

CALIBRATION

This section of the Manual is divided into two parts: "Initial Calibration" and "Touch-Up Adjustments." The "Initial Calibration" must always be performed after the Oscilloscope has been serviced or parts have been replaced.

The "Touch-Up Adjustments" must always be performed after the "Initial Calibration" and any time you doubt the accuracy of your calibrated Oscilloscope.

INITIAL CALIBRATION

The following equipment is needed to calibrate your Oscilloscope:

VTVM — Accurate to within 1% at 15 volts DC and able to measure 1700 VDC.

Heathkit Oscilloscope Calibrator — OR — A Square Wave Generator capable of producing 1 kHz to 1 MHz signals; with up to 5 volts output, rise time ≤ 5 nS, and overshoot $\leq 1\%$.

A 1000 Hz Square Wave Voltage Calibrator (1 to 100 volt output) is also recommended, but not necessary; accurate in amplitude to 1% at 1 volt; accurate in frequency to 1%.

Controls and adjustments associated with Channel Y1 are identified as Y1, CH1, or a "-1" following the circuit component number, such as R119-1. Channel Y2 controls and adjustments are identified as Y2, CH2, or a "-2" following the circuit component number. Use a plastic alignment tool to make the adjustments.

If you do not obtain the proper results, turn the Oscilloscope off, refer to the "In Case of Difficulty" section of the Manual, and correct any difficulties before you proceed.

Turn off the Oscilloscope and disconnect the line cord plug from the AC power source.

Loosen the knurled knob on each side of the chassis and remove the top and bottom covers. Be careful not to touch any of the circuitry when you move the Oscilloscope around for various adjustments. Dangerous voltages are present. See Figure 23 (in the "Illustration Booklet").

VOLTAGE ADJUSTMENTS

Refer to Parts A and B of Figure 15 (in the "Illustration Booklet") for the following steps.

1. Adjust your voltmeter to measure -15 volts DC.
2. Connect the common voltmeter lead to the Oscilloscope chassis.
3. Measure the voltage at test point 4 (TP4, on the low voltage circuit board). Adjust control R309 (on the low voltage circuit board) for a -15 volt meter indication. (Interchange your meter leads if necessary.)
4. Adjust your voltmeter to measure -2000 volts DC.
5. Measure the voltage at lug 1 of control R2. Adjust the HI VOLT ADJ control (R419, on the high voltage circuit board) for -1700 volts DC (± 10 volts).

BEAM ADJUSTMENTS

Refer to Figure 1 (in the "Illustration Booklet") for the circuit component number of any front panel control or switch.

1. Set the indicated front panel controls as follows:

Y1:

INPUT switch (AC-GND-DC) GND

VOLTS/CM 50 mV

VARIABLE Fully clockwise (CAL)

POSITION Fully counterclockwise (OFF)

Y2:

INPUT switch (AC-GND-DC) GND

VOLTS/CM 50 mV

VOLTS VARIABLE Fully clockwise (CAL)

POSITION Center trace on screen

OTHER:

VARIABLE - X5 Fully clockwise (CAL) and pushed in.

TRIG Y1, +

LEVEL Center of rotation and pushed in.

TRIGGER MODE AC

TIME/CM EXT

HORIZ POS Center spot on screen.

2. Turn the INTENSITY control counterclockwise to decrease the brightness of the spot. Readjust this control as necessary to keep the spot small when you make the following focus and astigmatism adjustments.

3. Alternately adjust the FOCUS control and the ASTIGMATISM control R427 (a screwdriver adjustment through the rear panel) to obtain the smallest possible round spot on the CRT screen.

4. Set the indicated front panel controls as follows:

TIME/CM .1 mS

Y2 POSITION Fully counterclockwise (OFF)

Y1 POSITION Center trace on screen

HORIZ POSITION Position trace on screen

VERTICAL AMPLIFIER BALANCE

NOTE: During the following steps, you may experience the rare situation that the vertical amplifier of one channel will not balance properly. If this happens, interchange transistors Q101 and Q102 of the channel that does not balance. The transistor leads are not soldered to the socket pins.

Channel Y1: Perform the following numbered steps 1-11. Adjust only the controls associated with Channel Y1.

1. Adjust the POSITION control to place the trace on the horizontal centerline.
2. Turn the VARIABLE control fully counterclockwise. The trace may move off the screen.
3. Adjust the POSITION control to return the trace to the center horizontal graticule line.
4. Turn the VARIABLE fully clockwise (CAL).
5. Slowly adjust the DC BAL control (a screwdriver adjustment through the front panel) to return the trace to the center horizontal graticule line.
6. Repeat steps 2 through 5 until the trace does not move when you turn the VARIABLE control. Leave the VARIABLE control in the fully clockwise position (CAL).
7. Turn the VOLTS/CM switch to the 10mV position.
8. Adjust the BAL control [R124, on the vertical circuit board (see Figure 16)] to return the trace to the center horizontal graticule line.
9. Turn the VOLTS/CM switch back and forth between the 10mV position and the 50mV position and adjust the BAL control so the trace does not move when the switch is turned from one position to the other.

10. Repeat steps 2 through 5.

11. Turn the Y1 POSITION control fully counterclockwise (OFF). Then turn the Y2 POSITION control clockwise and center the trace on the screen.

Channel Y2: Perform the previous numbered steps 1-10. Adjust only the controls associated with Channel Y2.

TRIGGER

1. Set the Y1 and Y2 INPUT switches to GND.
2. Adjust the Y1 and Y2 POSITION controls to place both traces on the horizontal centerline.
3. Adjust your voltmeter to measure -3.0 volts DC.
4. Connect the common voltmeter lead to the Oscilloscope chassis.
5. Measure the voltage at TP14 (test point 14) on the vertical circuit board. (See Figure 16 in the "Illustration Booklet.") Adjust the Y1 ZERO control (R149-1, on the vertical circuit board) for zero volts.
6. Measure the voltage at TP15 on the vertical circuit board. Adjust the Y2 ZERO control (R149-2, on the vertical circuit board) for zero volts.
7. Disconnect the voltmeter.

VERTICAL AMPLIFIER

- Set the indicated front panel controls as follows:

TIME/CM 1 mS

Y1:

VOLTS/CM 200 mV

POSITION Center trace on screen

INPUT switch GND

Y2:

VOLTS/CM 200 mV

POSITION Fully counterclockwise (OFF)

INPUT switch GND

- Channel Y1: Perform the following lettered steps (A-G). Adjust only the controls marked Y1 or associated with Channel Y1.

- Adjust the POSITION control to place the trace on the horizontal centerline.
- Make sure the VARIABLE control is fully clockwise (CAL) position.
- Set the INPUT switch to AC.
- Connect the test cable inner lead to the 1V P-P connector on the front panel. NOTE: A Square Wave Voltage Calibrator may be used instead of the 1V P-P output from the Oscilloscope.
- Adjust the CAL control (R164, on the vertical circuit board) and the POSITION control for a waveform exactly 5 cm high between the flattest portions.
- Disconnect the test leads from the 1V P-P connector.
- Turn the POSITION control fully counterclockwise (OFF).

- Channel Y2: Turn the TRIG switch to the Y2, + position. Then perform the previous lettered steps (A-G) again for Channel Y2. Adjust only the controls marked Y2 or associated with Channel Y2.

SWEEP

- Set the indicated front panel controls as follows:

Y1 INPUT switch AC

TRIG Y1, +

TIME/CM 1 mS

VARIABLE CAL

- Connect a 1000 Hz square wave signal to the Y1 INPUT connector. Adjust the signal amplitude for a 2-4 cm vertical display.
- Adjust the SWEEP LENGTH control (R255, on the horizontal circuit board) so the trace is 10 cm long.
- Refer to Figure 17 in the "Illustration Booklet" and carefully adjust the X CAL control (R268, on the horizontal circuit board) and the HORIZ POS control for exactly 10 cycles in 10 centimeters (1 cycle per centimeter) as shown in Figure 18. Use the leading edge of the second and tenth cycle for this adjustment.
- Readjust the SWEEP LENGTH control (R255, on the horizontal circuit board) so the trace is 10 cm long.
- Turn the HORIZ POS control counterclockwise to move the right-hand end of the trace 1 cm to the left.
- Adjust the SWEEP LENGTH control (R255, on the horizontal circuit board) to move the right-hand end of the trace back to the right 1 cm.
- Readjust the HORIZ POS control so the left-hand edge of the trace starts at the left-hand graticule line.
- Pull out the VARIABLE — X5 switch.

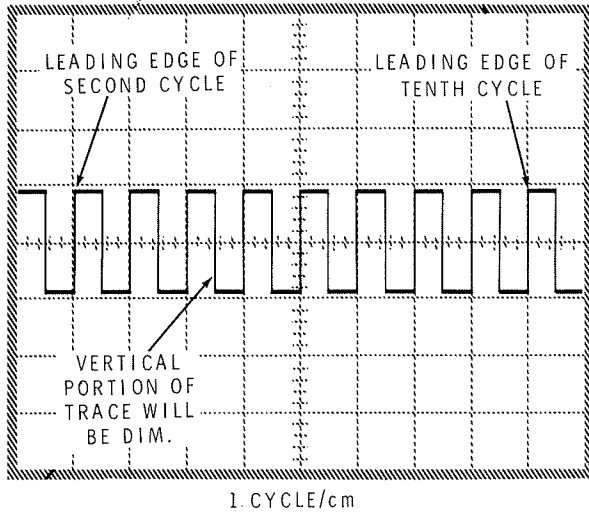


Figure 18

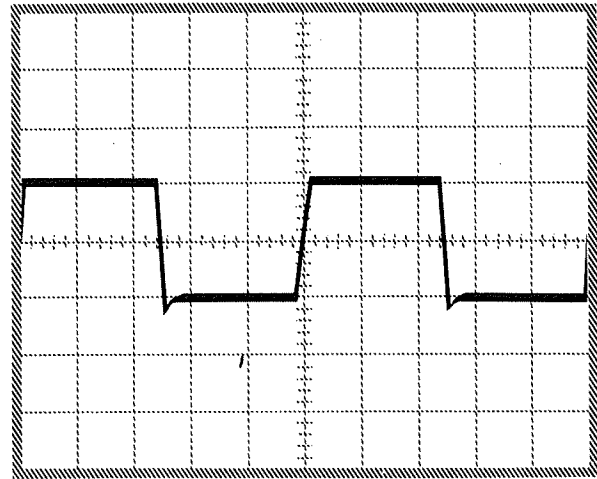


Figure 19

10. Adjust the X5 CAL control (R278, on the horizontal circuit board) and the HORIZ POS control for exactly 2 cycles in 10 centimeters as shown in Figure 19. When you make this adjustment, place the leading edge of the first cycle on the left-hand graticule line and the leading edge of the second cycle on the center graticule line.
11. Push in on the VARIABLE — X5 switch.
12. Place the Y1 INPUT switch in the GND position.
13. Adjust the RAMP ZERO control (R248, on the horizontal circuit board) until the bright spot on the left end of the trace disappears. (This is not a critical adjustment.)
14. Place the INPUT switch to AC.
15. Refer to Figure 17 in the "Illustration Booklet," and carefully readjust the X CAL control (R268, on the horizontal circuit board) and the HORIZ POS control for exactly 10 cycles in 10 centimeters (1 cycle per centimeter) as shown in Figure 18. Use the leading edge of the second and tenth cycle for this adjustment.
16. Turn the TIME/CM switch to 1 μ S.

17. Connect a 1 MHz square wave signal to the Y1 INPUT connector.
18. Use a plastic alignment tool and adjust trimmer capacitor C229 (located on the TIME/CM switch) for 1 cycle per centimeter.
19. Disconnect the square wave signal.

X-Y

1. Turn the Y1 VOLTS/CM switch to the 200mV position.
2. Turn the TIME/CM switch to the X-Y position.
3. Turn the TRIG switch to Y2, +.
4. Adjust the Y1 and Y2 POSITION controls to center the spot on the graticule. Adjust the HORIZ POS control so the Y1 POSITION control will move the spot off the screen in both directions.
5. Set the Y1 INPUT switch to AC.
6. Connect the Y1 test cable inner lead to the 1V P-P connector on the front panel. NOTE: A square wave voltage calibrator may be used instead of the oscilloscope 1V P-P output.

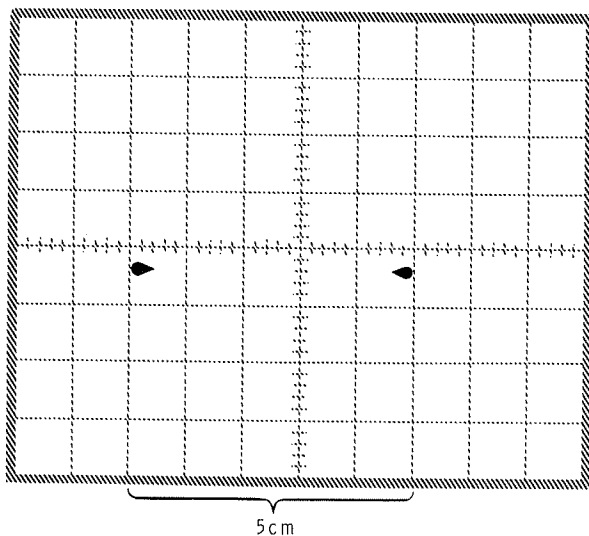


Figure 20

7. Adjust the X-Y CAL control (R258, on the horizontal circuit board) to place the two dots exactly 5 cm apart as shown in Figure 20.
8. Disconnect the Y1 test cable from the 1V P-P connector.

CHOPPED BLANKING

1. Turn the TIME/CM switch fully counterclockwise to the EXT position.
2. Use the Y1, Y2, and HORIZ POSITION controls and position the dots as shown in Figure 20A or 20B.
3. If the dots look like those in Figure 20A, proceed to "Attenuator Compensation."

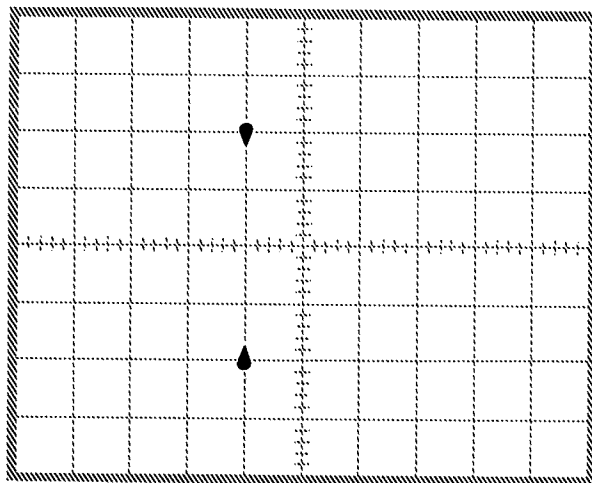


Figure 20A

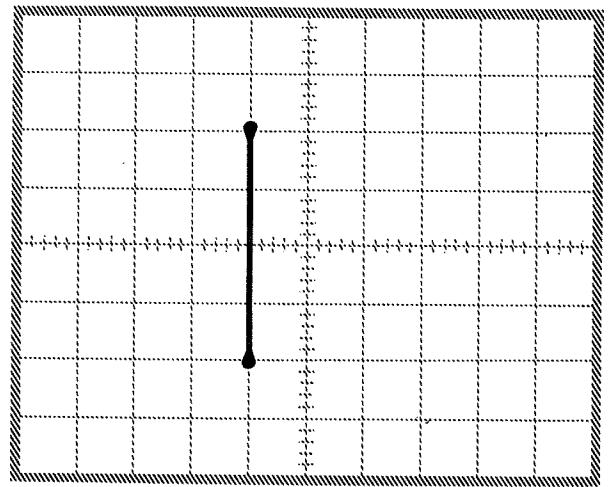


Figure 20B

If the dots look like these in Figure 20B (connected together), turn CHOP BLANK ADJ control R428 counterclockwise until the dots look like those in Figure 20A. Then proceed to "Attenuator Compensation."

ATTENUATOR COMPENSATION

The purpose of the following adjustments is to obtain the proper amount of high frequency compensation for each position of the VOLTS/CM switch. Parts A, B, and C of Figure 21 show the conditions of too much compensation, too little compensation, and the correct amount of compensation respectively. Use a plastic alignment tool to make the following adjustments.

1. Set the indicated front panel controls as follows:

TIME/CM	.2 mS
TRIG	Y1, +
Y1:	
INPUT switch	AC
VARIABLE	Fully clockwise (CAL)
VOLTS/CM	100 mV
POSITION	Center trace on screen

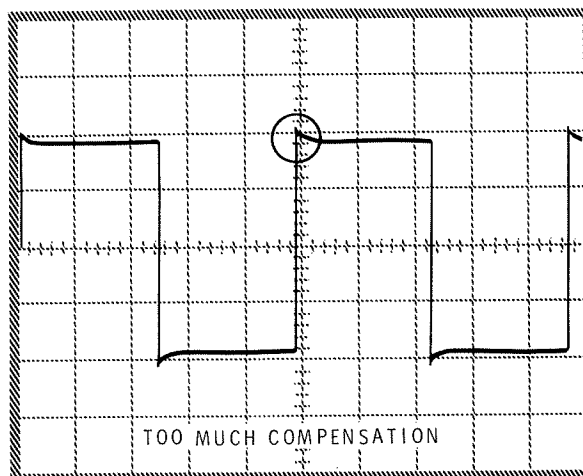
Y2:

INPUT switch AC
VARIABLE Fully clockwise (CAL)
VOLTS/CM 100mV
POSITION Fully counterclockwise (OFF)
HORIZ POS Center the trace on the screen.

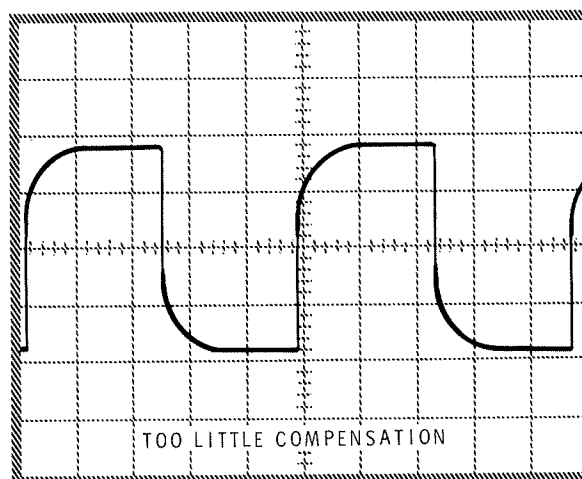
2. Channel Y1: Refer to Figures 16 and 21, and perform the following lettered steps (A-I). Adjust only the controls that are marked Y1 or associated with Channel Y1.

- A. Adjust the POSITION control to place the trace on the horizontal centerline.
- B. Connect a 1000 Hz square wave signal to the INPUT connector. Adjust the signal amplitude of this signal for a trace 4 cm high. Readjust the amplitude of this signal as necessary in the following steps to maintain a suitable size trace (1-4 cm). (If your generator is a fixed amplitude type, you may use the 200 mV or 500 mV VOLTS CM position to obtain the proper display size.)
- C. Adjust trimmer capacitor C107 ($\div 10$) to obtain the proper amount of compensation.
- D. Turn the VOLTS/CM switch to the 1V position (or 2V or 5V if necessary).
- E. Adjust trimmer capacitor C104 ($\div 100$) to obtain the proper amount of compensation.
- F. Turn the VOLTS/CM switch to the 10V position (or 20V or 50V if necessary).
- G. Adjust trimmer capacitor C101 ($\div 1000$) to obtain the proper amount of compensation.
- H. Disconnect the square wave signal.
- I. Turn the POSITION control fully counterclockwise (OFF).

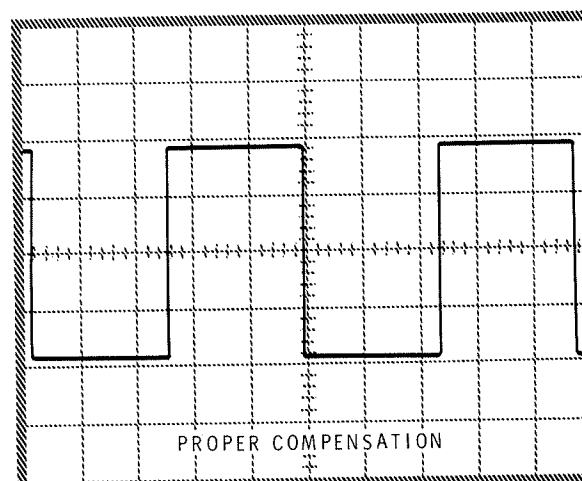
3. Channel Y2: Turn the TRIG switch to Y2+. Then perform the previously lettered steps (A-I). Adjust only the controls that are marked Y2 or associated with Channel Y2.



A



B



C

Figure 21

SQUARE WAVE COMPENSATION

1. Connect a 1 MHz square wave signal to the Y1 INPUT connector.

2. Set the indicated front panel controls as follows:

TIME/CM .2 μ S

TRIG Y1, +

Y1:

INPUT switch AC

VARIABLE Fully clockwise (CAL)

VOLTS/CM As necessary to produce a display similar to that shown in Figure 22.

POSITION Center the trace on the screen.

Y2:

INPUT switch GND

VARIABLE Fully clockwise (CAL)

VOLTS/CM Same as Y1, above

POSITION Fully counterclockwise (OFF)

NOTE: In the following step you will be instructed to adjust the displayed square wave for a certain "overshoot." This will produce the widest possible bandwidth for your Oscilloscope. You may adjust the square wave for a flat top. However, this will somewhat reduce your Oscilloscope bandwidth. Nevertheless, the bandwidth will still meet specifications.

3. Position the trace as shown in Figure 22, with the VERT POS and HORIZ POS controls. The bottom of the dip should be on a horizontal graticule line. The "overshoot" peak height will vary with the setting of C118, the high frequency compensation trimmer (on the vertical circuit board). (Your dip may not look like the one shown.)

4. Adjust trimmer C118-1, with a nonmetallic screwdriver, so the top of the peak is no more than 4 mm from the bottom of the dip. NOTE: If you have trouble with this adjustment, check the two blue wires connected to the CRT socket for proper positioning.

5. Set the indicated front panel controls as follows:

Y1:

INPUT switch GND

POSITION Fully counterclockwise (OFF)

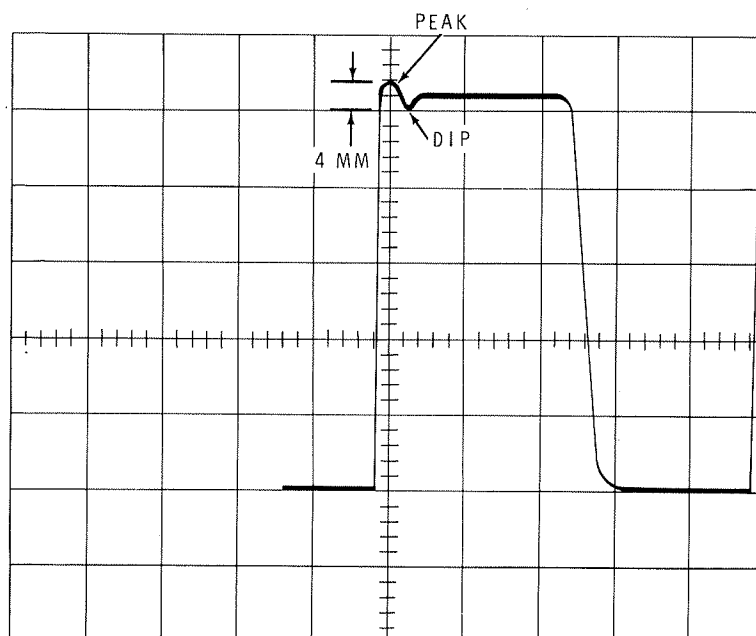
Y2:

INPUT switch AC

POSITION Center trace on screen

TRIG Y2, +

Figure 22



6. Disconnect the 1 MHz square wave signal from the Y1 INPUT connector.
7. Connect a 1 MHz square wave signal to the Y2 INPUT connector.
8. Position the trace as shown in Figure 22. Then adjust trimmer C118-2 so the top of the peak is no more than 4 mm from the bottom of the dip.
9. Disconnect the 1 MHz square wave signal.
10. Turn the Y2 POSITION control fully counterclockwise (OFF).
2. Connect the low capacitance probe to the Y1 INPUT connector.
3. Connect the probe end to a 1000 Hz square wave signal. Adjust the amplitude of this signal for a 4-5 cm display.
4. Adjust the probe trimmer for the proper amount of compensation as shown in Part C of Figure 21. Do not try to obtain the ultimate adjustment at this time.

NOTE: The trimmer capacitors called out in the following steps are on the vertical circuit board.

This completes the "Calibration" of your Oscilloscope unless you have a low capacitance (X10) probe. Proceed to "Touch Up Adjustments" if you do not have such a probe. If you do, perform the following steps.

LOW CAPACITANCE PROBE

Perform the following steps only if you have a low capacitance (X10) probe that will compensate to approximately 40 pF (35-47 pF).

Probe Compensation and Amplifier Equalization

This adjustment procedure equalizes the input capacitance of both vertical amplifiers so a low capacitance probe can be used on either channel without the need to recompensate. If you have two probes, set one of them aside temporarily. Perform the following adjustments using one probe. Then connect the other probe and adjust only the probe trimmer for the proper amount of compensation.

1. Set the indicated front panel controls as follows:

Y1:

VOLTS/CM	10 mV
POSITION	Center the trace on the screen.
INPUT switch	AC
TIME/CM	.2 mS
TRIG	Y1, +

5. Adjust the Y1 input trimmer capacitor C111-1 ($\div 1$) to obtain the maximum amount of overshoot on the leading edge of the waveform as shown in Part A of Figure 21. This adjustment sets the Y1 input trimmer capacitor at minimum capacitance.
6. Readjust the probe trimmer for the correct amount of compensation.
7. Disconnect the probe from the Y1 INPUT connector and connect it to the Y2 INPUT connector.
8. Set the indicated front panel controls as follows:

Y1:

POSITION Fully counterclockwise (OFF)

Y2:

POSITION	Center the trace on the screen.
VOLTS/CM	10 mV (or 20 mV or 50 mV if necessary)
INPUT switch	AC
TRIG	Y2, +

9. Adjust Y2 input trimmer capacitor C111-2 ($\div 1$) for the correct amount of compensation. If you obtain proper compensation, disregard the following lettered steps and proceed to step 10. If you cannot obtain proper compensation, perform the following lettered steps.

- A. Adjust Y2 input trimmer capacitor C111-2 ($\div 1$) for the maximum amount of overshoot on the leading edge of the waveform as shown in Part A of Figure 21. This adjustment sets the Y2 input capacitor to minimum capacitance.
- B. Adjust the probe trimmer for the proper amount of compensation.
- C. Disconnect the probe from the Y2 INPUT connector and connect it to the Y1 INPUT connector.
- D. Set the indicated front panel controls as follows:

Y1 POSITION	Center the trace on the screen
Y2 POSITION	Fully counterclockwise (OFF)
TRIG	Y1, +
- E. Adjust the Y1 input trimmer capacitor C111-1 ($\div 1$) for the proper amount of compensation.

10. Set the indicated front panel controls as follows:

Y1:

POSITION	Center the trace on the screen.
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VOLTS/CM	100 mV (or 200 mV or 500 mV if necessary)
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Y2:

POSITION	Fully counterclockwise (OFF)
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VOLTS/CM	100 mV (or 200 mV or 500 mV if necessary)
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TRIG	Y1, +
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11. Connect the probe to the Y1 INPUT connector.

Input Compensation

NOTE: Readjust the 1000 Hz square wave amplitude as necessary throughout the following procedure to increase the display amplitude.

1. Channel Y1: Perform the following lettered steps (A-K). Adjust only the controls and trimmer capacitors marked Y1 or associated with Channel Y1.

- A. Adjust the POSITION control to put the trace in the center of the screen.
- B. Adjust trimmer capacitor C108 ($\div 10$) for the proper amount of compensation.
- C. Turn the VOLTS/CM switch to the 1V position (or 2V or 5 V if necessary).
- D. Adjust trimmer capacitor C105 ($\div 100$) for the proper amount of compensation.
- E. Turn the VOLTS/CM switch to the 10V position (or 20V if necessary).
- F. Adjust trimmer capacitor C102 ($\div 1000$) for the proper amount of compensation. Examine this display carefully as it may be quite small.
- G. Turn the POSITION control fully counterclockwise (OFF) and decrease the amplitude of the 1000 Hz square wave signal.
- H. Turn the TRIG switch to Y2, +.

Disconnect the probe from the Y1 INPUT connector and connect it to the Y2 INPUT connector.

Channel Y2: Perform the previous lettered steps (A-G). Adjust only the controls and trimmer capacitors marked Y2 or associated with Channel Y2.

Disconnect the square wave signal from the Oscilloscope.

Set the indicated front panel controls as follows:

Y1:

INPUT switch	GND
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POSITION	Center the trace on the screen
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Y2:

INPUT switch	GND
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POSITION	Fully counterclockwise (OFF)
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Proceed to "Touch-Up Adjustments."