ADJUSTMENT PROCEDURE

INTRODUCTION

IMPORTANT—PLEASE READ BEFORE USING THIS PROCEDURE

The "Adjustment Procedure" is used to restore optimum performance or return the instrument to conformance with its "Performance Requirements" as listed in the "Specification" (Section 1). As a general rule, these adjustments should be performed every 2000 hours of operation or once a year if used infrequently.

PARTIAL PROCEDURES

This procedure is divided into subsections to permit calibration of individual sections of the instrument whenever complete instrument calibration is not required. To perform a partial procedure, first set the instrument as directed in the Initial Setup Conditions at the beginning of the section, then make any changes called for within the procedure. Perform all steps within a subsection, both in the sequence presented and in their entirety to ensure that control settings will be correct for the following steps.

The adjustments in CAL 01, 02, 03, and 04 should be performed in numerical sequence, i.e., CAL 01 should be done before CAL 02, CAL 02 should be done before CAL 03, etc. Performing partial procedures when setting the automatic calibration constants (i.e. only one or two of the CAL steps) is not recommended and should only be done if the calibration constants set in the preceding steps are known to be correct.

BEFORE YOU BEGIN:

NOTE

When performing any of the automatic calibration routines (CAL 01 through CAL 04), the CAL/NO CAL jumper P501 must be moved to its CAL position (between pins 1 and 2) before turning the power on. When the desired calibration has been performed, return the jumper to its NO CAL position.

a. Turn instrument Power on.

NOTE

The instrument MUST have a 20-minute warmup period before making any adjustments. Performing the adjustment procedure while the temperature is drifting may cause erroneous calibration settings.

POWER SUPPLIES

Equipment Required (see Table 4-1)

Oscilloscope With 10X P6131 Probe (Item 7)
Digital Multimeter (Item 19)
Alignment Tool (Item 20)
1X Probe (Item 21)

See [redacted] *and* [redacted]

at the rear of this manual for test point and adjustment locations.

NOTE

If the instrument displays "DIAGNSTIC. PUSH A/B TRIG TO EXIT" at power on, one of the power-up tests has failed. If the error message on the bottom line of the display is "TEST 04 FAIL xx" where "xx" is 01, 10 or 11, stored calibration data is in error, and the instrument should be recalibrated. If this is the case, pressing the A/B TRIG button will force entry to the normal operating mode; however, the accuracy of any measurement taken could be in error.

If any other error message occurs, the failure is probably not related to calibration. In this case, the instrument should be repaired before attempting calibration.

Initial Control Settings.

Controls settings not listed will not affect the procedure.

VERTICAL VOLTS/DIV	
CH 2	0.1 V
CH 3 and CH 4	0.1 V (buttons out)
CH 1 and CH 2 VAR	In detent
Input Coupling	
CH 1 and CH 2	1 MΩ DC
VERTICAL MODE	
CH 1	On (button in)
CH 2, CH 3, and CH 4	Off (buttons out)
ADD, INVERT, and BW LIMIT	Off (buttons out)
ALT/CHOP	ALT (button out)
VERTICAL POSITION	Midrange
A and B SEC/DIV	X-Y (knobs locked)
A and B SEC/DIV VAR	In detent
Horizontal POSITION	Midrange
TRIGGER	
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC
SLOPE	+ (plus)
LEVEL	Midrange
HOLDOFF	In detent
ΔV and Δt	Off (press and release until readout display disappears
INTENSITY	Visible display
READOUT INTENSITY	Visible display (CCW from MIN)
SCALE ILLUM	Fully CCW
FOCUS	Defocused dot

1. Check/Adjust Power Supply DC Levels, Regulation, and Ripple (R1292).

a. Connect the Digital Multimeter (DMM) negative lead to chassis ground. Connect the positive lead to the first test point listed in Table 5-1 (all test points are on the Main Board).

b. CHECK—That the reading is within the limits given in Table 5-1.

c. ADJUST—Volt Ref Adj (R1292) for a DMM reading of precisely 10.00 V. The adjustment is accessable through a hole in the top cover plate.

Table 5-1
Power Supply Voltage and Ripple Tolerances

Power Supply	Test Point (+ Lead)	Reading	Total p-p Ripple	p-p Ripple at Two Times Line Frequency
+10 V	J119-4	+ 9.99 to +10.01	100 mV	1 mV
+87 V	J119-8	+85.26 to +88.74	80 mV	5 mV
+42.4 V	J119-9	+41.55 to +43.25	80 mV	2 mV
+15 V	J119-6	+14.775 to +15.225	15 mV	11mV
Digital +5 V	J119-2	+4.85 to +5.15	150 mV	30 mV
Analog +5 V	J119-12	+4.925 to +5.075	15 mV	1 mV
−5 V	J119-5	−4.965 to −5.035	15 mV	1 mV
−8 V	J119-11	−7.88 to −8.12	100 mV	1 mV
−15 V	J119-1	−14.775 to −15.225	10 mV	2 mV

d. Repeat parts a and b for the other test points listed in Table 5-1.

e. Disconnect the DMM.

f. Set the test oscilloscope as follows:

Sweep Speed	5 ms/div
Input Coupling CH 1	1 MΩ AC
Vertical controls	To display CH 1
Trigger controls	Line source, triggered display
Volts/Division	2 mV
BW Limit	20 MHz (button in)

g. Using a 1X probe, connect the test oscilloscope probe ground lead to chassis ground. Connect the probe tip to the first test point listed in Table 5-1.

h. CHECK—Ripple at two times the line frequency and the total peak-to-peak ripple do not exceed the values given in Table 5-1.

i. Repeat part h for each test point in Table 5-1.

j. Disconnect the test oscilloscope.

CRT ADJUSTMENTS

Equipment Required (see Table 4-1)

Primary Leveled Sine-Wave Generator (Item 2)
Time-Mark Generator (Item 6)
50 Ω BNC Cable (2 required) (Item 10)
Alignment Tool (Item 20)

See [redacted] *at the rear of this manual for location of adjustments and test points.*

NOTE

All crt adjustments (other than the Front-Panel ASTIG, FOCUS, and TRACE ROTATION adjustments) are accessed through the High Voltage shield located on the left side of the instrument near the rear of the crt. The location of each adjustment is indicated on the shield.

Initial Control Settings.

Control settings not listed do not affect the procedure.

VERTICAL VOLTS/DIV	
CH 1 and CH 2	0.1 V
CH 1 and CH 2 VAR	In detent
Input Coupling	
CH 1 and CH 2	1 MΩ GND
VERTICAL MODE	
CH 2 and BW LIMIT	On (buttons in)
CH 1, CH 3, and CH 4	Off (buttons out)
ADD and INVERT	Off (buttons out)
ALT/CHOP	ALT (button out)
VERTICAL POSITION	Midrange
A and B SEC/DIV	X-Y (knobs locked)
A and B SEC/DIV VAR	In detent
Horizontal POSITION	Midrange
TRIGGER	
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC
SLOPE	+ (plus)
LEVEL	Midrange
HOLDOFF	In detent
ΔV and Δt	Off (press and release until readout display disappears
TRACKING/INDEP	INDEP (button out)
INTENSITY	Visible display
READOUT INTENSITY	Scale factors off (CCW from MIN)
SCALE ILLUM	Fully CCW
FOCUS	Best focused display

1. Adjust ASTIG Preset (R977) and Grid Bias (R1878).

a. Position the dot in the center area of the graticule using the CH 1 and CH 2 POSITION controls.

b. Focus the displayed dot as well as possible using the front-panel FOCUS control.

c. ADJUST—ASTIG (R977 on the front panel), in conjunction with the FOCUS control, for the sharpest possible dot.

d. Set the INTENSITY control knob CCW so the index mark points directly left (less than full CCW rotation).

e. ADJUST—Grid Bias (R1878) for a barely visible dot.

f. CHECK—No dot is visible when the INTENSITY control is rotated fully CCW.

g. If necessary, repeat parts d and e until the CHECK in part f is correct.

2. Adjust TRACE ROTATION (R975) and Y-Axis Alignment (R1848).

NOTE

If the previous step was not performed, first setup the Initial Control Settings at the beginning of the CRT adjustments, then proceed as follows.

a. Set:

A and B SEC/DIV	50 μs (knobs locked)
INTENSITY	As required for a well defined trace
Δt	(Δt readout)
INTENSITY	As required for well defined vertical cursors

b. Using the CH 2 Vertical POSITION control, align the trace with the center horizontal graticule line.

c. Position one of the Δt cursors to the center vertical graticule line using either the Δ or the ΔREF OR DLY POS control.

d. ADJUST—TRACE ROTATION (R975 on the front panel) to align the trace with the center horizontal graticule line.

e. ADJUST—Y-Axis Alignment (R1848) to align the Δt cursor with the center vertical graticule line.

f. Repeat parts d and e as necessary for the best aligned display.

3. Adjust Geometry (R1870).

NOTE

If the previous step was not performed, first setup the Initial Control Settings at the beginning of the CRT adjustments, then proceed as follows.

a. Set:

Input Coupling CH 2	50 Ω DC
ΔV and Δt	Off (no readout)

b. Connect 10 μs time markers from the Time-Mark Generator to the CH 2 input connector via a 50 Ω BNC cable.

c. Use the Horizontal POSITION control to align the time markers with the vertical graticule lines. Use the CH 2 POSITION control to align the base of the signal with the bottom graticule line.

d. Set the CH 2 VOLTS/DIV switch for at least a 6-division vertical display.

e. Use the CH 2 POSITION control to set the tops of the time markers to graticule center.

f. Set the CH 2 VOLTS/DIV switch one position clockwise to overscan the display.

g. ADJUST—Geometry (R1870) for minimum curvature of the time markers across the entire graticule.

h. Disconnect the test setup.

4. Adjust Edge Focus (R1864).

NOTE

If the previous step was not performed, first setup the Initial Control Settings at the beginning of the CRT adjustments, then proceed as follows.

a. Set:

Input Coupling CH 2	50 Ω DC
VOLTS/DIV CH 2	0.2 V
INTENSITY	Midrange

b. Connect a 50 kHz, 8-division signal from the Primary Leveled Sine-Wave Generator to the CH 2 input connector via a 50 Ω BNC cable.

c. Center the display on the graticule.

d. ADJUST—Edge Focus (R1864), FOCUS (front-panel control), and ASTIG (R977, front-panel preset) for the most uniform focus over the entire display.

e. Disconnect the test setup.

5. Adjust Z-Axis Transient Response (R1834).

NOTE

If the previous step was not performed, first setup the Initial Control Settings at the beginning of the CRT adjustments, then proceed as follows.

a. Set:

A and B SEC/DIV	50 ns (knobs locked)
Input Coupling CH 2	1 MΩ GND
INTENSITY	Slightly left of center

b. Use the Horizontal POSITION control to place the beginning of the trace within the graticule.

c. ADJUST—Z-Axis Transient Response (R1834) for the most uniform intensity across the first division of display.

6. Adjust High Drive Focus (R1842).

NOTE

If the previous step was not performed, first set up the Intial Control Settings at the beginning of the CRT adjustments, then proceed as follows.

The following adjustment has the most effect on the first two divisions of the trace which will probably cause the readout to be compromised slightly. This will not be a problem as the readout is not used at full intensity.

a. Set:

ΔV	On (ΔV readout)
VOLTS/DIV CH2	0.2 V
Input Coupling CH 2	50 Ω DC
A and B SEC/DIV	200 ns (knobs locked)
READOUT INTENSITY	Fully CW
INTENSITY	Fully CW

b. Connect a 10 MHz, 6-division signal from the Primary Leveled Sine-Wave Generator to the CH 2 input connector via a 50 Ω BNC cable.

c. Center the display on the graticule.

d. ADJUST-High Drive Focus (R1842) for the best overall focus of the trace and readout.

e. Disconnect the test setup.

DAC REF, CH 1 AND CH 2 INPUT CAPACITANCE, AND VERTICAL READOUT JITTER ADJUSTMENTS

Equipment Required (see Table 4-1)

Calibration Generator (Item 3)
50 Ω BNC Cable (Item 10)
50 Ω Termination (Item 12)
Digital Multimeter (DMM) (Item 19)
Alignment Tool (Item 20)
Normalizer (Item 22)

See [redacted] *and* [redacted]

at the rear of this manual for test point and adjustment locations.

Initial Control Settings.

Control settings not listed do not affect the procedure.

VERTICAL VOLTS/DIV	
CH 1 and CH 2	0.1 V
CH 1 and CH 2 VAR	In detent
Input Coupling	
CH 1 and CH 2	1 MΩ DC
VERTICAL MODE	
CH 1	On (buttons in)
CH 2, CH 3, and CH 4	Off (buttons out)
ADD, INVERT, and BW LIMIT	Off (buttons out)
ALT/CHOP	ALT (button out)
VERTICAL POSITION	Midrange
A and B SEC/DIV	0.1 ms (knobs locked)
A and B SEC/DIV VAR	In detent
Horizontal POSITION	Midrange
TRIGGER	
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC
SLOPE	+ (plus)
LEVEL	Midrange
HOLDOFF	In detent
Δt	On (Δt readout)
TRACKING/INDEP	INDEP (button out)
INTENSITY	Left of center
READOUT INTENSITY	As required for a visible display
SCALE ILLUM	Fully CCW
FOCUS	Best focused display

1. Adjust DAC Ref (R2127)

NOTE

The objective of this step is to make the total range of the DAC output voltage (sum of the CCW and CW readings) equal to 2.5 V.

a. Connect the digital multimeter (DMM) negative lead to the chassis ground. Connect the positive lead to pin 2 of J118 (on the Main Board).

b. Set the DMM to measure approximately 1.5 Vdc.

c. Rotate the ΔREF OR DLY POS control CCW until the DMM reading remains at a constant value (approximately −1.250 V). Note the reading.

d. Rotate the ΔREF OR DLY POS control CW until the DMM reading remains at a constant value (approximately +1.250 V). Note the reading.

e. Add the absolute values of the readings noted in parts c and d together (approximately 2.500 V).

f. Subtract the total in part e from 2.500 V, then divide the difference by two.

g. ADJUST—DAC Ref (R2127 on the Control Board) to add the (signed) number obtained in part f to the reading obtained in part d.

h. Repeat parts c through g as necessary to obtain a total DAC range of 2.500 V.

2. Adjust CH 1 and CH 2 Input Capacitance (C105 and C205).

NOTE

If the previous step was not performed, first setup the Initial Control Settings before the DAC Ref adjustment, then proceed as follows.

NOTE

The objective of this adjustment is to match the input capacitance of the 50 mV per division position of the VOLTS/DIV switches to the 0.1 V per division position. The front corner of an input square-wave signal is used to indicate when the capacitances are matched.

a. Connect a 1 KHz square-wave signal from the Calibration Generator high-amplitude output to the CH 1 OR X input connector via a 50 Ω BNC cable, a 50 Ω termination, and a normalizer. Adjust the generator output level for a 6-division signal vertically centered on the graticule.

b. Set the normalizer for a square front corner over approximately the first 40 μs (0.4 division) of the positive portion of the waveform.

c. Change the CH 1 VOLTS/DIV switch to the 50 mV position and adjust the generator for a 6-division signal display.

d. ADJUST—The CH 1 50 mV C Adj (C105 on the Main Board) for the same waveform front corner noted in part b.

e. Repeat parts b through d until no change is observed in the waveform front corner when the CH 1 VOLTS/DIV switch is alternated between the 50 mV and 0.1 V positions. When switching between positions, reestablish the reference display amplitude at each position, and observe the square-wave front corner to make the comparison.

f. Move the input signal to CH 2 and change the VERTICAL MODE to display CH 2 only. Adjust the generator amplitude for a 6-division signal amplitude.

g. Set the normalizer for a square front corner over approximately the first 40 μs (0.4 division) of the positive portion of the waveform.

h. Change the CH 2 VOLTS/DIV switch to the 50 mV position and adjust the generator for a 6-division display.

i. ADJUST—The CH 2, 50 mV C Adj (C205 on the Main Board) for the same waveform front corner noted in part g.

j. Repeat parts g through i until no change is observed in the waveform front corner when the CH 2 VOLTS/DIV switch is alternated between the 50 mV and 0.1 V positions. When switching between positions, reestablish the reference signal amplitude at each position, and observe the square-wave front corner to make the comparison.

k. Disconnect the test setup.

3. Adjust Vertical Readout Jitter (R618).

NOTE

If the previous step was not performed, first setup the Initial Control Settings before the DAC Ref adjustment, then proceed as follows.

a. Set the CH 1 Input Coupling to 50 Ω DC.

b. Press and release the ΔV button to obtain a ΔV display.

c. Use the ΔREF OR DLY POS control to position one cursor 3 divisions above graticule center. Use the Δ control to position the other cursor 3 divisions below graticule center.

d. Connect a 1 kHz, fast-rise signal from the Calibration Generator to the CH 1 OR X input connector via a 50 Ω BNC cable.

e. Set the generator output level for an 8-division display.

f. Use the CH 1 Vertical and Horizontal POSITION controls to center the CH 1 display on the graticule.

g. ADJUST—Vertical Readout Jitter (R618) for minimum vertical jitter of the readout characters and cursors.

h. Disconnect the test setup.

AUTOMATIC CALIBRATION CONSTANTS, HORIZONTAL AND VERTICAL GAIN, CENTERING, AND TRANSIENT RESPONSE ADJUSTMENTS

NOTE

Within the following procedure, the calibration constants for timing, vertical gain, and trigger level are generated by the system microprocessor and are stored in nonvolatile memory. The adjustments in CAL 01, 02, 03, and 04 should be performed in numerical sequence, i.e., CAL 01 should be done before CAL 02, CAL 02 should be done before CAL 03, etc. Performing partial procedures (i.e. only one or two of the CAL steps) is not recommended and should only be done if the calibration constants that would have been set in the preceding steps are known to be correct.

The CAL functions are available only if the CAL/NO CAL jumper (P501 on the Control Board) is in the CAL position (between pins 1 and 2) when power is turned on. When the automatic calibration procedures are completed, return the jumper to the NO CAL position to prevent entry into the calibration routines.

Equipment Required (see Table 4-1)

Calibration Generator (Item 3)
Time-Mark Generator (Item 6)
50 Ω BNC Cable (Item 10)
Dual-Input Coupler (Item 11)
5X Attenuator (Item 17)
Digital Multimeter (DMM) (Item 19)
Alignment Tool (Item 20)

See [redacted] *at the rear of this manual for test point and adjustment locations.*

Initial Control Settings.

CAL/NO CAL jumper	CAL position (between pins 1 and 2) prior to turning on power

NOTE

When performing the automatic CAL steps, initial setting of the front-panel controls is not required.

CAL 01—HORIZONTAL

1. Check/Adjust Horizontal Timing, X1 Gain (R860), X10 Gain (R850), Hrz Ctr (R801), and Trans Resp (R802).

a. Simultaneously press in and hold the Δt and the ΔV push buttons, then press and hold the SLOPE switch. Hold all three switches in for approximately one second, then release them.

b. CHECK—Top line of the readout display says: "DIAGNSTIC. PUSH A/B TRIG TO EXIT".

NOTE

The "menu" of calibration, test, and exercise routines are in a loop that may be scrolled through in single steps, either forward or backward. Pressing up or down on the TRIGGER MODE switch and releasing it respectively increments or decrements the menu position by one. As each routine is selected, its name appears in the lower left corner of the readout display.

When performing a calibration step, touch only the specific control or controls called out in the procedure. Movement of other controls may cause erroneous calibration results.

c. Scroll to CAL 01.

CAUTION

Upon entering CAL 01, the Input Coupling is automatically set to 50 Ω DC and the 50 Ω OVERLOAD protection is disabled. Before starting the procedure, make sure any 50 Ω OVERLOAD condition has been cleared.

NOTE

In this procedure, pressing up and releasing the TRIGGER COUPLING switch stores the current calibration parameter being set and increments the routine to the next step (except where otherwise noted).

d. Connect the DMM, set to measure approximately 500 mV, to the CALIBRATOR output.

e. Press up and release the TRIGGER COUPLING switch.

NOTE

The CALIBRATOR output will go to its LO level on odd CAL steps and to its HI level on even steps.

f. CHECK—CALIBRATOR output voltage is 0 mV ±1 mV.

g. CHECK—Readout indicates ADJUST Δ, (step) 1, 100 μs (for A Sweep), and 1 μs (for B Sweep).

NOTE

The readout prompts the operator by showing the control to be moved (upper left corner), the autocal step number (upper right corner), the A Sweep speed (bottom right center), and the B Sweep speed (bottom right corner) as set up by the routine. An example (from step g above) is:

ADJ Δ 1

100 μs 1 μs

h. Connect the Time-Mark Generator, set for 0.1 ms time markers, to the CH 1 OR X input connector via a 50 Ω BNC cable.

i. Set:

VOLTS DIV	As needed for a convenient signal display amplitude
TRACE SEP	As needed to separate the A and B Sweeps
CH 1 POSITION	As needed to view both A and B Sweeps
Horizontal POSITION	Position start of trace at the left graticule line

NOTE

Some sequential pairs of steps are iterative, i.e., the earlier step is recalled if an adjustment is made in the later step. Occasionally, on the earlier of some of these pairs, the readout may indicate "LIMIT" before the correct control setting is reached . If this occurs, proceed to the next AUTOCAL step. After the adjustment at the next step is performed, the previous step will automatically be recalled, and the adjustment may be performed in the normal manner.

j. ADJUST—ΔREF OR DLY POS and Δ controls to align both the intensified zones with the 6th time marker (near graticule center) and to superimpose the delayed B Sweep time markers. Press up and release the TRIGGER COUPLING switch.

k. CHECK—CALIBRATOR output voltage is between 398 mV and 402 mV of the reading noted in part f. Disconnect the DMM when through.

l. CHECK—Readout indicates ADJ Δ, (step) 2, 100 μs (for A Sweep), and 1 μs (for B Sweep).

m. ADJUST—ΔREF OR DLY POS control to intensify the 2nd time marker, and ADJUST—Δ control to intensify the the 10th time marker. Superimpose the delayed B Sweep time markers within 0.2 division.

n. Push up and release the TRIGGER COUPLING switch.

o. CHECK—Readout indicates ADJ Δ, (step) 3, 300 μs (for A Sweep), and 1 μs (for B Sweep).

p. ADJUST—ΔREF OR DLY POS control to intensify the 4th time marker, and ADJUST—Δ control to intensify the 28th time marker. Superimpose the delayed B Sweep time markers within 1.2 division.

q. Press up and release TRIGGER COUPLING switch. If the adjustment in step 3 was changed, step 2 will be recalled; otherwise step 4 will be initiated.

r. CHECK—Readout indicates ADJ Δ, (step) 4, 100 μs (for A Sweep), and 1 μs (for B Sweep). Set the Time-Mark Generator for 5 μs time markers.

s. ADJUST—Δ control CCW until no further movement of the B Sweep display occurs. Note the position of the 1st time marker, then adjust the Δ control CW until the 2nd time marker moves to the left and aligns with the position just noted.

t. Press up and release the TRIGGER COUPLING switch. Set the Time-Mark Generator for 10 μs time markers.

u. CHECK—Readout indicates X1, X10, HRZ CTR, (step) 5, and 10 μs (for A Sweep) and two vertical cursors appear on the display.

v. ADJUST—X1 Gain (R860) and Hrz Ctr (R801) to align the two cursors with the 2nd and 10th vertical graticule lines, then adjust X10 Gain (R850) for 1 time marker per division.

w. Press up and release TRIGGER COUPLING switch. Set the Time-Mark Generator for 10 ms time markers.

x. CHECK—Readout indicates ADJ Δ, (step) 6, 10 ms (for A Sweep), and 100 μs (for B Sweep).

y. ADJUST—ΔREF OR DLY POS control to intensify the 2nd time marker, and ADJUST—Δ control to intensify the 10th time marker. Superimpose the delayed B Sweep time markers within 0.2 division.

z. Press up and release TRIGGER COUPLING switch. Set the Time-Mark Generator for 1 μs time markers.

aa. For each step in Table 5-2, do the following:

1. Adjust the ΔREF OR DLY POS and Δ controls, as necessary, to intensify the indicated time marks on the A Sweep and superimpose the displayed B Sweep markers within the listed limits.

2. Press up and release the TRIGGER COUPLING switch.

NOTE

If the Δ control is adjusted at step 9, 12 or 14, the previous step will be repeated.

Table 5-2
Horizontal Timing

Step No.	Time-Marker Period	ΔREF Marker	Δ Marker	Superposition Tolerance In Tolerance In Divisions
7	1 μs	2	10	0.2
8	2 μs	2	10	0.2
9	2 μs	4	28	1.2
10	10 μs	2	10	0.2
11	50 μs	2	10	0.2
12	50 μs	4	28	1.2
13	0.5 μs	2	10	0.2
14	0.5 μs	4	28	1.2
15	100 ns	2	10	0.2
16	20 ns	2	10	0.1

bb. Set the TRACE SEP fully CW.

cc. For each step in Table 5-3 (except step 28), adjust the Δ control for the listed number of markers over the center 8 divisions, then press up and release the TRIGGER COUPLING switch. If the Δ control is adjusted at step 18, 20, 23, or 25, the previous step will be repeated. At step 28, adjust Trans Resp (R802 on the Main Board) as indicated.

NOTE

Change the CH 1 VOLTS/DIV switch setting as necessary to maintain adequate signal display amplitude.

Table 5-3
Horizontal Timing

Step No.	Time-Marker Period	Markers Over 8 Divisions
17	1 μs	8
18	1 μs	24
19	2 μs	8
20	2 μs	24
21	10 μs	8
22	50 μs	8
23	50 μs	24
24	500 ns	8
25	500 ns	24
26	100 ns	8
27	20 ns	8
28	2 ns	2[a]
29	1 ms	8

[a] **Adjust Trans Resp (R802) for precisely 2 cycles between the 2nd and 10th graticule lines.**

NOTE

If the remainder of the Adjustment Procedure will not be performed (in totality), readjustment of Horizontal Readout Jitter (R805) may be necessary if the X1 Gain (R860) or the X10 Gain (R850) was changed. See subsection 2 on page 5-16 for that procedure.

dd. Disconnect the test setup.

CAL 02—VERTICAL

2. Check/Adjust Vertical Preamp Gain, Gain (R638), and Vertical Centering (R639).

NOTE

If the previous step (CAL 01) was not performed, the adjustments in this subsection should only be performed if those constants that would have been set in CAL 01 are known to be correct.

a. Set the front-panel INTENSITY control at midrange.

b. Scroll to CAL 02.

c. Press up and release the TRIGGER COUPLING switch. The instrument will automatically increment through steps 100 to 111.

d. CHECK—Readout indicates CH 1 VAR, CH2 POS, (step) 111, 500 mV, and BWL.

NOTE

The readout prompts the operator by showing the controls to be moved (upper left corner and upper center), the autocal step number (upper right corner), the amplitude of signal to be applied to either the CH 1 or CH 2 connectors (lower left corner), and any other scope function that is enabled. An example (from step d above) is:

CH1 VAR CH2 POS 111
500 mV BWL

e. Connect a 0.5 V, standard-amplitude signal from the Calibration Generator to the CH 1 OR X input connector via a 50 Ω BNC cable.

f. Use the CH 2 POSITION control to vertically position the trace to within 1 division of the center graticule line.

g. ADJUST—CH 1 POSITION and VOLTS/DIV VAR controls to obtain a 10-division horizontal signal. Press up and release the TRIGGER COUPLING switch.

h. CHECK—Readout indicates MOVE SW, CENTER CH1 POS, (step) 112, 500 mV, and BWL; then press up and release the TRIGGER COUPLING switch.

i. ADJUST—CH 1 POSITION control carefully until the CH 1 input coupling "1 MΩ DC" indicator remains illuminated, then press up and release the TRIGGER COUPLING switch.

NOTE

In the following steps, if the "LIMIT" message appears, it probably indicates that the TRIGGER COUPLING (step) switch was moved before the required signal was applied. Press down and release the TRIGGER COUPLING switch, verify that the correct signal is applied, then press up and release the TRIGGER COUPLING switch.

j. CHECK—First step number listed in Table 5-4 appears in the readout.

k. Apply the corresponding standard-amplitude signal from the Calibration Generator, then press up and release the TRIGGER COUPLING switch.

l. Repeat steps j and k for each step-signal combination listed in Table 5-4.

Table 5-4
Vertical Calibration Signals

Autocal Step Readout Display	Standard-Amplitude Signal to Apply
113, 114 [a]	0.5 V
115	0.2 V
116	0.1 V
117	50 mV
118	20 mV
119	1 V
120	10 V

[a] When step 113 is performed, step 114 is also automatically done. No indication of step 114 will be shown unless a LIMIT error is encountered.

m. Move the signal to the CH 2 input connector.

n. CHECK—Readout indicates MOVE SW, CENTER CH 2 POS, (step) 121, 500 mV, 500 mV, and BWL.

o. Set the Calibration Generator for a 500 mV standard-amplitude signal, then press up and release the TRIGGER COUPLING switch.

p. ADJUST—CH 2 VERTICAL POSITION control until the CH 1 Input Coupling "1 MΩ DC" indicator remains illuminated, then press up and release the TRIGGER COUPLING switch.

q. CHECK—Readout indicates MOVE SW, CENTER CH 2 POS, (step) 122, 500 mV, 500 mV, and BWL.

r. With the Calibration Generator set for a 500 mV standard-amplitude signal, press up and release the TRIGGER COUPLING switch.

s. ADJUST—CH 2 VERTICAL POSITION control until the CH 1 Input Coupling "1 MΩ DC" indicator remains illuminated, then press up and release the TRIGGER COUPLING switch.

t. CHECK—First step number listed in Table 5-5 appears in the readout.

u. Apply the corresponding standard-amplitude signal, then press up and release the TRIGGER COUPLING switch.

v. Repeat steps t and u for each step-signal combination listed in Table 5-5.

Table 5-5
Vertical Calibration Signals

Autocal Step Readout Display	Standard-Amplitude Signal to Apply
123, 124 [a]	0.5 V
125	0.2 V
126	0.1 V
127	50 mV
128	20 mV
129	1 V
130	10 V

[a] When step 123 is performed, step 124 is also automatically done. No indication of step 124 will be shown unless a LIMIT error is encountered.

w. CHECK—Readout indicates MOVE SW, CENTER CH 2 POS, (step) 131, 10 V, ↓10 V, and BWL; then press up and release the TRIGGER COUPLING switch.

x. ADJUST—CH 2 POSITION control until the CH 1 Input Coupling "1 MΩ DC" indicator remains illuminated, then press up and release the TRIGGER COUPLING switch. The instrument will automatically increment through steps 132 to 142.

y. CHECK—Readout indicates MOVE SW, CENTER CH 1 POS, (step) 142, 50 mV, and BWL.

z. Move the signal to the CH 1 OR X input connector and set the Calibration Generator for a 50 mv standard-amplitude signal, then press up and release the TRIGGER COUPLING switch.

aa. ADJUST—CH 1 POSITION control until the CH 1 "1 MΩ DC" indicator remains illuminated, then press up and release the TRIGGER COUPLING switch. Wait approximately 10 seconds for automatic calibration of the ΔV cursors.

bb. CHECK—Readout indicates VERTICAL CENTER and GAIN.

cc. ADJUST—Gain (R638) for precisely 5 divisions between the two horizontal cursors.

dd. ADJUST—Vertical Centering (R639) to center the cursors on the graticule (align the cursors with the dotted 0% and 100(%) graticule lines).

ee. Press up and release the TRIGGER COUPLING switch.

CAL 03—TRIGGERING

3. Check/Adjust Triggering.

NOTE

If the previous steps (CAL 01 and CAL 02) were not performed, the adjustments in this subsection should only be performed if those constants that would have been set in CAL 01 and CAL 02 are known to be correct and if a DC Balance has been performed after a 20-minute warmup period.

a. Scroll to CAL 03.

b. Press up and release the TRIGGER COUPLING switch.

c. CHECK—Procedure automatically steps from 201 through 214 and stops at 215.

d. CHECK—Readout indicates CH 1, 500 mV, and (step) 215.

NOTE

The readout prompts the operator by showing which connector the input signal should be applied to (upper left corner), the amplitude of that signal (upper center), and the autocal step number (upper right corner). An example (from step d above) is:

CH1 500 mV 215

e. Connect a 0.5 V standard-amplitude signal from the Calibration Generator to the CH 1 OR X input connector via a 50 Ω BNC cable.

f. Press up and release the TRIGGER COUPLING switch.

g. CHECK—Readout indicates CH 1, 500 mV, and (step) 216.

h. Press up and release the TRIGGER COUPLING switch.

i. CHECK—Readout indicates CH 2, 500 mV, and (step) 217.

j. Move the signal to the CH 2 input connector. Press up and release the TRIGGER COUPLING switch.

k. CHECK—Readout indicates CH 3, 500 mV, and (step) 218.

l. Move the signal to the CH 3 input connector. Press up and release the TRIGGER COUPLING switch.

m. CHECK—Readout indicates CH 3, 2V, and (step) 219.

n. Change the generator output level to 2 V, then press up and release the TRIGGER COUPLING switch.

o. CHECK—Readout indicates CH 4, 500 mV, and (step) 220.

p. Move the signal to the CH 4 input connector and change the generator output level to 0.5 V. Press up and release the TRIGGER COUPLING switch.

q. CHECK—Readout indicates CH 4, 2V, and (step) 221.

r. Change the generator output level to 2 V, then press up and release the TRIGGER COUPLING switch.

s. Disconnect the test setup.

CAL 04—CH 2 DELAY ENABLE/DISABLE

4. Check/Adjust CH 2 Delay Enable/Disable.

a. Scroll to CAL 04.

b. Press up and release the TRIGGER COUPLING switch to initiate the routine.

c. CHECK—Readout alternately indicates "ENABLED" and "DISABLED" each time the TRIGGER COUPLING switch is pressed up and released.

d. Leave the readout display indicating "ENABLED". Press and release the A/B TRIG button to exit the routine.

e. Connect a 100 kHz, positive-going signal from the Calibration Generator fast-rise output to the CH 1 OR X and CH 2 input connectors via a 50 Ω BNC cable, a 5X attenuator, and a Dual-Input Coupler.

f. Set:

VERTICAL MODE	
CH 1 and CH 2	On (buttons in)
VOLTS/DIV	
CH 1 and CH 2	10 mV
Input Coupling	
CH 1 and CH 2	50 Ω DC
A and B SEC/DIV	5 ns (knobs locked)
TRIGGER	
SOURCE	CH 1
MODE	AUTO LVL
COUPLING	DC
SLOPE	+ (plus)

g. Set the generator amplitude for a 3- to 5-division display amplitude. Use the CH 1 and CH 2 POSITION controls to vertically overlay the traces near the center of the graticule area.

h. Set the Horizontal POSITION control to set the rising edge of the signal near the center vertical graticule line.

i. Press the X10 MAG button in to obtain a magnified display.

j. Pull out the B SEC/DIV knob.

k. CHECK—Readout indicates "CH 2 DLY—TURN Δ" and that the Δ control will move the leading edge of the CH 2 trace at least 1 division to either side of the CH 1 trace.

l. ADJUST—Δ control to superimpose the leading edges.

m. Push in the B SEC/DIV knob.

NOTE

If the CH 2 Delay Adjust feature is to be disabled for normal instrument use, perform the following steps; otherwise, proceed to step r below.

n. Reenter the Diagnostic Monitor by pressing the ΔV and Δt buttons simultaneously (hold them in), then press and hold the TRIGGER SLOPE button. Release the buttons after about 1 second.

o. Scroll to CAL 04.

p. Press up and release the TRIGGER COUPLING switch until the readout indicates "DISABLED."

q. Press and release the A/B TRIG button to return to normal operating mode.

r. Return the CAL/NO CAL jumper to the NO CAL position and disconnect the test setup.

DYNAMIC CENTERING, CRT TERMINATION, VERTICAL GAIN, VERTICAL CENTERING, TRANSIENT RESPONSE, HF ADJ, READOUT JITTER, DC BALANCE, AND X-Y PHASE DIFFERENTIAL ADJUSTMENTS

Equipment Required (see Table 4-1)

Primary Leveled-Sinewave Generator (Item 2)	5X Attenuator (Item 17)
Calibration Generator (Item 3)	Alignment Tool (Item 20)
50 Ω BNC Cable (Item 10)	Tunnel Diode Pulser (Item 23)

See [redacted] *and* [redacted]

at the rear of this manual for location of test points and adjustments.

Initial Control Settings.

Control settings not listed do not affect the procedure.

VERTICAL VOLTS/DIV	
CH 1 and CH 2	10 mV
CH 1 VAR	CCW (out of detent)
CH 2 VAR	In detent
Input Coupling	
CH 1 and CH 2	50 Ω DC
VERTICAL MODE	
CH 1	On (button in)
CH 2, CH 3 and CH 4	Off (buttons out)
ADD, INVERT, and BW LIMIT	Off (buttons out)
ALT/CHOP	ALT (button out)
VERTICAL POSITION	Midrange
A and B SEC/DIV	20 ns (knobs locked)
A and B SEC/DIV VAR	In detent
Horizontal POSITION	Midrange
TRIGGER	
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC
SLOPE	+ (plus)
LEVEL	Midrange
HOLDOFF	In detent
ΔV	On (RATIO readout)
TRACKING/INDEP	INDEP (button out)
ΔREF OR DLY POS and Δ	Cursors near the 3rd line above and 3rd line below graticule center (6 division spacing)
INTENSITY	Left of center
READOUT INTENSITY	Right of center
SCALE ILLUM	Fully CCW
FOCUS	Best focused display

1. Adjust Dynamic Centering (R3401 and R3407).

a. Rotate the READOUT INTENSITY control from midrange to fully CW and note any horizontal and vertical shift that occurs in the readout characters.

b. ADJUST—Horizontal Dynamic Centering (R3401) to minimize the horizontal component of the shift.

c. ADJUST—Vertical Dynamic Centering (R3407) to minimize the vertical component of the shift.

d. Repeat steps a through c as necessary to minimize readout shift until no further improvement is noted.

2. Check/Adjust CRT Termination (R1501), Vertical Gain (R638), Vertical Centering (R639), High-Frequency Trans Resp (C404, R403, R411, C403, and L403), HF Adj (R417), Vertical Readout Jitter (R618), Horizontal Readout Jitter (R805), and X-Y Phasing (C118).

NOTE

If the previous step was not performed, first setup the Initial Control Settings before the Dynamic Centering adjustments, then proceed as follows.

NOTE

CRT Termination, High Frequency Transient Response, Vertical Gain, Vertical Centering, and Readout Jitter adjustments are interactive. This procedure optimizes these adjustments together.

a. Rotate the ΔREF OR DLY POS control CCW until the RATIO readout is constant.

b. Rotate the Δ control until the readout display indicates 130.0%.

c. CHECK—One cursor is near the bottom horizontal graticule line and the other is near dotted graticule line marked 100(%).

d. Rotate the ΔREF OR DLY POS control until the readout displays exactly 100.0%. The cursors should now be on or near the dotted graticule lines marked 0% and 100(%).

e. Set the CH 1 VOLTS/DIV VAR to the detent position.

NOTE

Care must be taken not to disturb the position of the controls adjusted in parts b through e during the balance of this procedure. If they are accidentally moved, repeat the procedure from the beginning.

f. Connect the high-amplitude output of the Calibration Generator to the CH 1 OR X input connector via a 50 Ω BNC cable, a Tunnel Diode Pulser, and a 5X attenuator.

g. Set the generator Period switch to 100 kHz, and set the generator amplitude control to maximum.

h. Rotate the pulser Trigger control CW (from a fully CCW position) until a stable signal first appears on the graticule. Display amplitude will be approximately 5 divisions. The oscilloscope TRIGGER LEVEL control may need to be adjusted to obtain a stable display.

NOTE

As a guide when performing the following adjustments, optimum performance is achieved when the CH 1 and CH 2 step response aberrations are ≤ 4% when using 10 mV/division deflection factors (≤ 0.2 division on a 5-division signal).

i. ADJUST—CRT Termination (R1501) for best flat-top approximately 5 ns past the rising edge of the waveform. The adjustment is accessable through a hole in the top cover plate. Squeezing the output leads of the termination inductors (LR1513 and LR1514) toward each other will reduce the spike that may be present approximately 6 ns behind the leading edge.

j. ADJUST—Trans Resp adjustments (C404 and R403) alternately for the best flat top on the first 10 ns of the positive portion of the waveform. When adjusting R403, use only the range between 1/4 CCW to fully CCW. Repeat steps i and j as necessary for best flat top over the first 20 ns.

k. ADJUST—Vertical Gain (R638) and Vertical Centering (R639) to vertically center the cursors precisely 5 divisions apart (align with the dotted 0% and 100(%) graticule lines).

l. Press the ΔV button to turn off the cursors.

NOTE

Inductor L403 is a selectable component chosen to match transient response characteristics of the Vertical system. If spreading the coil turns as described in step m below will not correct the front corner overshoot, a smaller value coil should be installed. The proper coils to use are:

60 nH—3 turn inductor	Part No. 108-0420-00
45 nH—2 turn inductor	Part No. 108-0578-00
35 nH—1 turn inductor	Part No. 108-0557-00

m. ADJUST—Trans Resp adjustments (R411, C403) and HF Adj (R417) alternately for the squarest front corner and flatest top of the positive portion of the waveform. If the front corner is overshot, adjust the small coil (L403) by spreading the coil leads apart, then readjust R411 and C403.

n. Move the test signal to CH 2 and set the VERTICAL MODE switches to display CH 2.

o. Repeat parts j and m for CH 2, switching between CH 1 and CH 2 as necessary, until both CH 2 and CH 1 aberrations are minimized. When minimized, leave CH 2 selected.

p. Disconnect the Calibration Generator and connect the Secondary Leveled Sine-Wave Generator to the CH 2 input via a BNC cable.

q. Set the generator for a 6-division display at the reference frequency.

r. Change the generator output frequency to 300 MHz.

s. CHECK—Display amplitude is between 4.4 divisions and 5.0 divisions. Optimum performance of the Vertical system is obtained when this value is between 4.6 and 4.8 divisions.

s1. CHECK—Display amplitude does not drop below 4.4 divisions when sweeping the generator frequency from 300 MHz to 250 MHz.

t. ADJUST—If necessary, compromise the settings in parts j and m to obtain the best flat top with the proper bandwidth. HF Adj (R417) will have the most effect on the bandwidth.

u. Move the input signal to CH 1 and select CH 1 for display.

v. Repeat parts q through t for CH 1. If readjustment of R417 is necessary, repeat parts j through t.

w. Set the A and B SEC/DIV switch to 1 ms.

x. Select CH 1 for display.

y. Press and release the ΔV button to obtain a ΔV display.

z. Use the ΔREF OR DLY POS control to position one cursor 3 divisions above graticule center and use the Δ control to position the other cursor 3 divisions below graticule center.

aa. Connect a 1 kHz, fast-rise signal from the Calibration Generator to the CH 1 OR X input connector via a 50 Ω BNC cable.

bb. Set the generator output level for an 8-division display.

cc. Use the CH 1 Vertical and the Horizontal POSITION controls to center the CH 1 display on the graticule.

dd. ADJUST—Vertical Readout Jitter (R618) for minimum vertical jitter of the readout characters and cursors.

ee. Press the Δt button to obtain a Δt cursor display.

ff. Using the ΔREF OR DLY POS and Δ controls, position the cursors to the 2nd and 10th graticule lines.

gg. Press the X10 MAG button to magnify the display.

hh. ADJUST—Horizontal Readout Jitter (R805) for minimum horizontal jitter of the readout characters and cursors.

ii. Disconnect the test setup.

3. Set CH 1 and CH 2 DC Balance.

NOTE

The instrument must have had a 20-minute warmup prior to performing the next step to ensure accuracy.

a. Set:

Input Coupling	
CH 1 and CH 2	1 MΩ AC

b. Press up momentarily and release the CH 1 and CH 2 Input Coupling switches simultaneously.

c. CHECK—A moving dot display replaces the normal display for approximately 10 seconds, then the display returns to normal.

d. CHECK—For less than 0.2-division vertical trace shift when the CH 1 VOLTS/DIV switch is rotated through all of its settings.

e. Set the VERTICAL MODE switches to disable CH 1 and display CH 2.

f. CHECK—For less than 0.2-division vertical trace shift when the CH 2 VOLTS/DIV switch is rotated through all of its settings.

4. Adjust X-Y Phasing (C118).

a. Set:

VOLTS/DIV	
CH 1	50 mV
Input Coupling	50 Ω DC
A SEC/DIV	X-Y
VERTICAL MODE	
CH 1	On (button in)
CH 2	Off (button out)

b. Connect the Primary Leveled Sine-Wave Generator to the CH 1 OR X input connector via a 50 Ω BNC cable.

c. Set the generator frequence to 1 MHz and adjust the amplitude for a 6-division vertical signal display.

d. Use the CH 1 POSITION control to vertically center the display on the graticule.

e. ADJUST—X-Y Phasing (C118) for no opening in the elipse.

f. Set the generator frequency to 2 MHz and adjust the amplitude for a 6-division vertical signal display.

g. CHECK—Horizontal opening in the elipse is 0.3 division or less, measured at the center horizontal graticule line.

i. Disconnect the test setup.

j. Turn POWER Off.