5. Out-of-Range Period Measurements

This procuedure can be used if when the sweep VARIABLE control is in the fully clockwise CAL position the waveform is longer than 10 divisions on one TIME/DIV control setting and less than 3 divisions long on the next higher TIME/DIV scale. This general procedure may also be used to compare the period of an unknown frequency to a standard.

1. Connect the vertical INPUT to the 0.25V CAL terminal using the X1 input probe. (another reference frequency may be used if desired)
2. Set up the scope controls for a normal sweep display.
3. Set scope controls as follows:
   -VOLTS/DIV to 50mV position
   -V.VARIABLE to CAL
   -TIME/DIV to .1mS
   -sweep VARIABLE to CAL
4. The displayed square wave should now be 10 divisions long. Since the TIME/DIV control is in the 0.1mS/DIV position the period is 0.1mS/DIV X 10 div/cycle = 1mS/cycle. The frequency is:

   $$\text{Frequency} = \frac{1}{1\text{X}10^{-3}\text{sec/cycle}} = 1\text{X}10^{3}\ \text{cycle/sec or 1KHz.}$$

   Note that the accuracy of the CAL signal is ±5%.
5. Move the sweep VARIABLE control until the square wave is 5 divisions long. With the sweep VARIABLE control in this position the time per division of each position of the TIME/DIV switch is doubled. The 10mS/DIV position is now 20mS/DIV, the 1mS/DIV is now 2mS/DIV etc. By leaving the sweep VARIABLE control in this position, period and frequency measurements may be made using the procedures in this manual.

6. Phase Difference Measurement (point-shift method)

This method may be used to determine the phase difference of two sine waves.

1. Set the scope controls to obtain a normal sweep display then set the controls as follows:
   -MODE to NORM
   -SOURCE Selector to EXT
2. Connect the leading signal to both the vertical INPUT jack and the EXT INPUT jack.
3. The scope is now being triggered through the EXT INPUT. This will be the reference signal. Set the scope controls so that one or two sine waves are displayed. It may be helpful to make one cycle an exact number of divisions in length.
4. Position the sine wave so that the center of the sine wave is on the center horizontal graticule line. (see Fig. 9a)
5. Set the H. POSITION control so that the trace begins on exactly the left-most vertical graticule line.

(a) Centered display (b) Shifted display

Fig. 9 Displays for phase difference measurement

6. Set the triggering LEVEL control so that the sine wave begins on the center horizontal graticule line. (see Fig. 9a) Make sure this control remains undisturbed for the rest of this procedure.
7. Leave the leading signal connected to the EXT INPUT (this is the reference signal the scope is triggering on) and disconnect the signal from the vertical INPUT.
8. Connect the lagging signal to the vertical INPUT jack.
9. Note the number of divisions of difference between the starting point of the reference signal displayed previously and this signal (see Fig. 9b).

   The phase angle difference can be calculated by first determining the period of the waveform T. Count the divisions covered by one complete cycle of the waveform. The phase angle can then be calculated using the following equation:

$$\frac{\text{Number of divisions of shift (t) X 360}}{\text{Number of divisions of period (T)}} = \text{phase shift angle}$$

$$\text{or } \frac{360t}{T} = \text{phase shift angle}$$

Remember that the TIME/DIV settings are multiplied by two.

7. Comparative Frequency Measurements and Phase Comparisons

This method can be used to compare two frequencies if they are both sine waves and if one is adjustable in frequency or one is a harmonic of the other, and the signals are somehow synchronized.

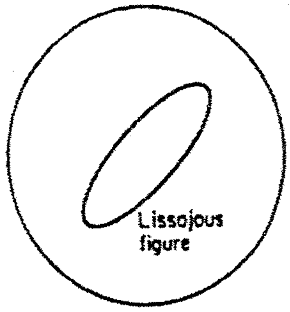
This method can also be used to make a rough phase comparison between two sinusoidal signals.

1. To make a phase or frequency comparison of two signals, connect one signal to the EXT INPUT jack on the rear of the scope. The deflection of this signal is about 0.1V per division and is not externally adjustable on the scope. Therefore, for an acceptable display the input signal must be between about 0.3V and 1V with the X1 input or 3V to 10V with the X10 probe.

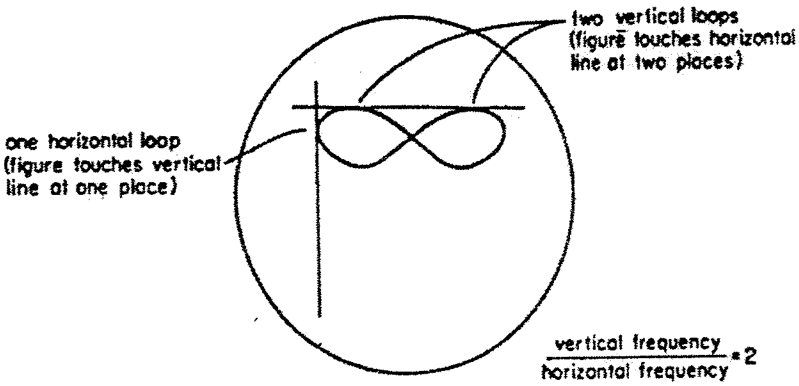
2. Connect the other signal to the vertical INPUT jack on the front pannel.
3. Set the AC-GND-DC switch to AC.
4. Set the MODE selector to EXT.
5. Adjust the VOLTS/DIV selector and the V. VARIABLE for a good display.

For frequency comparison the frequency ratio of vertical to horizontal will be the ratio of the number of vertical loops to the number of horizontal loops. See Fig. 10 for some examples. These patterns will vary as the phase relationship between the signal varies. (see Fig. 11, 12 and 13) If one frequency is adjustable, adjust for the desired ratio and for a stable display.

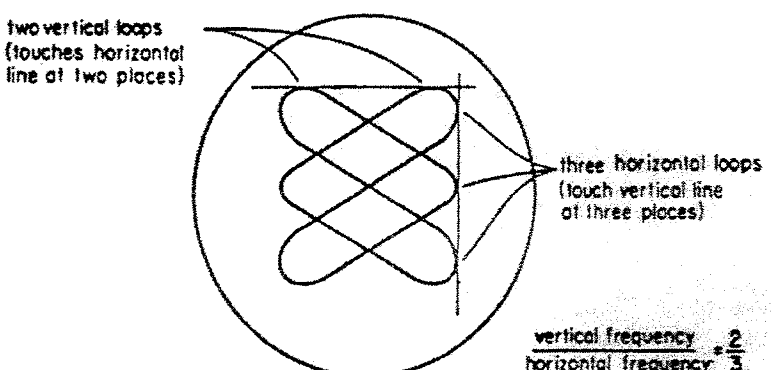
For phase comparison of two signals of the same frequency see Figs. 11 and 12. These figures are for undistorted sine waves. From these figures it is not possible to determine which signal is leading or lagging. To do the phase comparison of Fig. 12, both horizontal and vertical amplitudes must be equal.



(a) Lissajous figure with vertical and horizontal inputs at the samefrequency (out of phase)



(b) Lissajous pattern when the vertical frequency is twice the horizontal frequency



(c) Lissajous pattern when the ratio of vertical frequency to horizontal frequency

Fig. 10 Lissajous patterns for frequency comparisons

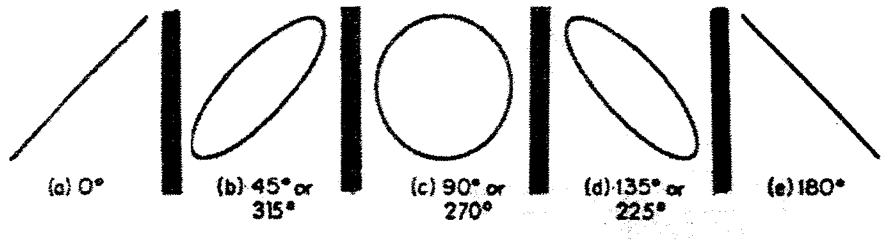


Fig. 11 Lissajous figures for phase difference between vertical and horizontal sine waves at the same frequency

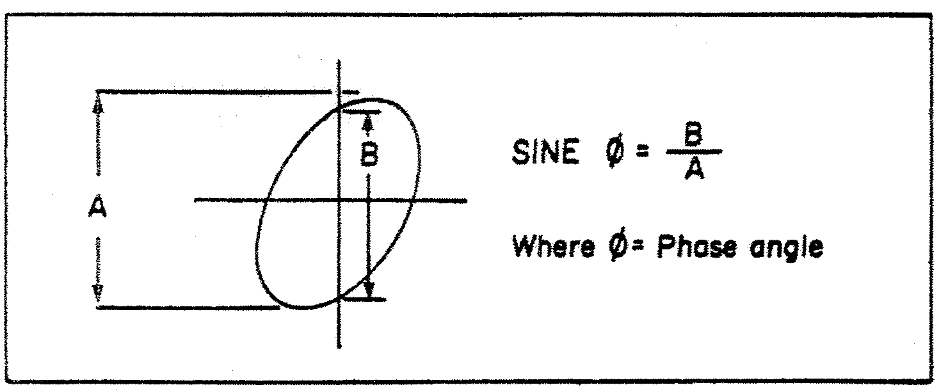


Fig. 12 Lissajous figure phase measurement

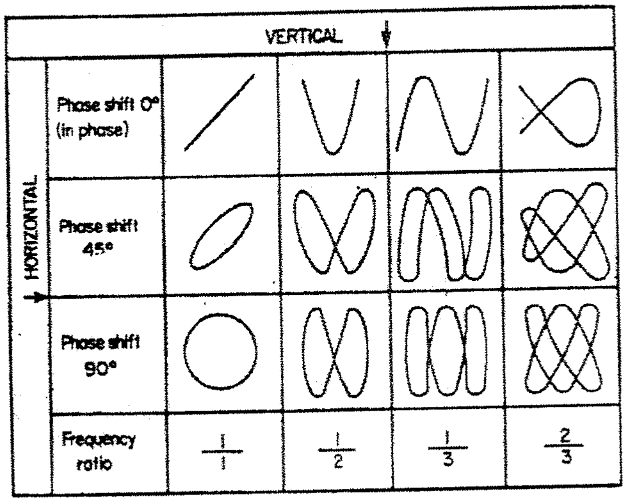


Fig. 13 Lissajous figure phase and frequency comparisons

GENERAL ADJUSTMENTS AND CHECKS

1. Probe Compensation
   1. Connect the 10:1 input probe to the vertical INPUT jack and to the 0.25V CAL terminal on the front of the scope.
   2. Set the scope controls to obtain a good display of 2 or 3 square waves of 4 or 5 divisions amplitude
   3. Adjust the compensation trimmer on the 10:1 probe plug (Fig. 14) for flat tops on the square waves (see Fig. 15)

2. Horizontal Trace Alignment with Graticule

   If the horizontal sweep is not aligned with the horizontal graticule lines, loosen the rear CRT mounting plate screws and rotate the plate until correct alignment is obtained. (see Fig. 2)

3. Quick Calibration Check

   A quick check of horizontal and vertical calibration may be done with the 0.25V CAL signal from the front panel. This is only a rough check, however, because the CAL signal is only ±3% in amplitude and ±5% in frequency. Accurate calibration requires a more accurate signal source.

   To perform the quick check proceed as follows:
   1. Connect the X1 input lead the vertical INPUT jack and to the 0.25V CAL signal on the front panel.
   2. Set the scope controls as indicated:
      - -VOLTS/DIV to 50mV
      - -V.VARIABLE to CAL
      - -MODE selector to AUTO
      - -SOURCE to INT
      - -TIME/DIV to .1mS
      - -sweep VARIABLE to CAL

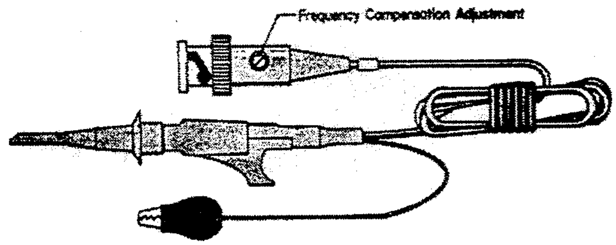
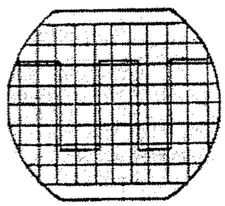
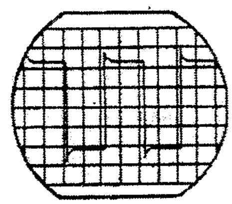


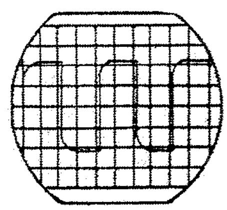
Fig. 14 Frequency compensation adjustment on the 10:1 input probe



(a) Correct compensation



(b) Over compensation



(c) Insufficient compensation

Fig. 15 Frequency compensation waveforms

3. The displayed square wave when properly centered should be 5 divisions high and 10 divisions long (5 divisions positive, 5 divisions negative) (see Fig. 16).

   If the square wave is not 5 divisions high, use an accurate standard to check the vertical calibration procedure contained elsewhere in this manual. If vertical calibration is within tolerance, check the voltage output of the CAL signal and adjust it if necessary according to the procedure contained elsewhere in this manual.

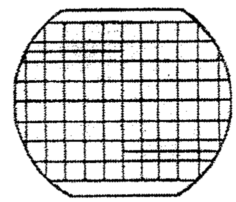


Fig. 16 Calibration signal display

If the square wave is not 10 divisions long, then check the horizontal calibration with an accurate standard and perform horizontal calibration according to the procedure contained elsewhere in this manual. If the horizontal calibration is correct, check the output frequency of the CAL signal and adjust it if necessary according to the procedure given in this manual.

If the negative portion of the square wave is not the same length as the positive portion then a need for adjustment of the CAL signal is indicated.

4. Case Removal

Caution: High voltages up to 1200V are present inside the scope when the unit is in operation. Line voltages are also present in certain locations even when the power switch is off. Remember also that some capacitors may hold a charge for a considerable time after the equipment is de-energized. Be sure to follow all applicable precautions contained in the safety precaution section of this manual. The case should only be removed by qualified service personnel.

To remove the case remove the 10 case screws, 4 on each side and two at the front on the top. The case may then be lifted off.

Caution must also be exercized to assure that no objects strike the CRT. This may result in implosion of the CRT which could propel pieces of glass at high speeds for considerable distances with obvious safety hazards to nearby personnel.

The case must be removed to perform most of the following adjustments with the exception of fuse replacement.

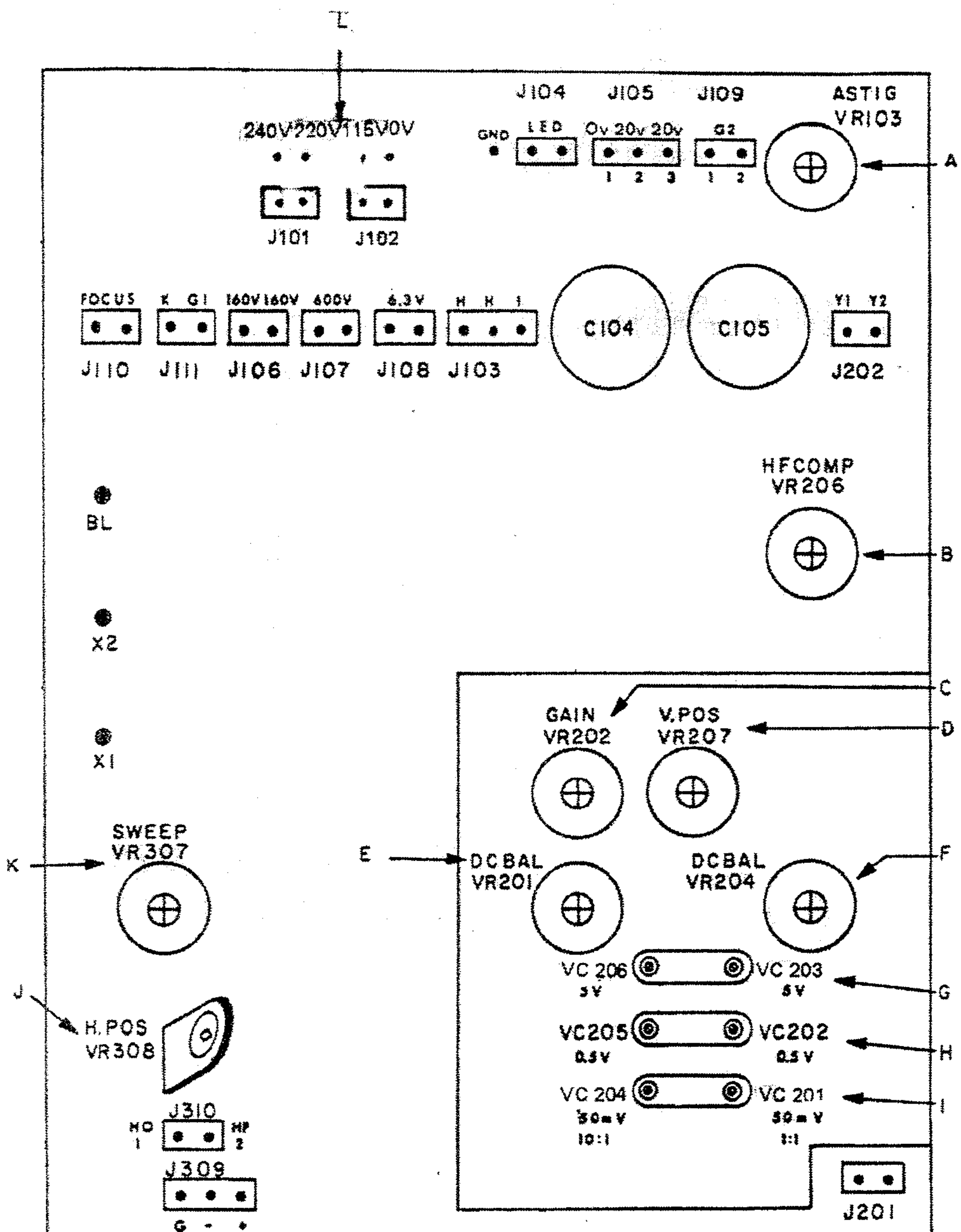


Fig. 17 Main circuit board

5. Fuse Replacement

During normal operation of the scope the fuse should never need replacement. If the fuse is found to be open there is probably a problem with the scope. It should be checked before replacing the fuse. Replace the fuse only with a 0.5A fuse for scopes set to operate on 100-120V or 0.3A for scopes set to operate on 200-240V supply. Fuse location is on the rear panel of the scope. (see Fig. 2 (19))

6. Changing Voltage of Operation

This oscilloscope is capable of being set to operate on either 100-120VAC or 200-240VAC 50 or 60 Hz supplies. To change the operating voltage, jumper wires at the rear of the main circuit board must be moved. (see Fig. 17 (L))

For 115V operation the red wire from the power switch should be plugged onto the pin marked 115V, as shown in Fig. 18.

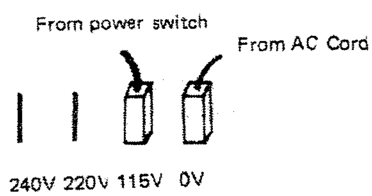


Fig. 18 Connections for 115V AC operation

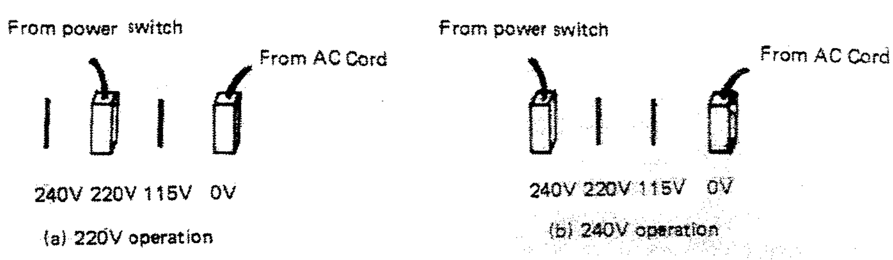


Fig. 19 Connections for 220V or 240V AC operation

For 220V or 240V operation the wire from the power switch should be connected to the 220V pin for 220V operation (see Fig. 19a) or to the 240V pin for 240V operation (see Fig. 19b).

7. Power Supply Voltage Checks

AC line 110V or 220V ±10%
DC ±9V supply ±10%
±15V supply ±10%
+190V supply ±10%
+170V supply ±10%
-1170V supply ±20%

8. Astigmatism Adjustment

Set the AC-GND-DC selector to the GND position and the MODE selector to the X-Y position. Then adjust the ASTIG pot VR103 (see Fig. 17 (A)) and the focus control for the clearest round spot.

VERTICAL CIRCUITS ADJUSTMENTS

1. DC Balance Adjustment
   1. Set the AC-GND-DC selector to GND and the VOLTS/DIV Switch to the 5mV/DIV range.
   2. Adjust the DC BAL potentiometers (pots) VR 201 and VR 204 until the trace does not shift when the V.VARIABLE control is turned. (see Fig. 17 (E) and (F))

2. High Frequency Compensation
   1. Set the VOLTS/DIV switch to 5mV/DIV and connect a 30mV, 100KHz square wave signal of good quality with flat extremes to the INPUT jack.
   2. Adjust HF COMP pot VR206 (see Fig. 17 (B)) so that the display has flat extremes as shown in Fig. 15

3. Vertical Gain Calibration
   1. Connect a 1KHz 25mV p-p square wave to the INPUT jack.
   2. Set the V.VARIABLE control fully clockwise to the CAL position.
   3. Set the VOLTS/DIV switch to the 5mV/DIV position
   4. Adjust the GAIN pot VR202 (see Fig. 17 (C)) so that the observed waveform is exactly 5 divisions high.

4. Vertical Position Centering
   1. Turn the front panel V.POSITION control to approximate center of its travel.
   2. Adjust the internal V.POSITION pot VR207 (see Fig. 17 (D)) to center the trace on the screen.

5. Vertical Frequency Compensation

1. Six frequency compensation trimmers are in the scope, two for each of the vertical deflection ranges 5V/DIV, 0.5V/DIV and 50mV/DIV. VC201 VC202 and VC203 are for direct input compensation (1:1) and VC204, VC205 and VC206 are for compensation using the 10:1 attenuator input probe.

   Optimum compensation is obtained when the V.VARIABLE control is fully clockwise in the CAL position. Since compensation of the 3 vertical ranges is necessary, square waves of different amplitudes will be necessary. The square waves should be at a frequency of 1KHz and be of good quality with flat amplitude extremes.
2. For 1:1 compensation of the 50mV/DIV range connect a 1KHz square wave with an amplitude of between 0.2V and 0.4V to the vertical INPUT jack using the direct probe. Set the scope controls to display two or three cycles of the square wave. (see Fig. 15)
3. Adjust VC201 (see Fig. 17 (I)) for flat extremes on the square wave. See Fig. 15 for representative waveforms.
4. For 1:1 compensation of the 0.5V/DIV range connect a 1KHz square wave with an amplitude between 2V and 4V to the vertical INPUT jack using the direct probe. Set the scope controls to display two or three cycles of the square wave.
5. Adjust VC202 (Fig. 17 (H)) for flat extremes on the square wave. See Fig. 15 for representative waveforms.
6. For 1:1 compensation of the 5V/DIV range connect a 1KHz square wave with an amplitude between 20V and 40V to the vertical INPUT jack using the direct probe. Set the scope controls to display two or three cycles of the square wave.
7. Adjust VC203 (Fig. 17 (G)) for flat extremes on the square wave. See Fig. 15 for representative waveforms.
8. For 10:1 compensation use the 10:1 attenuator probe and repeat steps 2 through 7 above multiplying the required square wave input amplitude by 10 and adjusting VC204 for step 3, VC205 for step 5 and VC206 for step 7.

HORIZONTAL CIRCUIT ADJUSTMENTS

1. Horizontal VARIABLE Range Adjustment
   1. Set the TIME/DIV switch to 0.1mS/DIV and apply a marker signal or sine wave of 1 mS duration to the INPUT jack.
   2. Rotate the H.VARIABLE control fully clockwise to the CAL position.
   3. Adjust the SWEEP calibrate pot VR307 (see Fig. 17 (K)) until one cycle of the displayed waveform is exactly 10 divisions long.
   4. Turn the H.VARIABLE control fully counterclockwise.
   5. Adjust the variable range pot VR303 on the front control panel circuit board until there are 12 cycles of the displayed waveform within the 10 divisions of the graticule.

2. Time Base Calibration
   1. Set the TIME/DIV switch to the 1mS/DIV range and apply a marker signal or sine wave of 1mS duration to the INPUT jack.
   2. Rotate the H.VARIABLE control fully clockwise to the CAL position.
   3. Re-adjust the SWEEP calibrate pot VR307 (see Fig. 17 (K)) until 10 cycles of the displayed waveform are exactly 10 divisions long.

3. Horizontal Position Adjustment
   1. Connect a 1KHz sine wave to the INPUT jack.
   2. Adjust the internal H.POSITION pot VR308 (see Fig. 17 (J)) so that when the front panel H.POSITION control is rotated from fully clockwise to fully counterclockwise the distances A and B shown in Fig. 20 are the same.
   3. Note: this adjustment will change the external horizontal position adjustment.

(a) H.POSITION control rotated fully clockwise

(b) H.POSITION control rotated fully counterclockwise

Fig. 20 Horizontal position centering

4. <u>External Horizontal EXT Sensitivity and Position Adjustments</u>

1. Set the AC-GND-DC switch to GND.
2. Set the MODE switch to X-Y, and apply a 1KHz 1V p-p sine wave to the EXT input jack.
3. If the displayed line is longer or shorter than 10 divisions, then adjust the EXT GAIN pot VR309 (see Fig. 21) clockwise to increase the length of the display and counterclockwise to decrease its length. This adjustment will cause the display to shift right or left so adjust the H. POS. pot VR301 until the display line is centered again.

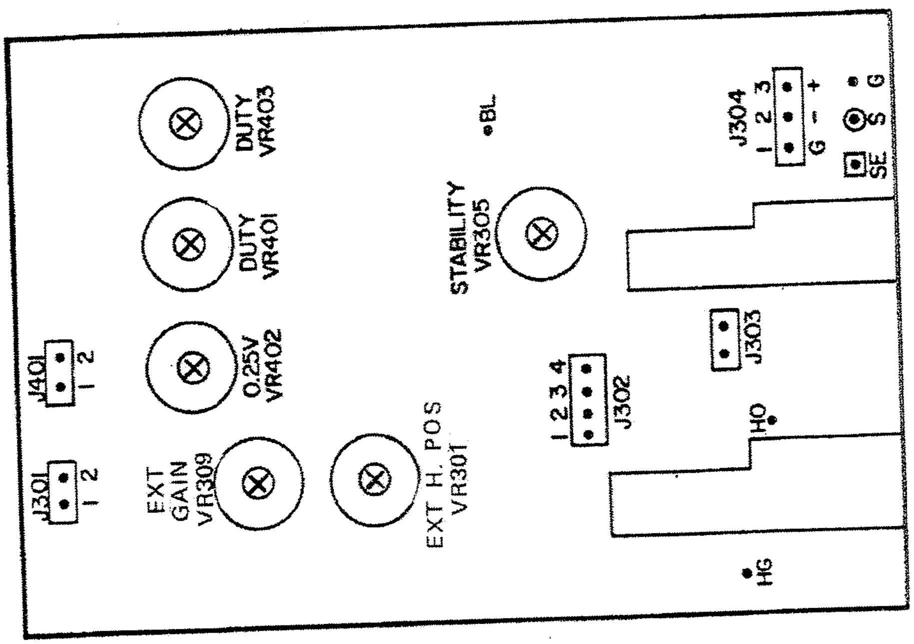


Fig. 21 Triggering and horizontal sweep board

4. Repeat these adjustments until the display line is exactly 10 divisions long.
5. Once this adjustment is made, remove the 1KHz signal and rotate the front panel H.POSITION control clockwise and counterclockwise to see if the spot will move equal distances left and right so that distances A and B as shown in Fig. 22 are equal. If the spot does not move equal distances, adjust H. POS pot VR301 until it does.

5. <u>Triggering Stability Adjustment</u>

1. Set the MODE switch to AUTO
2. Set the TIME/DIV switch to the 10mS/DIV range.
3. Apply a 30Hz sine wave to the vertical INPUT and set the VOLTS/DIV and V.VARIABLE controls so that there is 0.5 divisions vertical height of the display.
4. Set the MODE selector to NORM.

(a) H.POSITION control rotated fully clockwise

(b) H.POSITION control rotated fully counterclockwise

Fig. 22 External horizontal position centering

5. Rotate the LEVEL control fully clockwise.
6. Temporarily connect a 330K resistor in parallel with R343 (see Fig. 21).
7. Adjust the STABILITY pot VR305 clockwise until there is a signal display, then turn it counterclockwise just to the point where the sweep stops leaving a 0.5 division high vertical line.
8. Remove the 330K resistor. This should set the triggering sensitivity within the specifications given in Table I.

INT	0.5 Div. on screen, 30 Hz to 2 MHz
	1.5 Div on screen, 2 MHz to 10 MHz
EXT	0.5Vp-p, 30 Hz to 2 MHz
	1Vp-p, 2 MHz to 10 MHz

Table I

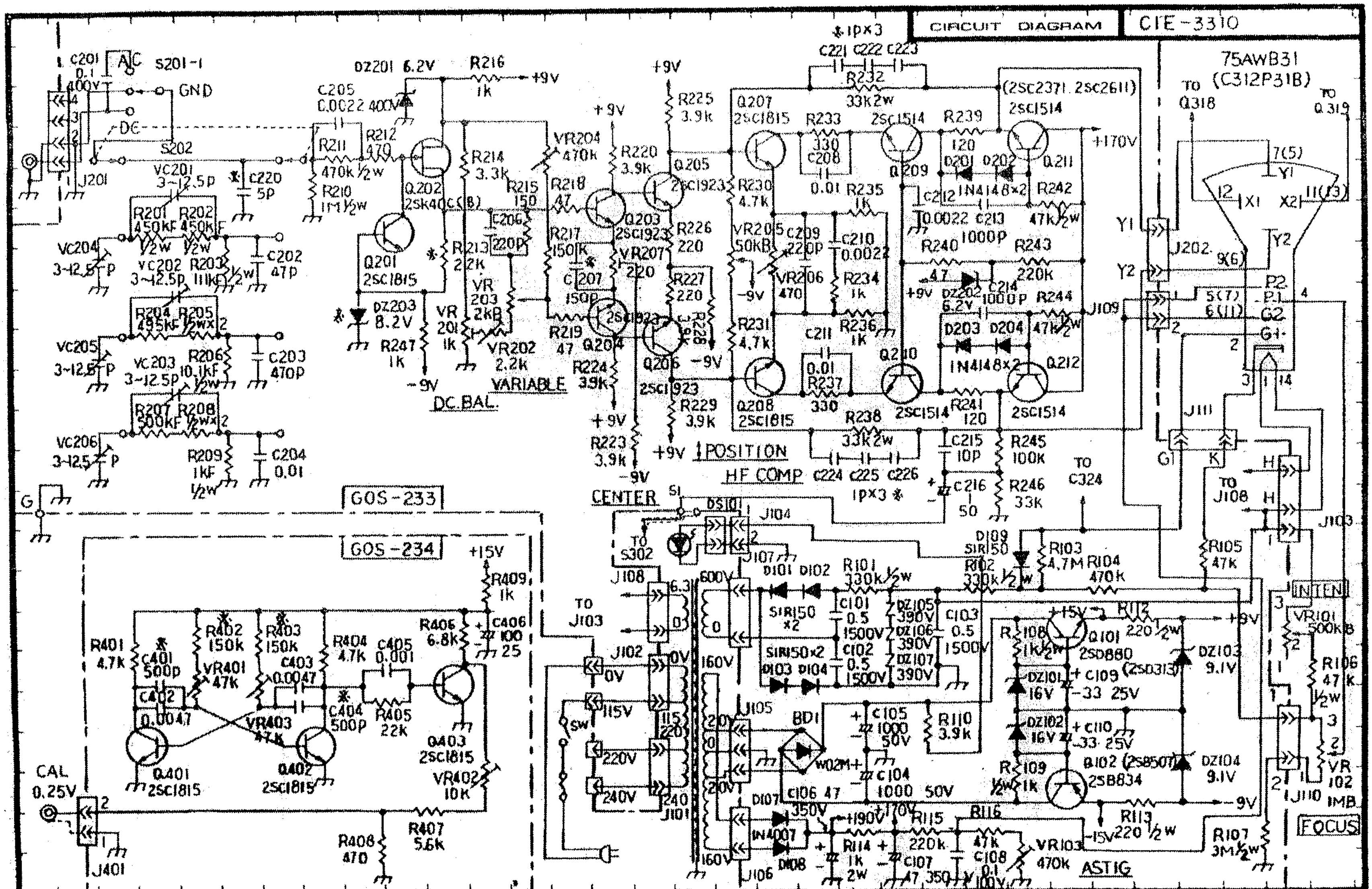
Calibrate Signal Adjustment

1. Calibrate Signal Frequency and Symmetry Adjustment
    1. Set the TIME/DIV switch to the 0.1mS range.
    2. Set the VOLTS/DIV switch to the 50mV/DIV range.
    3. Set the H.VARIABLE control fully clockwise.
    4. Connect the 0.25V CAL signal to the V. INPUT jack.
    5. Set the SLOPE switch to + (pushed in) and set the LEVEL control for a stable display.
    6. Adjust the H.POSITION so that the positive portion of the square wave begins on the left-most vertical graticule line.
    7. Adjust VR403 until the positive portion of the square wave is exactly 5 divisions long.

8. Adjust VR401 until the negative portion of the square wave is exactly 5 divisions long and the entire square wave is 10 divisions long. See Fig. 21 for control locations.

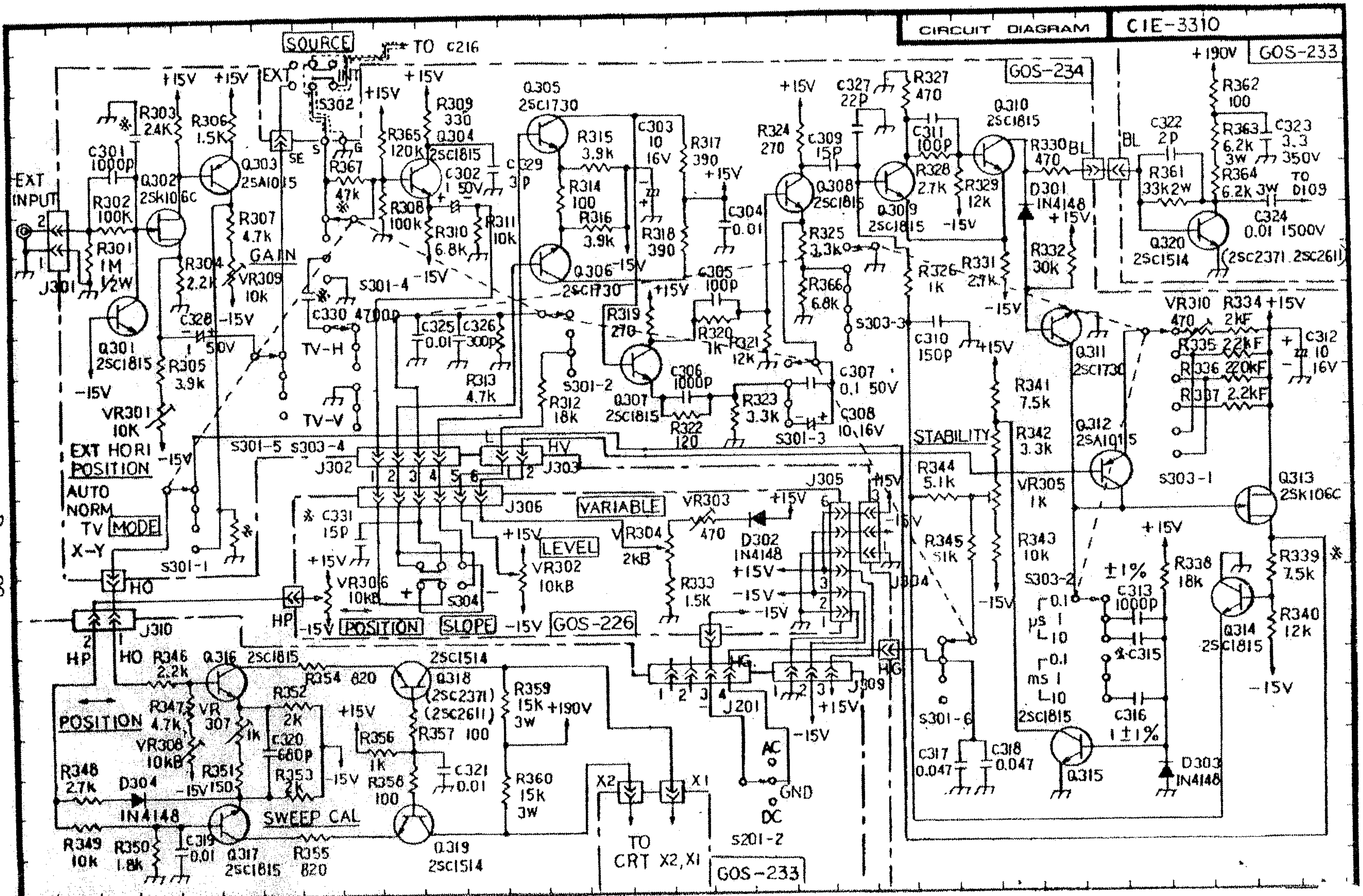
2. <u>Calibrate Signal Voltage Adjustment</u>

   1. Set up the scope controls like the calibrate signal frequency and symmetry adjustment above.
   2. Set the V.VARIABLE control fully clockwise.
   3. Adjust the 0.25V adjustment VR302 until the amplitude of the sqaure wave is exactly 5 divisions high. The correct calibrate signal with these scope settings is shown in Fig. 16.



Notes:
1. ※ - installed if needed
2. Resistance in ohms
3. Resistors ¼ watt unless specified
4. Capacitaces in μf unless specified

1. Vertical Amplifier and Power Supply



Notes:

1. ※ - installed if needed
2. Resistance in ohms
3. Resistors ¼ watt unless specified
4. Capacitaces in μf unless specified

2. Trigger and Horizontal Amplifier Circuits