, a Primary Phase Angle Standard, such as the Dytronics Model 311/RT-1/717S may be used for accuracy measurements between 30Hz and 10kHz. A second alternative is the use of a Computing Counter System, such as the HP Model 5360A when used with a suitable phase shifting circuit.

4.2 TEST EQUIPMENT REQUIRED

The test equipment below is required to perform the following tests.

a. Low Distortion Oscillator: frequency range from 1Hz to 100kHz with quadrature output. Distortion <0.01% from 10Hz to 20kHz rising to 0.1% at 100kHz. Krohn-Hite Model 4024A or equivalent.

b. RC Oscillator: frequency range from 10Hz to 10MHz with balanced output. Two Krohn-Hite Model 4300B (operating in synchronism as shown in Figure 4.1) or HP Model 654A.

c. Variable Phase Generator: adjustable phase angle from 0° to 360°. HP Model 203A or equivalent.

d. DVM: Fluke Model 8012A or equivalent.

e. Matched set of coaxial cables (BNC) of the same type and length.

4.3 PROCEDURE

4.3.1 Display Calibration

After the Model 6600 has been operating for a minimum of ½ hour, with covers in place, proceed with calibration.

1. Press and <u>hold</u> the 0° key in the CALIBRATE section and adjust the screwdriver control below the key so DISPLAY indicates 00.0°.
2. Press and <u>hold</u> the 360° key in the CALIBRATE section and adjust the screwdriver control below the key so DISPLAY indicates 360.0°.

> **NOTE**
>
> The 0° and 360° keys are momentary switches. They must be held down during calibration.

4.3.2 Low Frequency Sinewave Check

Connect the output of the low-distortion oscillator, with matched cables (same type and length), to <u>both</u> the REFERENCE and SIGNAL inputs. Set both waveform selectors of the phasemeter to the sine wave mode, the oscillator frequency to 100Hz and its amplitude to 0.5Vrms. Press the 0 key in the CALIBRATE section until the DISPLAY indicates 00.0° and then release it. The DISPLAY should indicate 00.0° ±0.1°. Press the 360 CALIBRATE key until the DISPLAY indicates 360° and then release it. The DISPLAY should indicate 360.0° ±0.1°. Repeat this procedure at 10Hz. 1kHz, 10kHz and 50kHz, and oscillator amplitudes of 1.5V and 5Vrms.

4.3.3 High Frequency Sinewave Check

Connect the output of the RC oscillator, with matched cables to <u>both</u> inputs. Set the oscillator frequency to 100kHz and its amplitude to 0.5Vrms. Press the 0 key until the DISPLAY indicates 00.0° and then release it. The DISPLAY should indicate 00.0° ±0.4°. Press the 360 key until the DISPLAY indicates 360.0° and then release it. The DISPLAY should indicate 360.0° ±0.4°. The same specifications apply when the above procedure is repeated at an amplitude of 1.5Vrms. Repeat the above procedure at 500kHz and 1MHz. The DISPLAY tolerance should be ±2° at 500kHz and ±4° at 1MHz.

4.3.4 Quadrature Low Frequency Check

Connect the output of the low distortion oscillator to the REFERENCE input and the quadrature output to the SIGNAL input. Set the oscillator to 100Hz and the amplitude of both outputs to 0.5Vrms. Record the phase reading.

Reverse the inputs and record the phase readings. The sum of both readings should be 360.0° ±0.2°. The tolerance of this sum is twice the specified accuracy of 0.1°. Repeat this procedure at 1kHz, 10kHz and 50kHz.

4.3.5 Balanced High Frequency Sinewave Check

Connect the output of one RC oscillator to the REFERENCE input of the phasemeter and the output of another RC oscillator to the SIGNAL input. Set both oscillators to the sine wave mode. Balanced output, as shown in Figure 4.1, is obtained by synchronizing the two oscillators. Set both oscillators to 100kHz and their amplitudes to 0.5Vrms. Fine tune one oscillator, by monitoring both oscillators on a suitable scope, to obtain balanced output. Record the phase reading.

Reverse the two inputs and record the phase readings. The sum of both readings should be 360.0° ±0.8°. The tolerance of this sum is twice the specified accuracy of 0.4°. Repeat this procedure at 500kHz and 1MHz. Tolerance of the total reading is ±4.0° at 500kHz and ±8.0° at 1MHz.

4.3.6 Balanced Low Frequency Squarewave Check

Connect two RC oscillators as in 4.3.5. Set both oscillators to the square wave mode at a frequency of 100Hz and amplitude of 1.5Vrms. Fine tune one oscillator, by monitoring both oscillators on a suitable scope, to obtain balanced output. Record the phase reading.

Reverse the two inputs and record the phase readings. The sum of both readings should be 360.0° ±0.4°. The tolerance of this sum is twice the specified accuracy of 0.2°. Repeat this procedure at 10Hz, 1kHz, 10kHz and 50kHz.

4.3.7 Balanced High Frequency Squarewave Check

Connect two RC oscillators as in 4.3.5. Set both RC oscillators to square wave mode at afrequency of 100kHz and their amplitudes to 1.5Vrms. Fine tune one oscillator, to obtain balanced output. Record the phase reading.

Reverse the two inputs and record the phase readings. The sum of both readings should be 360.0° ±1.6°. The tolerance of this sum is twice the specified accuracy of 0.8°. Repeat this procedure at 500kHz and 1MHz. Tolerance of the total reading is ±8° at 500kHz and ±16° at 1MHz.

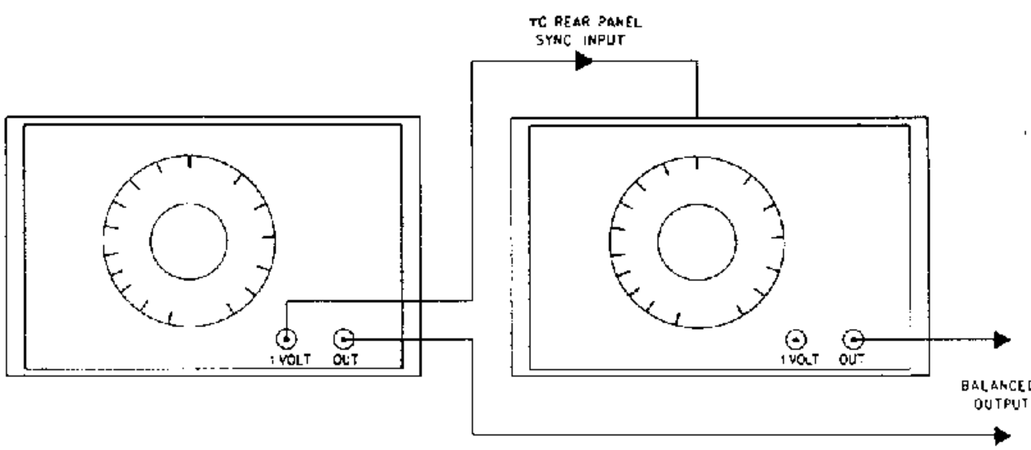


Figure 4.1 Synchronized RC Oscillators

4.3.8 Analog Output Check

Connect the sine wave output of a variable phase generator, or two Krohn-Hite Model 4300B oscillators operating in synchronism, to the phasemeter inputs. Set both oscillators or variable phase generator to 1kHz at 1Vrms. Connect the DVM in the DC mode to the rear panel analog output connector. Set the variable phase generator for 180° or adjust one of the Model 4300B oscillators to obtain 180° phase shift, as shown on the DISPLAY of the phasemeter. The DVM should indicate 1.8Vdc. When the oscillators or generator are set to 170°, as shown on the DISPLAY, the analog output should drop to 1.7Vdc or 10mV/degree. This will apply to any phase angle between 0° and 360°.

4.3.9 BCD Output Check (optional)

The BCD output can be checked out by inputting a known phase and monitoring the appropriate pin-out on the rear panel BCD output connector. Section 4.8 provides detailed information about the BCD and its output pin connections. If a suitable variable phase generator is not available, two Krohn-Hite Model 4300B RC oscillators, operating in synchronism, will provide variable phase over a limited range.

Set both RC oscillators to 1kHz at 5Vrms output. Monitor pin 8 of the output connector with a DVM and <u>fine</u> tune one oscillator so DISPLAY varies from 180.0° to 180.1°. Pin 8 should be "low" at 180.0° and "high" at 180.1°. It will also be "high" when the least significant digit is 3, 5, 7 or 9. This procedure can be used to provide phase variation up to approximately ±80° to check out all pin-outs.

A simple procedure that uses only the 360° front panel screwdriver calibration control of the phasemeter, will check out most pin-outs simultaneously. When the 360° calibrate key is pressed and held down so the phasemeter remains in the calibration mode, the DISPLAY should indicate 360.0° and the 200, 100, 40 and 20 pin-outs should be in the "high" position. If the 360° screwdriver control is then adjusted for a DISPLAY of 359.7, the 200, 100, 40, 10, 8, 1, 0.4, 0.2 and 0.1 pin-outs should be "high". By adjusting the control for a DISPLAY of 359.9°, the 200, 100, 40, 10, 8, 1, 0.8 and 0.1 pin-outs should be "high". This procedure checks out all the pin-outs except 2, 4 and 80.