PERFORMANCE CHECK AND FUNCTIONAL VERIFICATION PROCEDURE

INTRODUCTION

This procedure is used to verify proper operation of instrument controls and to check the instrument's performance against the requirements listed in the "Specification" (Section 1). This procedure verifies instrument function and may be used to determine need for readjustment. These checks may also be used as an acceptance test and as a preliminary troubleshooting aid.

Removing the wrap-around cabinet is not necessary to perform this procedure. All checks are made using the operator accessible front- and rear-panel controls and connectors.

Within the procedure, steps to verify proper operation of an instrument control or function that is not specified in the "Specification" section begin with the word "VERIFY". These functions ARE NOT specifications and should not be interpreted as such. Steps to check performance specifications begin with the word "CHECK".

PREPARATION

Test equipment items 1 through 18 listed in Table 4-1 are required to perform this procedure. The specific pieces of equipment required to perform the checks within each section are listed at the beginning of that section. The item numbers in parenthesis next to each piece of equipment refer to the numbered equipment list of Table 4-1. Items 19 through 23 are used only for instrument calibration (see the Adjustment Procedure in Section 5).

Before performing this procedure, ensure that the LINE VOLTAGE SELECTOR switch is set for the ac power source being used (see "Preparation for Use" in Section 2). Connect the instrument to be checked and the test equipment to an appropriate power source. Turn the instrument on and ensure that no error message is displayed on the crt. If an error message is present, have the instrument repaired or calibrated by a qualified service technician before performing this procedure.

The procedure is divided into sections to permit functional and performance verifications of individual sections of the instrument without performing the entire procedure. Perform all steps within a section, both in the sequence presented and in their entirety to ensure that control settings are correct for the following step.

When performing partial procedures, the Initial Control Settings at the first of the section should be setup first; then make any changes noted at the first of the subsection to be performed. When performing the procedures in sequence, merely change those controls that have changed from the previous step.

Table 4-1
Test Equipment Required

Item and Description	Minimum Specification	Use	Example of Applicable Test Equipment
1. Variable Power Supply	Variable output voltage: 0V to +16V.	Check input overload switching.	TEKTRONIX PS 503A.
2. Leveled Sine-Wave Generator (Primary)	Frequency: 50 kHz to 250 MHz. Output: 0 V to 5 V. Reference frequency: 50 kHz.	Check bandwidth and triggering.	TEKTRONIX SG 503.
3. Calibration Generator	Fast-rise, low-abberation amplitudes: to 1 V. Rise time: 1 ns or less. Repetition rate: 1 kHz to 100 kHz. Precision amplitudes: 0.01 V to 50 V ±0.25%.	Signal source for gain and transient response.	TEKTRONIX PG 506.
4. Leveled Sine-Wave Generator (Secondary)	Frequency: 245 to 500 MHz. Output: 0 V to 5 V. Reference frequency: 50 kHz.	Check bandwidth and triggering.	TEKTRONIX SG 504 with Leveling Head.
5. Function Generator	Repetition rate: 1 kHz to 1 MHz. Output to 15 V p-p.	Check triggers and coupling.	TEKTRONIX FG 501A.
6. Time-Mark Generator	Markers: 2 ns to 5 s in a 1-2-5 sequence. Marker accuracy: ±0.1%.	Check horizontal timing.	TEKTRONIX TG 501
7. Oscilloscope with P6131 10X Standard Accessory Probe.	Bandwidth: 300 MHz. General Purpose.	Check power supply ripple and output signals. Troubleshooting.	TEKTRONIX 2465.
8. T-Connector	Impedance: 50 Ω. Connectors: BNC.	Signal interconnection.	TEKTRONIX Part Number 103-0030-00.
9. Precision BNC Cable	Impedance: 50 Ω. Connectors: BNC. Length: 36 in.	Signal interconnection.	TEKTRONIX Part Number 012-0482-00.
10. BNC Cable (2 required)	Impedance: 50 Ω. Connectors: BNC Length: 42 in.	Signal interconnection.	TEKTRONIX Part Number 012-0057-01
11. Dual-Input Coupler	Connectors: BNC female-to-dual-BNC male.	Signal interconnection.	TEKTRONIX Part Number 067-0525-02
12. Termination (2 required)	Impedance: 50 Ω. Connectors: BNC.	Signal interconnection.	TEKTRONIX Part Number 011-0049-01.
13. Adapter	Mini probe-tip-to-BNC male.	Signal interconnection.	TEKTRONIX Part Number 013-0195-00.
14. Adapter	BNC female-to-BNC female.	Signal interconnection.	TEKTRONIX Part Number 103-0028-00.
15. Adapter	Connectors: BNC female-to-dual banana.	Signal interconnection.	TEKTRONIX Part Number 103-0090-00.
16. Attenuator	Attenuation factor: 2X. Impedance: 50 Ω. Connectors: BNC.	Signal attenuation.	TEKTRONIX Part Number 011-0069-02.
17. Attenuator	Attenuation factor: 5X. Impedance: 50 Ω. Connectors: BNC.	Signal attenuation.	TEKTRONIX Part Number 011-0060-02.
18. Attenuator	Attenuation factor: 10X. Impedance: 50 Ω. Connectors: BNC.	Signal attenuation.	TEKTRONIX Part Number 011-0059-02.

Table 4-1 (cont)

Item and Description	Minimum Specification	Use	Example of Applicable Test Equipment
19. Digital Multimeter (DMM)	DC volts range to +20 V. Accuracy ±0.2%.	Check power supplies and CALIBRATOR.	TEKTRONIX DM 502A.
20. Low-Capacitance Alignment Tool	Shaft length: 2 in.	Adjust variable resistors and capacitors.	TEKTRONIX Part Number 003-0675-00.
21. 1X Probe	Attenuation: 1X. Bandpass: <20 MHz.	Check power supply ripple.	TEKTRONIX P6101.
22. Normalizer	Input resistance: 1 MΩ. Input capacitance: 15 pf.	Check input capacitance.	TEKTRONIX Part Number 067-0537-00.
23. Tunnel Diode Pulser	Rise time: 125 ps or less.	Check transient response.	TEKTRONIX Part Number 067-0681-01.

VERTICAL

Equipment Required (see Table 4-1)

- Power Supply (Item 1)
- Primary Leveled Sine-Wave Generator (Item 2)
- Calibration Generator (Item 3)
- Secondary Leveled Sine-Wave Generator (Item 4)
- P6131 10X Probe (supplied with 2465) (Item 7)
- Precision 50 Ω BNC Cable (Item 9)
- 50 Ω BNC Cable (Item 10)
- Dual-Input Coupler (Item 11)
- 50 Ω BNC Termination (Item 12)
- Mini Probe Tip-to-BNC Adapter (Item 13)
- BNC Female-to-BNC Female Adapter (Item 14)
- BNC Female-to-Dual Banana Adapter (Item 15)
- 2X Attenuator (Item 16)
- 5X Attenuator (Item 17)
- 10X Attenuator (Item 18)

Initial Control Settings.

Control settings not listed do not affect the procedure.

Set:

VERTICAL MODE	
CH 1	On (button in)
CH 2, CH 3, CH 4, ADD, and INVERT	Off (buttons out)
CHOP/ALT	ALT (button out)
20 MHz BW LIMIT	Off (button out)
VOLTS/DIV	
CH 1 and CH 2	1 V
CH 1 and CH 2 VAR	In detent
CH 3 and CH 4	0.1 V (buttons out)
Input Coupling	
CH 1 and CH 2	1 MΩ GND
A and B SEC/DIV	10 ms (knobs locked)
A and B SEC/DIV VAR	In detent
X10 MAG	Off (button out)
Δt and ΔV	Off (press and release until associated readout is off)
TRACKING	Off (button out)
TRACE SEP	Fully CW
TRIGGER	
HOLDOFF	Fully CCW
LEVEL	Midrange
SLOPE	+ (plus)
A/B TRIG SELECT	A
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC

1. Verify CH 1 and CH 2, 50 Ω OVERLOAD Protection.

a. Connect the Power Supply to the CH 1 OR X input connector via a 50 Ω BNC cable and a BNC female-to-dual banana adapter.

b. Using the CH 1 VERTICAL POSITION control, position the trace on the bottom horizontal graticule line.

c. Change the CH 1 Input Coupling switch to 1 MΩ DC.

d. Turn the Power Supply on.

e. Adjust the Power Supply output level until the CH 1 trace rises to 1 division above the center graticule line (+5 V).

f. Change the CH 1 Input Coupling switch to 50 Ω DC.

g. VERIFY—For a period of one minute, the readout display does not indicate any overload condition (50 Ω OVERLOAD).

h. Change the CH 1 VOLTS/DIV control to 5 V and the CH 1 Input Coupling to 1 MΩ DC.

i. Increase the Power Supply output level until the CH 1 trace rises to the center graticule line (+20 V).

CAUTION

To prevent damage to the input circuitry when in 50 Ω DC, the 20 V source must not be applied to the CH 1 OR X or CH 2 input connectors for longer than 15 seconds. If the automatic OVERLOAD switching does not occur within 15 seconds, turn the Power Supply off immediately.

j. Set the CH 1 Input Coupling switch to 50 Ω DC.

k. VERIFY—Approximately 10 seconds after the CH 1 input coupling switch is set to 50 Ω DC, the readout display indicates "50 Ω OVERLOAD", the CH 1 Input Coupling switch changes to 1 MΩ GND automatically, and the trace returns to the bottom horizontal graticule line.

l. Turn the Power Supply Off.

m. Disconnect the Power Supply.

n. Clear the OVERLOAD condition by pressing up on the CH 1 Input Coupling switch.

o. VERIFY—The CH 1, 1 MΩ DC indicator is lit and the readout display no longer indicates "50 Ω OVERLOAD".

p. Set the VERTICAL MODE switches to display CH 2 and repeat parts a through o to verify 50 Ω OVERLOAD protection for that channel.

2. Check CH 1 and CH 2 Low-Frequency AC Coupling.

a. Set:

VERTICAL MODE	
CH 1	In (button in)
CH 2	Off (button out)
A and B SEC/DIV	10 ms (knobs locked)
VOLTS/DIV	
CH 1 and CH 2	10 mV
Input Coupling	
CH 1 and CH 2	1 MΩ GND

NOTE

Prior to performing the following steps, the 10X probe must be properly compensated. Refer to "Probe Low-Frequency Compensation" in Section 2 of this manual.

b. Connect the CALIBRATOR output signal to the CH 1 OR X input connector using a 10X probe.

c. Position the ground-reference trace 2 divisions below the center horizontal graticule line.

d. Set the CH 1 Input Coupling switch to 1 MΩ DC.

e. CHECK—Displayed signal is vertically centered and has an amplitude of 3.88 to 4.12 divisions.

f. Set the CH 1 Input Coupling to the upper 1 MΩ GND position .

g. Using the CH 1 POSITION control, align the trace with the center horizontal graticule line.

h. Set the CH 1 Input Coupling switch to 1 MΩ AC.

i. CHECK—Displayed signal is a tilted square wave, 4.5 to 4.9 divisions in amplitude, vertically centered on the graticule.

j. Move the probe to the CH 2 input connector.

k. Set the VERTICAL MODE switches to deselect CH 1 and display CH 2.

l. Repeat parts c through i for CH 2.

m. Disconnect the test setup.

3. Check CH 1 and CH 2 VOLTS/DIV, CH 2 INVERT, ΔV and TRIGGER LEVEL Readout Accuracies, Variable VOLTS/DIV, Vertical Linearity, and ADD.

a. Set:

Input Coupling	
CH 1 and CH 2	1 MΩ AC
VERTICAL MODE	
BW LIMIT	On (button in)
ΔV	On (press and release for a ΔV readout)
VOLTS/DIV	
CH 1 and CH 2	2 mV
A and B SEC/DIV	1 ms (knobs locked)

TRIGGER MODE	AUTO

NOTE

The instrument must have had at least 20 minutes warmup prior to performing the following steps.

b. Press up and momentarily hold the CH 1 and CH 2 Input Coupling switches in their 1 MΩ AC positions until a moving dot display replaces the normal signal and readout displays (for approximately 15 seconds). This performs a DC Balance of CH 1 and CH 2.

c. When the signal and readout displays automatically return to normal, set the CH 1 and CH 2 Input Coupling to 1 MΩ DC.

d. Connect the Calibration Generator to the CH 1 OR X input connector via a 50 Ω BNC cable. Do not use a termination.

e. CHECK—CH 1 and CH 2 VOLTS/DIV, ΔV, and TRIGGER LEVEL readout accuracies as follows:

1. Set VOLTS/DIV control to the first position listed in Table 4-2.
2. Set the Calibration Generator STD AMPLITUDE output level to the corresponding Standard Amplitude Input Level in Table 4-2.

NOTE

To properly verify TRIGGER LEVEL Readout Accuracy, the Calibration Generator's STD AMPLITUDE output must have rising and falling transition times (10% to 90%) > 20 ns. No overshoot should appear on the waveform.

3. Verify that the generator output meets the requirements noted above.
4. Return the A and B SEC/DIV switch to 1 ms (knobs locked).
5. Use the VERTICAL POSITION control to set the bottom of the signal 2 divisions below graticule center.
6. Rotate the ΔREF OR DLY POS control to align the reference cursor with the bottom of the waveform.
7. Rotate the Δ control to align the Δ cursor with the top of the signal display.
8. CHECK—Vertical Deflection Accuracy (measured against the graticule) and ΔV Readout Accuracy are within the limits listed in Table 4-2.
9. Set the TRIGGER LEVEL control at the most positive voltage that produces a barely triggered, jittering display for each position of the SLOPE switch.
10. CHECK—The A Trigger Level readings (see Figure 2-8) are within the limits given in the +Peak column of Table 4-2.
11. Set the TRIGGER LEVEL control at the most negative voltage that produces a barely triggered, jittering display for each position of the SLOPE switch.
12. CHECK—The A Trigger Level readings are within the limits given in the −Peak column of Table 4-2.
13. Set the TRIGGER LEVEL for a stable display.
14. Pull the SEC/DIV knob out and set the B TRIGGER MODE to TRIG AFT DLY.
15. Adjust ΔREF OR DLY POS control for a delay readout of 0.000 ms.
16. Set the TRIGGER LEVEL control to the most positive voltage that produces an intensified point on the waveform display for each position of the SLOPE switch.
17. CHECK—The B Trigger Level readings are within the limits given in the +Peak column of Table 4-2.
18. Set the TRIGGER LEVEL control to the most negative voltage that produces an intensified point on the waveform display for each position of the SLOPE switch.
19. CHECK—The B Trigger Level readings are within the limits given in the −Peak column of Table 4-2.
20. Push the B SEC/DIV knob in.
21. Change the VOLTS/DIV switch to the next position listed in Table 4-2.
22. Set the Calibration Generator to the corresponding signal amplitude setting.
23. Press and release the ΔV pushbutton to reobtain the ΔV readout display.
24. Repeat subparts 5 through 23 of part e for each VOLTS/DIV setting listed in Table 4-2.
25. Set the TRIGGER COUPLING switch to NOISE REJ.

26. Set the CH 1 and CH 2 Input Coupling switches to 50 mV.

27. CHECK—Trigger Level Readout is within the limits given in Table 4-2 for NOISE REJ Coupling.

f. Return the TRIGGER COUPLING switch to DC.

g. Set the CH 1 VOLTS/DIV switch and the Calibration Generator output level to produce a vertical signal display 5 divisions in amplitude.

h. CHECK—Display amplitude reduces to 2 divisions or less when the VOLTS/DIV VAR control (of the channel under test) is rotated fully CCW. Return the VOLTS/DIV VAR control to its maximum CW (detent) position.

i. Set the Calibration Generator output level and VERTICAL POSITION controls for a 2-division display vertically centered on the graticule. Use the CH 1 VAR control if necessary to obtain the correct display amplitude.

j. Set the VERTICAL POSITION control to align the top edge of the display with the top graticule line.

k. CHECK—Signal display amplitude is 1.9 to 2.1 divisions.

l. Set the VERTICAL POSITION control to align the bottom edge of the signal display with the bottom graticule line.

m. CHECK—Signal display amplitude is 1.9 to 2.1 divisions.

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

o. Repeat parts e through m for CH 2.

p. Rotate the ΔREF OR DLY control CCW until the cursor stops moving.

Table 4-2
Accuracy Limits
CH 1, CH 2, CH 2 INVERT, and Delta Volts Readouts

VOLTS/DIV Switch Setting CH 1 and CH 2	Standard Amplitude Input Level	Vertical Deflection Accuracy (±2% in divisions)	Delta Volts Readout Accuracy (limits) 1.25% +.03 div	Limits of Trigger LEVEL Readout			
				DC Coupling		NOISE REJ Coupling	
				+ Peak	− Peak	+Peak	−Peak
2 mV	10 mV	4.90 to 5.10	9.81 mV to 10.20 mV	8.5 mV to 11.5 mV	+1.2 mV to −1.2 mV		
5 mV	20 mV	3.92 to 4.08	19.6 mV to 20.4 mV	17.3 mV to 22.7 mV	+2.1 mV to −2.1 mV		
10 mV	50 mV	4.90 to 5.10	49.0 mV to 50.9 mV	44.5 mV to 55.5 mV	+4 mV to −4 mV		
20 mV	0.1 V	4.90 to 5.10	98.1 mV to 102.0 mV	89 mV to 111 mV	+7.5 mV to −7.5 mV		
50 mV	0.2 V	3.92 to 4.08	196 mV to 204 mV	177 mV to 223 mV	+17 mV to −17 mV	147 mV to 253 mV	+47 mV to −47 mV
0.1 V	0.5 V	4.90 to 5.10	490 mV to 509 mV	0.449 V to 0.551 V	+0.036 V to −0.036 V		
0.2 V	1.0 V	4.90 to 5.10	0.981 V to 1.020 V	0.90 V to 1.10 V	+0.07 V to −0.07 V		
0.5 V	2.0 V	3.92 to 4.08	1.96 V to 2.04 V	1.78 V to 2.22 V	+0.14 V to −0.14 V		
1.0 V	5.0 V	4.90 to 5.10	4.90 V to 5.09 V	4.50 V to 5.50 V	+0.35 V to −0.35 V		
2.0 V	10.0 V	4.90 to 5.10	9.81 V to 10.2 V	9.0 V to 11.0 V	+0.7 V to −0.7 V		
5.0 V	20.0 V	3.92 to 4.08	19.6 V to 20.4 V	17.8 V to 22.2 V	+1.4 V to −1.4 V		

q. CHECK—Cursor is aligned with the bottom graticule line within ±0.2 division.

r. Rotate the Δ control CW until the cursor stops moving.

s. CHECK—Cursor is aligned with the top graticule line within ±0.2 division.

t. Turn the INVERT function on (button in), return the CH 2 VOLTS/DIV VAR control to the calibrated detent position, and reobtain a 5-division signal as explained in part g above.

u. VERIFY—A down-arrow symbol appears to the left of the CH 2 VOLTS/DIV readout.

v. CHECK—Display amplitude is between 4.9 divisions and 5.1 divisions in amplitude (5 divisions ±2 %). Turn the INVERT function off (button out) when finished.

w. Connect a 5 V standard-amplitude signal from the Calibration Generator to the CH 1 OR X and CH 2 input connectors via a 50 Ω BNC cable and a Dual-Input Coupler.

x. Set:

VOLTS/DIV	
CH 1 and CH 2	2 V
VERTICAL MODE	
CH 1 and CH 2	Off (buttons out)
ADD	On (button in)

y. CHECK—Vertical deflection amplitude is 4.9 to 5.1 divisions.

z. CHECK—Signal amplitude reduces to 0.2 division or less when CH 2 INVERT is on (button in).

aa. Set:

VERTICAL MODE	
CH 3	On (button in)
CH 1, CH 2, CH 4, ADD, and INVERT	Off (buttons out)

bb. Move the Dual-Input Coupler to the CH 3 and CH 4 input connectors.

cc. CHECK—VOLTS/DIV and TRIGGER LEVEL Readout accuracies for both switch setting-input level combinations listed in Table 4-3 as in subparts 5 through 23 of part e.

dd. Set the Calibration Generator output level and VERTICAL POSITION controls for a 2-division display vertically centered on the graticule.

ee. Set the VERTICAL POSITION control to align the top edge of the display with the top graticule line.

ff. CHECK—Signal display amplitude is 1.9 to 2.1 divisions.

gg. Set the VERTICAL POSITION control to align the bottom edge of the signal display with the bottom graticule line.

hh. CHECK—Signal display amplitude is 1.9 to 2.1 divisions.

ii. Set the VERTICAL MODE switches to disable CH 3 and display CH 4.

jj. Repeat parts cc through hh for CH 4.

kk. Disconnect the test setup.

Table 4-3
CH 3 and CH 4 Accuracy Limits

VOLTS/DIV Switch Setting CH 3 and CH 4	Standard Amplitude Signal Input Level	Vertical Deflection Accuracy (±10% in divisions)	Trigger LEVEL Readout When Barely Triggered at the Indicated Peak	
			+Peak	−Peak
0.1 V	0.5 V	4.50 to 5.50	0.454 V to 0.545 V	+0.03 V to −0.03 V
0.5 V	2.0 V	3.60 to 4.40	1.81 V to 2.19 V	+0.13 V to −0.13 V

4. Check Channel 2 Delay.

a. Set:

VERTICAL MODE	
CH 1 and CH 2	On (buttons in)
CH 3 and CH 4	Off (buttons out)
Input Coupling	
CH 1 and CH 2	50 Ω DC
VOLTS/DIV	
CH 1 and CH 2	10 mV
A and B SEC/DIV	1 μs (knobs locked)
TRIGGER	
SOURCE	CH 1

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

c. Set the output level of the Calibration Generator for an approximate 5-division, vertically-centered display for both channels.

d. Use either the CH 1 or CH 2 VAR control to match signal amplitude between both channels.

e. Set:

A and B SEC/DIV	5 ns (knobs locked)
X10 MAG	On (button in)

f. Use the Horizontal POSITION control to move the rising edges of the CH 1 and CH 2 displays to graticule center.

g. Pull the B SEC/DIV knob out to activate the CH 2 DLY feature.

NOTE

If the readout displays "CH 2 DLY DISABLED" instead of "CH 2 DLY—TURN Δ", the delay matching feature has been disabled and the remainder of this subsection cannot be performed. In this case, proceed to subsection 5 below.

h. CHECK—Δ control will position the CH 2 display 1 division or more (500 ps) to either side of the CH 1 display.

i. Superimpose the rising edges of the pulses using the Δ control.

j. Turn X10 MAG off (button out) and push in the B SEC/DIV knob.

k. Disconnect the test setup.

5. Check Vertical Bandwidth—All Channels .

a. Set:

A and B SEC/DIV	50 μs (knobs locked)
TRIGGER	
SOURCE	VERT
VOLTS/DIV	
CH 1 and CH 2	2 mV
CH 3 and CH 4	0.1 V (buttons out)
VAR	
CH 1 and CH 2	Calibrated (in detent)
VERTICAL MODE	
CH 1	On (button in)
CH 2, CH 3, and CH 4	Off (buttons out)
Input Coupling	
CH 1 and CH 2	50 Ω DC

b. Connect the output of the Primary Leveled Sine-Wave Generator to the CH 1 OR X input connector via a precision 50 Ω BNC cable and any combination of the 10X, 5X, or 2X Attenuators needed to reduce the signal amplitude to the level called out in the next step.

c. Set the generator output level for a 6-division display at the reference frequency, then change the output frequency to 100 MHz.

d. CHECK—Signal display amplitude is 4.25 divisions or greater.

e. Move the signal to the CH 2 input connector and set the VERTICAL MODE switches to disable CH 1 and display CH 2.

f. Repeat parts c and d for CH 2.

g. Disconnect the cable and attenuator(s) from the Primary Leveled Sine-Wave Generator and connect the attenuator(s) to the Secondary Sine-Wave Generator leveling head; then connect the signal to the CH 2 input connector.

h. Set the CH 1 and CH 2 VOLTS/DIV switch setting to 20 mV.

i. Set the generator output level for a 6-division display at the reference frequency, then change the generator output to 245 MHz.

j. CHECK—Signal display amplitude is 4.25 divisions or greater while sweeping the generator frequency from 245 MHz to 300 MHz.

k. Set the VOLTS/DIV switch to 0.5 V and repeat parts i and j.

l. Set the VOLTS/DIV switch to 1 V and the generator output level for a 4-division display at the reference frequency, then change the generator frequency to 245 MHz.

m. CHECK—Signal display amplitude is 2.82 divisions or greater while sweeping the generator frequency from 245 MHz to 300 MHz.

n. Move the signal to CH 1 OR X input connector and set the VERTICAL MODE switches to disable CH 2 and display CH 1.

o. CHECK—Repeat parts i through m for CH 1.

p. Set the VERTICAL MODE switches to display CH 3 only.

q. Attach the standard-accessory 10X probe (supplied with the instrument) to the CH 3 input connector and the probe tip to the CALIBRATOR terminal.

r. Set the A and B SEC/DIV (knobs locked) to 1 ms.

s. Adjust probe compensation for the best flat top on the square-wave signal display.

t. Disconnect the probe tip from the CALIBRATOR terminal. Remove the grabber tip from the probe, unscrew and remove the plastic barrel, and connect the probe to the output of the Secondary Sine-Wave Generator (with the leveling head) via a female-to-female BNC adapter, a 50 Ω termination, and a Mini probe-tip-to-BNC adapter.

u. Set the A and B SEC/DIV to 50 μs (knobs locked).

v. Set the generator output for a 4-division display at the reference frequency, then change the generator frequency to 245 MHz.

w. CHECK—Signal display amplitude is 2.82 divisions or greater while sweeping the generator frequency from 245 MHz to 300 MHz.

x. Move the signal to CH 4 and set the VERTICAL MODE switches to display CH 4 only.

y. CHECK—Repeat parts q through w for CH 4.

z. Disconnect the test setup.

6. Check Common Mode Rejection Ratio (CMRR).

a. Set:

VERTICAL MODE	
CH 1, ADD, and INVERT	On (button in)
CH 2, CH 3, and CH 4	Off (buttons out)
VOLTS/DIV	
CH 1 and CH 2	10 mV
CH 1 and CH 2 VAR	In detent
Input Coupling	
CH 1 and CH 2	50 Ω DC
A and B SEC/DIV	50 μs (knobs locked)
TRIGGER	
MODE	AUTO LVL
SOURCE	CH 1

b. Connect a reference frequency signal from the Primary Leveled Sine-Wave Generator 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.

c. Set the generator output level for an 8-division display of the reference signal on CH 1.

d. Adjust either the CH 1 VAR control or the CH 2 VAR control for a minimum ADD display amplitude while leaving the other control in the calibrated detent (whichever provides the best CMRR).

e. Set the generator frequency to 50 MHz.

f. Set the SEC/DIV switch to 20 ns.

g. CHECK—ADD display amplitude is 0.4 division or less (discount trace width).

h. Set ADD and INVERT Off (buttons out) and rotate the CH 1 and CH 2 VAR controls CW to their calibrated detent positions.

i. Disconnect the test setup.

7. Check Channel Isolation.

a. Set:

VERTICAL MODE	
CH 1, CH 2, CH 3, and CH 4	On (buttons in)
CHOP/ALT	ALT (button out)
Input Coupling	
CH 1 and CH 2	50 Ω DC
VOLTS/DIV	
CH 1 and CH 2	0.1 V
CH 3 and CH 4	0.1 V (buttons out)
TRIGGER	
SOURCE	CH 1
A and B SEC/DIV	20 ns (knobs locked)

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 frequency to 100 MHz and adjust the output level for an 8-division display.

d. CHECK—Amplitude of each trace other than CH 1 is 0.08 division or less (discount trace width).

e. Move the signal to the CH 2 input connector and change the TRIGGER SOURCE switch to CH 2.

f. CHECK—Amplitude of each trace other than CH 2 is 0.08 division or less (discount trace width).

g. Add a 50 Ω BNC termination to the BNC cable and move the signal to CH 3.

h. Set the TRIGGER SOURCE switch to CH 3 and adjust the generator output for a signal display amplitude of 8 divisions.

i. CHECK—Amplitude of each trace other than CH 3 is 0.16 division or less (discount trace width).

j. Move the signal to CH 4 input connector and set TRIGGER SOURCE to CH 4.

k. CHECK—Amplitude of each trace other than CH 4 is 0.16 division or less (discount trace width).

l. Replace the Primary Leveled Sine-Wave Generator with the Secondary Leveled Sine-Wave Generator (with the leveling head) and connect the generator to the CH 1 OR X input connector.

m. Set the TRIGGER SOURCE switch to CH 1.

n. Set the generator output frequency to 300 MHz and the output level for an 8-division display.

o. CHECK—Amplitude of each trace other than CH 1 is 0.16 division or less (discount trace width).

p. Move the signal to the CH 2 input connector and set the TRIGGER SOURCE switch to CH 2.

q. CHECK—Amplitude of each trace other than CH 2 is 0.16 division or less (discount trace width).

r. Disconnect the test setup.

8. Set CH 1 and CH 2 DC Balance.

NOTE

For an accurate DC Balance setting, the instrument MUST be allowed to warmup for 20 minutes before performing the following steps.

a. Press up and hold both the CH 1 and CH 2 Input Coupling switches in the 1 MΩ AC position for approximately 1 second, then release them.

NOTE

At the completion of the automatic DC Balance, the Input Coupling settings will return to the states they previously held (if they were in those states for at least 7 seconds prior to performing the DC Balance procedure).

b. VERIFY—A moving dot display replaces the normal display for approximately 10 seconds (while the DC Balance levels are automatically reset), then the display returns to normal.

c. VERIFY—There is less than 0.2 division vertical trace shift between adjacent settings of the CH 1 and CH 2 VOLTS/DIV switches as they are rotated through each of their positions.

d. VERIFY—There is less than 1.0 division vertical trace shift as the CH 1 and CH 2 VOLTS/DIV VAR controls are rotated fully CCW.

e. VERIFY—There is less than 0.5 division vertical trace shift when the INVERT button is pressed in.

f. Return the VERTICAL VAR controls to their detent positions and turn the CH 2 INVERT function off (button out).

9. Check CH 2 SIGNAL OUT and Cascaded Operation.

a. Set:

VERTICAL MODE	
CH 1	On (button in)
CH 2, CH 3, and CH 4	Off (buttons out)
BW LIMIT	On (button in)
VOLTS/DIV	
CH 1 and CH 2	2 mV
Input Coupling	
CH 1	50 Ω DC
CH 2	1 MΩ DC
A and B SEC/DIV	1 ms
TRIGGER MODE	AUTO LVL
SOURCE	VERT
COUPLING	NOISE REJ

b. Connect a 1 kHz, 2 mV standard-amplitude signal from the Calibration Generator to the CH 2 input connector via a 50 Ω BNC cable.

c. Connect the CH 2 signal from the rear-panel CH 2 SIGNAL OUT connector to the CH 1 OR X input connector via a precision 50 Ω BNC cable.

d. CHECK—Display amplitude is 4.5 to 5.5 divisions (discount trace width).

e. Set CH 1 Input Coupling to GND and align the trace with the center graticule line.

f. Return CH 1 Input Coupling to 50 Ω DC.

g. Set the CH 1 VOLTS/DIV switch to 5 mV.

h. CHECK—The baseline of the display is within 2 divisions of the ground reference set above (discount trace width).

i. Set the CH 1 Input Coupling to 1 MΩ DC.

j. CHECK—Display amplitude is 3.6 to 4.4 divisions (discount trace width).

k. Disconnect the signal from the CH 2 input connector.

l. Set the CH 1 and CH 2 Input Coupling to 50 Ω DC.

m. Press and release the BW LIMIT button to turn the function off.

n. Connect a 50 kHz signal from the Primary Leveled Sine-Wave Generator to the CH 2 input connector via a precision 50 Ω BNC cable and a 10X attenuator.

o. Set the CH 1 VOLTS/DIV switch to 2 mV.

p. Adjust the generator output level to produce a 6-division CH 1 display.

q. Increase the generator frequency to 50 MHz.

r. CHECK—Display amplitude is 4.24 divisions or greater.

s. If the following step (step 10) is to be performed, skip part t below.

t. Disconnect the test setup.

10. Check BW LIMIT Operation.

a. Set:

VERTICAL MODE	
CH 1	Off (button out)
CH 2	On (button in)
BW LIMIT	On (button in)
A and B SEC/DIV	50 μs (knobs locked)
VOLTS/DIV	
CH 2	10 mV

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

c. Set the generator frequency to 50 kHz and adjust the output level for a 6-division display on the crt.

d. Gradually increase the generator output frequency until the display amplitude decreases to 4.24 divisions.

e. CHECK—Generator frequency is between 13 MHz to 24 MHz.

f. Turn BW LIMIT off (button out).

g. Disconnect the test setup.

TRIGGERING

Equipment Required (see Table 4-1)

Primary Leveled Sine-Wave Generator (Item 2)
Secondary Leveled Sine-Wave Generator (Item 4)
Function Generator (Item 5)
10X Probe (supplied with 2465) (Item 7)
Precision 50 Ω BNC Cable (Item 9)
50 Ω BNC Cable (2 required) (Item 10)
Dual-Input Coupler (Item 11)
50 Ω BNC Termination (2 required)(Item 12)

Initial Control Settings.

Control settings not listed do not affect the procedure.

Set:	
VERTICAL MODE	
CH 1 and CH 2	On (buttons in)
CH 3, CH 4, ADD and INVERT	Off (buttons out)
CHOP/ALT	ALT (button out)
20 MHz BW LIMIT	Off (button out)
VOLTS/DIV	
CH 1	0.1 V
CH 2	0.5 V
CH 1 and CH 2 VAR	In detent
CH 3 and CH 4	0.5 V (buttons in)
Input Coupling	
CH 1	1 MΩ DC
CH 2	50 Ω DC
A and B SEC/DIV	2 μs (knobs locked)
A and B SEC/DIV VAR	In detent
X10 MAG	Off (button out)
Δt and ΔV	Off (press and release until associated readout is off)
TRACKING	Off (button out)
TRACE SEP	Fully CW
TRIGGER	
HOLDOFF	B ENDS A (fully CW)
LEVEL	Midrange
SLOPE	+ (plus)
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC

1. Check A and B Triggers.

NOTE

The Trigger Level Readout Accuracies are checked in the Vertical Performance Checks.

a. Refer to Table 4-4 to determine what the A Trigger requirements are and at what frequencies various checks are made.

b. Using a 50 Ω BNC cable, connect one of the following test generators to the CH 1 input connector. Select the generator that produces the proper frequency range for the conditions being tested as called out in Tables 4-4 and 4-5. When using the leveled sine-wave generators (items 2 and 3 below), the output must be terminated into 50 Ω (either the 50 Ω input coupling or a 50 Ω termination may be used).

1. Function Generator (30 kHz and 80 kHz)
2. Primary Leveled Sine-Wave Generator (50 MHz)
3. Secondary Leveled Sine-Wave Generator (500 MHz)

NOTE

To obtain signal amplitudes less than 1 division, first set the signal for either 4, 5, or 10 times the specified amplitude; then reduce the amplitude by a factor of 4, 5, or 10 by increasing the VOLTS/DIV settings as necessary.

c. For each combination listed in the table, set the generator Test Frequency and the 2465 TRIGGER COUPLING as indicated, performing the following steps to verify the Triggering levels in each setup.

d. Set the VOLTS/DIV switch and the generator output level to obtain the test signal amplitude indicated for the particular combination being tested.

e. Set the SEC/DIV switch and the X10 MAG switch to obtain a well-defined display of the test signal.

NOTE

Normally, unless trigger sensitivity is very close to the specified limits, it is sufficient to check each of the indicated frequency-coupling combinations listed in the table in Channel 1 only; checks for Channels 2, 3 and 4 need only be done in DC COUPLING (to verify signal path).

f. CHECK—For a stably triggered display (unless otherwise indicated) for each of the Test Frequency-TRIGGER COUPLING combinations listed in Table 4-4. When testing the 500 MHz triggering, check that trigger jitter is < 50 ps (0.1 division at 5 ns/div with X10 MAG).

g. Press in the ADD button to select the function and press and release the CH 1 button to turn off the CH 1 display.

h. Repeat the DC TRIGGER COUPLING tests of Table 4-4 while in the ADD mode.

i. Move the 50 MHz and 500 MHz signals to the CH 2 input connector and repeat the DC TRIGGER COUPLING tests of Table 4-4 while in ADD mode.

j. Press the CH 2 button in to select the channel and press and release the ADD button to turn off the ADD display.

k. Repeat the DC TRIGGER COUPLING tests of Table 4-4 while in CH 2 mode.

l. If trigger sensitivity is close to the specified limits given in steps c through k above, test all of the frequency-coupling combinations given in Table 4-4 for CH 2.

m. Move the test signal to CH 3 and CH 4 in turn and repeat parts c through f using Table 4-5.

Table 4-4
CH 1 or CH 2 Triggering Conditions

Test Frequency	Minimum Vertical Display Levels at Which Triggering Should Occur				
	TRIGGER COUPLING				
	DC	NOISE REJ	HF REJ	LF REJ	AC
60 Hz	[a]	[a]	[a]	No Trigger, Freeruns	0.35 Div
30 kHz	[a]	[a]	0.5 Div	[a]	[a]
80 kHz	[a]	[a]	[a]	0.5 Div	[a]
50 MHz	0.35 Div	1.2 Div	No Trigger, Freeruns at 1.2 Div	0.5 Div	0.35 Div
500 MHz (trigger jitter < 50 ps)	1.0 Div	3.0 Div	No Trigger, Freeruns at 3.0 Div	1.0 Div	1.0 Div

[a]Not necessary to check.

Table 4-5
CH 3 or CH 4 Triggering Conditions

Test Frequency	Minimum Vertical Display Levels at Which Triggering Should Occur				
	TRIGGER COUPLING				
	DC	NOISE REJ	HF REJ	LF REJ	AC
60 Hz	[a]	[a]	[a]	No Trigger, Freeruns	0.18 Div
30 kHz	[a]	[a]	0.25 Div	[a]	[a]
80 kHz	[a]	[a]	[a]	0.25 Div	[a]
50 MHz	0.18 Div	0.6 Div	No Trigger, Freeruns at 0.6 Div	0.25 Div	0.18 Div
500 MHz (trigger jitter < 50 ps)	0.5 Div	1.5 Div	No Trigger, Freeruns at 1.5 Div	0.5 Div	0.5 Div

[a]Not necessary to check.

n. Set:

TRIGGER	
MODE	AUTO
LEVEL	Fully clockwise

o. Pull the B SEC/DIV knob out and set it 1 switch setting (CW) faster than the A SEC/DIV setting, then push the B SEC/DIV knob back in.

p. Verify that the crt readout displays DLY and not Δt. If Δt is displayed, press the Δt button in and release it to select the DLY function. When DLY is displayed, rotate the ΔREF OR DLY POS control CCW until the readout display indicates zero delay. (The display will indicate DLY?, which is normal.)

q. Press the A/B TRIG button to select the B TRIGGER.

r. Set B TRIGGER MODE to TRIG AFT DLY and adjust TRIGGER LEVEL for a stable signal display.

s. Repeat parts a through m for B TRIGGER, changing the A and B SEC/DIV and X10 MAG switches as required to maintain a well-defined display.

t. Disconnect the test setup.

2. Check Composite Triggering.

a. Set:

VERTICAL MODE	
CH 1, CH 2, CH 3, and CH 4	On (buttons in)
ADD	Off (button out)
CHOP/ALT	ALT (button out)
Input Coupling	
CH 1	50 Ω DC
CH 2	1 MΩ DC
TRIGGER	
A/B TRIG	A
MODE	NORM
SOURCE	VERT
COUPLING	DC
A and B SEC/DIV	10 μs

b. Connect the Function Generator to the CH 1 and CH 2 inputs via a 50 Ω BNC cable and a Dual-Input Coupler.

c. Set the Function Generator for a 50 kHz, 1.35-division display for CH 1 and CH 2.

d. Connect the Primary Leveled Sine-Wave Generator to the CH 3 input connector using a 50 Ω BNC cable and a 50 Ω termination.

e. Set the generator output level for a 0.7-division display at the reference frequency (50 kHz).

f. Connect the Secondary Leveled Sine-Wave Generator to the CH 4 input using a BNC cable and a 50 Ω termination.

g. Set the generator output level for a 0.7-division display at the reference frequency.

h. CHECK—Display will trigger as the TRIGGER LEVEL control is rotated through its range.

i. Pull the B SEC/DIV knob out, rotate it to 5 μs, and push it back in.

j. Press the A/B TRIG button and set the B TRIGGER MODE to TRIG AFT DLY.

k. Rotate the ΔREF OR DLY POS control CCW until the delay readout indicates DLY? 0.00 μs.

l. CHECK—Display will trigger as the TRIGGER LEVEL control is rotated through its range.

m. Rotate the B SEC/DIV knob back to 10 μs (knobs locked).

n. Disconnect the test setup.

3. Check Trigger Noise Rejection—All Channels.

a. Set:

VERTICAL MODE	
CH 1	On (button in)
Input Coupling	
CH 1 and CH 2	1 MΩ DC
VOLTS/DIV	
CH 1	10 mV
CH 2	0.1 V
CH 3 and CH 4	0.1 V (buttons out)

A and B SEC/DIV	10 μs (knobs locked)
TRIGGER	
MODE	AUTO LVL
SOURCE	VERT

b. Connect the Function Generator to the CH 1 input via a 50 Ω BNC cable, a 50 Ω termination, and a 10X attenuator.

c. Set the Function Generator output frequency and level for a 50-kHz, 4-division display.

d. Set the CH 1 VOLTS/DIV switch to 0.1 V.

e. Set the TRIGGER COUPLING switch to NOISE REJ.

f. CHECK—Display will not trigger (freeruns).

g. Pull the B SEC/DIV knob out, rotate it to 5 μs and push it back in.

h. Press the A/B TRIG button to select the B TRIGGER.

i. Set the TRIGGER MODE switch to B TRIG AFT DLY.

j. CHECK—Display will not trigger for any setting of the LEVEL control.

k. Rotate the B SEC/DIV switch back to 10 μs (knobs locked).

l. Move the input signal to CH 2, CH 3, and CH 4 in turn, selecting each channel as the display source. Repeat parts f through k for each channel.

4. Check Slope Selection and Verify Line Trigger.

a. Set:

A and B SEC/DIV	2 ms (knobs locked)
X10 MAG	Off (button out)
TRIGGER	
MODE	AUTO
SOURCE	LINE
COUPLING	AC
VOLTS/DIV	
CH 1	5 V
Input Coupling	
CH 1	1 MΩ DC

CAUTION

In the next part, DO NOT connect the probe ground lead to the ac power source.

b. Attach the 10X probe to the CH 1 OR X input connector and connect the probe tip to the ac power source.

c. CHECK—Display can be triggered in both the + (plus) and − (minus) positions of the SLOPE switch using the TRIGGER LEVEL control and that the displayed slope agrees with the selected slope.

d. CHECK—Display phase shifts slightly as the TRIGGER COUPLING switch is changed from AC to DC.

e. Disconnect the test setup.

HORIZONTAL

Equipment Required (see Table 4-1)

Primary Leveled Sine-Wave Generator (Item 2)	Time-Mark Generator (Item 6)
Calibration Generator (Item 3)	Precision 50 Ω BNC Cable (Item 9)

Initial Control Settings.

Control settings not listed do not affect the procedure.

Set:	
VERTICAL MODE	
CH 1	On (button in)
CH 2, CH 3, CH 4, ADD, and INVERT	Off (buttons out)
CHOP/ALT	ALT (button out)
20 MHz BW LIMIT	Off (button out)
VOLTS/DIV	
CH 1	0.5 V
CH 1 VAR	In detent
CH 3 and CH 4	0.1 V (buttons out)
Input Coupling	
CH 1	50 Ω DC
A and B SEC/DIV	200 ns (knobs locked)
A and B SEC/DIV VAR	In detent
X10 MAG	Off (button out)
ΔV and Δt	Off (press and release until associated readout is off)
TRACKING	Off (button out)
TRACE SEP	Fully CW
TRIGGER	
HOLDOFF	B ENDS A
LEVEL	Midrange
SLOPE	+ (plus)
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC

1. Check Horizontal Display Modes (A, A INTEN, ALT, and B).

a. Use a 50 Ω BNC cable to connect 200 ns time markers from the Time-Mark Generator to the CH 1 OR X input connector.

b. Adjust the TRIGGER LEVEL control as necessary for a stable signal display.

c. Pull the B SEC/DIV knob out and set the B TRIGGER MODE to RUN AFT DLY.

d. Set the ΔREF OR DLY control for a DLY readout of approx 1000 ns.

e. VERIFY—An intensified zone appears on the displayed signal near graticule center.

f. Rotate the ΔREF OR DLY POS control to center the intensified zone on one of the time markers near graticule center.

g. Set the B SEC/DIV control to 50 ns (knob out).

h. Rotate the TRACE SEP control CCW to separate the the A and B sweep displays.

i. CHECK—The B sweep is displayed with the A sweep.

j. Push the B SEC/DIV knob in.

k. CHECK—Only the B sweep is displayed.

2. Check A and B Timing, A Cursor Accuracies, and A Cursor Range.

a. Set:

A and B SEC/DIV	5 ns (knobs locked)
TRACE SEP	Fully CW
Δt	On (press and release for Δt display)

b. Select 5 ns time markers from the Time-Mark Generator and adjust the TRIGGER LEVEL control for a stable display.

c. Use the Horizontal POSITION control to align the 2nd time marker with the 2nd vertical graticule line (2nd from the left edge of the display).

NOTE

The 2 ns and the 5 ns time markers are sinusodial. Use either the rising or falling zero-crossings as alignment points.

d. Align the ΔREF cursor with the 2nd time marker and align the Δ cursor with the 10th time marker.

e. CHECK—The A Sweep timing and cursor readout accuracies are within the limits given in Tables 4-6 and 4-7.

NOTE

If the 2nd and 10th time markers are within ±0.06 division of the 2nd and 10th vertical graticule lines for unmagnified sweeps and within ±0.1 division for magnified sweeps, the sweep timing accuracy is conservatively within limits. When the timing accuracy is checked at each sweep speed, note any SEC/DIV setting at which the timing error exceeds the 0.6-division limit. Check these sweep speeds against the major-division time-interval limits given in Table 4-7.

NOTE

For A and B SEC/DIV switch settings of 5 ns and 10 ns, the time-marker period is greater than 1 division when the sweep is magnified. At 500 ps per division (SEC/DIV setting of 5 ns with X10 MAG), check for 2 cycles between the 2nd and 10th vertical graticule lines (within ±0.1 division). For 1 ns per division, check for 4 cycles between the 2nd and 10th vertical graticule lines (±0.1 division).

f. Repeat parts c, d, and e for each A SEC/DIV-time marker combination given in Table 4-6 for both unmagnified and magnified sweeps.

Table 4-6
Settings for A and B Timing Accuracy Checks and A Cursor Accuracy Limits

A and B SEC/DIV Switch	Unmagnified		X10	
	Time Markers	Limits of Δt Cursor Readout	Time Markers	Limits of Δt Cursor Readout
5 ns	5 ns	39.65 ns to 40.35 ns	2 ns 4 Div/cycle	3.94 ns to 4.06 ns (2 cycles)
10 ns	10 ns	79.30 ns to 80.70 ns	2 ns 2 Div/cycle	7.89 ns to 8.11 ns (4 cycles)
20 ns	20 ns	158.60 ns to 161.40 ns	2 ns	15.78 ns to 16.22 ns
50 ns	50 ns	396.5 ns to 403.5 ns	5 ns	39.45 ns to 40.55 ns
0.1 μs	0.1 μs	793.0 ns to 807.0 μs	10 ns	78.90 ns to 81.10 ns
0.2 μs	0.2 μs	1586.0 ns to 1614.0 ns	20 ns	157.80 ns to 162.20 ns
0.5 μs	0.5 μs	3965 ns to 4035 ns	50 ns	394.5 ns to 405.5 ns
1 μs	1 μs	7.930 μs to 8.070 μs	0.1 μs	789.0 ns to 811.0 ns
2 μs	2 μs	15.860 μs to 16.140 μs	0.2 μs	1578.0 ns to 1622.0 ns
5 μs	5 μs	39.65 μs to 40.35 μs	0.5 μs	3945 ns to 4055 ns
10 μs	10 μs	79.30 μs to 80.70 μs	1 μs	7.890 μs to 8.110 μs
20 μs	20 μs	158.60 μs to 161.40 μs	2 μs	15.780 μs to 16.220 μs
50 μs	50 μs	396.5 μs to 403.5 μs	5 μs	39.45 μs to 40.55 μs
0.1 ms	0.1 ms	793.0 μs to 807.0 μs	10 μs	78.90 μs to 81.10 μs
0.2 ms	0.2 ms	1586.0 μs to 1614.0 μs	20 μs	157.80 μs to 162.20 μs
0.5 ms	0.5 ms	3965 μs to 4035 μs	50 μs	394.5 μs to 405.5 μs
1 ms	1 ms	7.930 ms to 8.070 ms	0.1 ms	789.0 μs to 811.0 μs
2 ms	2 ms	15.860 ms to 16.140 ms	0.2 ms	1578.0 μs to 1622.0 μs
5 ms	5 ms	39.65 ms to 40.35 ms	0.5 ms	3945 μs to 4055 μs
10 ms	10 ms	79.30 ms to 80.70 ms	1 ms	7.890 ms to 8.110 ms
20 ms	20 ms	158.60 ms to 161.40 ms	2 ms	15.780 ms to 16.220 ms
50 ms	50 ms	396.5 ms to 403.5 ms	5 ms	39.45 ms to 40.55 ms
A SEC/DIV ONLY	(B Sweep does not have these sweep speeds)			
0.1 s	0.1 s	793.0 ms to 807.0 ms	10 ms	78.90 ms to 81.10 ms
0.2 s	0.2 s	1578.0 ms to 1622.0 ms	20 ms	157.00 ms to 163.00 ms
0.5 s	0.5 s	3945 ms to 4055 ms	50 ms	392.5 ms to 407.5 ms

Table 4-7
Horizontal Timing Accuracy Checked Against the Graticule

	Over Any									
	1 Div	**2 Div**	**3 Div**	**4 Div**	**5 Div**	**6 Div**	**7 Div**	**8 Div**	**9 Div**	**10 Div**
Time-marker Accuracy (X10 MAG off) Should Be	± 0.07 Div	± 0.07 Div	± 0.08 Div	± 0.09 Div	± 0.10 Div	± 0.10 Div	± 0.11 Div	± 0.12 Div	± 0.12 Div	± 0.13 Div
or (with X10 MAG on)	± 0.07 Div	± 0.08 Div	± 0.1 Div	± 0.11 Div	± 0.12 Div	± 0.13 Div	± 0.14 Div	± 0.16 Div	± 0.17 Div	± 0.18 Div
As Measured Against These Time-Marker Pairs (X10 MAG off only)	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	1-11
	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	2-11	
	3-4	3-5	3-6	3-7	3-8	3-9	3-10	3-11		
	4-5	4-6	4-7	4-8	4-9	4-10	4-11			
	5-6	5-7	5-8	5-9	5-10	5-11				
	6-7	6-8	6-9	6-10	6-11					
	7-8	7-9	7-10	7-11						
	8-9	8-10	8-11							
	9-10	9-11								
	10-11									

g. Rotate the ΔREF OR DLY POS control CCW until the cursor stops moving.

h. CHECK—ΔREF cursor aligns with the 1st graticule line within ±0.2 division.

i. Rotate the Δ control CW until the cursor stops moving.

j. CHECK—Δ cursor aligns with the 11th graticule line within ±0.2 division.

k. Set the A and B SEC/DIV switches to 10 ns.

l. Rotate the ΔREF OR DLY and the Δ controls to precisely superimpose the cursors near the 2nd graticule line.

m. CHECK—Δt readout indicates a difference of 0.30 ns or less.

n. Rotate the ΔREF OR DLY and the Δ controls to precisely superimpose the cursors near the 10th graticule line.

o. CHECK—Δt readout indicates a difference of 0.30 ns or less.

p. Set:

B SEC/DIV	5 ns (knob in)
B TRIGGER MODE	RUN AFT DLY
X10 MAG	Off (button out)
Δt	Off (DLY)
ΔREF OR DLY POS	Set for zero delay

q. CHECK—The B sweep timing accuracy as in parts b through f, making sure that the A SEC/DIV switch is set slower than the B SEC/DIV switch. Disregard the cursor accuracy data.

3. Check Delta Time Accuracy using the Delayed Sweep.

a. Set:

A SEC/DIV	10 ns
B SEC/DIV	5 ns (knob in)
X10 MAG	On (button in)
Δt	Off (DLY readout)
TRIGGER MODE	AUTO LVL
SOURCE	VERT

COUPLING	DC
SLOPE	+ (plus)
LEVEL	As required for a stable display
B TRIG MODE	RUN AFT DLY

NOTE

Certain time marks from the TG 501 (and other Time-Mark Generators) will vary in width and may be displace in time. This will happen in a repeatable sequence and is caused by the loading and interaction of the 2, 5, and 10 dividers. This is most noticable with 10 ns, 20 ns, and 50 ns markers. The following procedure will use the above markers to set up the proper references but the 5 ns markers will be used to make the actual measurement. Close inspection of apparent jitter or mistrigger of the time marks will show the trigger point to be stable with the apparent jitter to be variable with unique combinations of trigger holdoff and sweep speed. This is normal behavior with this type of signal and is not an instrument defect.

It is not necessary to count the number of marks given in the tables. Switching to 10 ns, 20 ns, or 50 ns markers as required and then to 5 ns will show the proper 5 ns mark to be used.

b. Set the Time-Mark Generator for 10 ns markers. Adjust the Vertical VOLTS/DIV as required for a display of 3 to 6 divisions.

c. Adjust the Δ REF OR DLY POS control for a readout display of DLY 10.64 ns.

d. Adjust the Horizontal POSITION control CCW until the cursor stops moving, then CW to display the leading edge of the 2nd time marker near the graticule center. This becomes the reference point for the following procedure. Set the Time-Mark Generator to 5 ns and adjust the Vertical VOLTS/DIV and Trigger LEVEL as required.

e. Press and release the Δt button to obtain the Δt display and rotate the Δ control for a readout display of Δt −10.64 ns. If the time marks are not superimposed, adjust the Δ control to do so.

f. CHECK—Δt readout is within the limits listed in Table 4-8 for the 1st 5 ns time marker; then check that the 3rd through 19th time markers are within the given limits as the Δ control is rotated CW to superimpose each successive time marker on the reference time marker.

g. Set:

A SEC/DIV	20 ns
Δt	Off (DLY readout)

h. Set the Time-Mark Generator for 20 ns time markers and adjust the ΔREF OR DLY POS control for a readout display of DLY 21.25 ns.

i. Position the leading edge of the 2nd time marker near graticule center using the Horizontal POSITION control. Set the Time-Mark Generator to 5 ns and adjust the Vertical VOLTS/DIV and Trigger LEVEL as required.

j. Press and release the Δt button to obtain a Δt display and adjust the Δ control for a readout display of Δt −20.00 ns. If the time markers are not superimposed, adjust the Δ control to do so.

Table 4-8
Delta Time Display Accuracy

Time-Marker Period and A SEC/DIV Switch Setting	B SEC/DIV Switch Setting	Marker Superimposed using the Δ (Delta) Control	Delta Time Readout Accuracy Limits
10 ns	500 ps[a]	1st	−9.86 ns to −10.14 ns
		3rd	−0.10 ns to 0.10 ns
		5th	9.86 ns to 10.14 ns
		7th	19.84 ns to 20.16 ns
		9th	29.80 ns to 30.20 ns
		11th	39.78 ns to 40.22 ns
		13th	49.74 ns to 50.26 ns
		15th	59.72 ns to 60.28 ns
		17th	69.68 ns to 70.32 ns
		19th	79.66 ns to 80.34 ns
20 ns	500 ps[a]	1st	−19.75 ns to −20.25 ns
		8th	19.75 ns to 20.25 ns
		36th	159.3 ns to 160.70 ns
50 ns	500 ps[a]	1st	−49.3 ns to −50.7 ns
		20th	49.3 ns to 50.7 ns
		90th	398.3 ns to 401.7 ns

[a]5 ns with X10 MAG on (button in).

k. CHECK—Δt readout is within the limits listed in Table 4-8 for the 1st 20 ns time marker; then check that the 8th and 36th time markers are within the given limits as the Δ control is rotated CW to superimpose each time marker on the reference time marker.

l. Set:

A SEC/DIV	50 ns
Δt	Off (DLY readout)

m. Set the Time-Mark Generator for 50 ns time markers and adjust the ΔREF OR DLY POS control for a readout display of 53.2 ns.

n. Position the leading edge of the 1st time marker near graticule center using the Horizontal POSITION control. Switch the Time-Mark Generator to 5 ns and adjust the A SEC/DIV and Trigger LEVEL as required.

o. Press and release the Δt button to obtain a Δt display and adjust the Δ control for a readout display of Δt −50.00 ns. If the time markers are not superimposed, adjust the Δ control to do so.

p. CHECK—Δt readout is within the limits listed in Table 4-8 for the 1st 5 ns time marker; then check that the 20th and 90th time markers are within the given limits as the Δ control is rotated CW to superimpose each time marker on the reference time marker.

q. Set:

TRACKING/INDEP	TRACKING (button in)
A SEC/DIV	0.1 μs
B SEC/DIV	10 ns (knob out)
X10 MAG	On (button in)

r. Select 0.1 μs time markers from the Time-Mark Generator.

s. Adjust the Δ and ΔREF OR DLY POS controls for a Δt readout display of Δt 800.0 ns.

t. Adjust the Horizontal POSITION control to align the leading edge of the 2nd time marker on the A sweep with the 2nd vertical graticule line.

u. Rotate the TRACE SEP control CCW to separate the traces.

v. Adjust the ΔREF OR DLY POS control to intensify the 2nd and 10th time markers (of the A sweep) and display the leading edges of the displayed B sweep time markers in the center area of the graticule.

w. VERIFY—The horizontal distance between the leading edges of the B sweep time markers is within the conservative guideline listed in Table 4-9. If this guideline is met, accuracy between each marker is ensured, and the following CHECK step need not be performed.

x. CHECK—The horizontal distance between the leading edges of the B sweep time markers is within the specified limits given in Table 4-9. The limit given is for separation between the 2nd and 10th marker; however, separation between the 2nd marker and each suceeding marker should also be checked, calculating the limits from the specification as listed at the top of the table.

y. Repeat part w (and x if necessary) for each combination of A SEC/DIV, B SEC/DIV, and X10 MAG settings listed in Table 4-9. The Δt readout should be set to indicate eight times the A SEC/DIV setting. At the slowest sweep speeds, the B SEC/DIV knob will need to be pushed in (B Sweep only) to increase the display repetition rate.

Table 4-9
Delayed Sweep Delta Time Accuracy

A SEC/DIV and Time Markers	B SEC/DIV as Displayed on Readout	Displayed Separation of Delayed Time Markers (for 2nd and 10th markers)	
		Conservative Guideline (divisions)	Specified Limit: (±0.3% time) interval +0.1% of full scale–divisions
0.1 μs	1 ns[a]	2.4	3.4
0.2 μs	2 ns[a]	2.4	3.4
0.5 μs	5 ns[b]	2.4	3.4
1 μs	10 ns	2.4	3.4
2 μs	20 ns	2.4	3.4
5 μs	50 ns	2.4	3.4
10 μs	100 ns	2.4	3.4
20 μs	200 ns	2.4	3.4
50 μs	500 ns	2.4	3.4
0.1 ms	1 μs	2.4	3.4
0.2 ms	2 μs	2.4	3.4
0.5 ms	5 μs	2.4	3.4
1 ms	10 μs	2.4	3.4
2 ms	20 μs	2.4	3.4
5 ms	50 μs	2.4	3.4
10 ms	100 μs	2.4	3.4
20 ms	200 μs	2.4	3.4
50 ms	500 μs	2.4	3.4
0.1 s	1 ms	2.4	3.4
0.2 s	2 ms	6.4	7.4
0.5 s	5 ms	6.4	7.4

[a] X10 MAG On (button in).
[b] For remainder of Table, turn X10 MAG off.

4. Check Delay Jitter.

Set:

TRACKING	Off (button out)
A SEC/DIV	1 ms
B SEC/DIV	0.5 μs (knob out)

b. Select 1 ms time markers from the Time-Mark Generator.

c. Align the intensified zones with the 10th time marker using the ΔREF OR DLY POS and Δ controls. Superimpose the zones to obtain a Δt readout display of 0.000 ms.

d. Push in the B SEC/DIV knob and adjust TRACE SEP to separate the traces.

e. CHECK—For 0.8 division or less of horizontal jitter on the rising edge of both time markers.

5. Check A and B SEC/DIV VAR Range and Accuracy.

a. Set:

A and B SEC/DIV	10 μs (knobs locked)
A and B SEC/DIV VAR	In detent
Δt	Off (press and release to eliminate Δt readout)

b. Select 10 μs time markers from the Time-Mark Generator and adjust the Time-Mark Generator variable timing control for exactly 1 time marker per division. Note the variable timing % error on the Time-Mark Generator.

c. Adjust the SEC/DIV VAR control for a sweep-speed readout (on bottom line) of 20 μs and adjust the Time-Mark Generator variable timing control for exactly 2 time markers per division.

d. CHECK—The Time-Mark Generator variable timing % of error has changed 2% or less from the reading noted in part b.

e. Adjust the SEC/DIV VAR control fully CCW.

f. CHECK—Sweep speed readout displays 30.0 μs.

g. Set the Time-Mark Generator variable timing control for exactly 3 time markers per division.

h. CHECK—The Time-Mark Generator variable timing % of error has changed 2% or less from the reading noted in part b.

i. Set:

A SEC/DIV	50 μs
B SEC/DIV	10 μs (knob in)
SEC/DIV VAR	CW (in detent)
Δt	Off (DLY readout)
ΔREF OR DLY POS	Zero delay
B TRIGGER MODE	RUN AFT DLY

j. Repeat parts b through h for the B Sweep.

k. Rotate the SEC/DIV VAR control CW to the detent position and disconnect the test setup.

6. Check X-Axis Gain.

a. Set:

VERTICAL MODE	
CH 2	On (button in)
CH 1, CH 3, CH 4, ADD, and BW LIMIT	Off (buttons out)
A and B SEC/DIV	X-Y (knobs locked)
VOLTS/DIV	
CH 1 and CH 2	10 mV
Input Coupling	
CH 1	1 MΩ DC
CH 2	1 MΩ GND

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

c. CHECK—Signal display amplitude is 4.9 to 5.1 horizontal divisions.

d. Disconnect the test setup.

7. Check X-Axis Bandwidth.

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

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

c. Set the generator output for a 6-division horizontal display.

d. Change the generator frequency to 3 MHz.

e. CHECK—Signal display is ⩾ 4.2 horizontal divisions.

8. Check X-Y Phase Differential.

a. Set the Primary Leveled Sine-Wave Generator for a 1 MHz, 6-division horizontal display.

b. Press and release the CH 2 VERTICAL MODE switch (CH 2 off). CH 1 displays automatically.

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

d. CHECK—Elipse opening is 0.1 division or less, measured horizontally.

e. Press in the CH 2 VERTICAL MODE switch (CH 2 on).

f. Set the generator for a 2 MHz, 6-division horizontal display.

g. Press and release the CH 2 VERTICAL MODE switch (CH 2 off).

h. CHECK—Elipse opening is 0.3 division or less, measured horizontally.

i. Press in the CH 2 VERTICAL MODE switch (CH 2 on).

9. Check X-Axis Low-Frequency Linearity.

a. Set the Primary Leveled Sine-Wave Generator and the CH 1 POSITION control for a 50 kHz, 2-division horizontal display centered on the graticule.

b. Use the CH 1 POSITION control to align the left edge of the signal with the left side vertical graticule line.

c. CHECK—Signal display is 1.8 to 2.2 divisions, measured horizontally.

d. Use the CH 1 POSITION control to position the right edge of the signal on the right side vertical graticule line.

e. CHECK—Signal display is 1.8 to 2.2 divisions, measured horizontally.

f. Disconnect the test setup.

CALIBRATOR, EXTERNAL Z-AXIS AND GATE OUTPUTS

Equipment Required (see Table 4-1)

Calibration Generator (Item 3)
Time-Mark Generator (Item 6)
Oscilloscope with 10X Probe (Item 7)
50 Ω BNC T-Connector (Item 8)
50 Ω BNC Cables (2 required) (Item 10)

Initial Control Settings.

Control settings not listed do not affect the procedure.

Set:

VERTICAL MODE	
CH 1 and CH 2	On (buttons in)
CH 3, CH 4, ADD, and INVERT	Off (buttons out)
CHOP/ALT	CHOP (button in)
20 MHz BW LIMIT	Off (button out)
VOLTS/DIV	
CH 1 and CH 2	0.1 V
CH 1 and CH 2 VAR	In detent
Input Coupling	
CH 1	1 MΩ DC
CH 2	50 Ω DC
A and B SEC/DIV	1 ms (knobs locked)
A and B SEC/DIV VAR	In detent
X10 MAG	Off (button out)
ΔV and Δt	Off (press and release until associated readout is off)
TRIGGER	
HOLDOFF	B ENDS A (fully CW)
LEVEL	Midrange
SLOPE	+ (plus)
MODE	AUTO LVL
SOURCE	CH 1
COUPLING	DC

1. Check CALIBRATOR Repetition Rate.

NOTE

Refer to the Adjustment Procedure to check the accuracy of the CALIBRATOR output levels.

a. Connect a 10X probe from the CALIBRATOR terminal to the CH 1 OR X input connector.

b. Connect 1 ms time markers from the Time-Mark Generator to the CH 2 input connector via a 50 Ω BNC cable.

c. Adjust the CH 2 VOLTS/DIV switch for several divisions of marker display.

d. CHECK—Horizontal drift for any time marker is 1 division or less per second (10 seconds or more for 1 marker to drift 10 horizontal divisions).

e. Set the CH 2 VERTICAL MODE switch to Off (button out).

f. CHECK—1 cycle is displayed per 2 horizontal divisions for each position of the A SEC/DIV switch from 0.1 s to 0.1 μs.

g. Disconnect the test setup.

2. Check External Z-Axis Operation.

a. Set:

INTENSITY	Fully clockwise
A and B SEC/DIV	1 ms
VOLTS/DIV	
CH 1	0.5 V

b. Connect a 1 kHz, 2 V standard-amplitude signal from the Calibration Generator to the CH 1 OR X input connector and the rear-panel EXT Z-AXIS input connector using a 50 Ω BNC T-Connector and two 50 Ω BNC cables.

c. CHECK—The positive portion of the 4-division signal display is blanked out.

d. Disconnect the test setup and adjust the crt INTENSITY as desired.

3. Check A and B GATE Outputs and Verify TRIGGER HOLDOFF.

a. Set:

A SEC/DIV	100 μs
B SEC/DIV	50 μs (knob in)
Δt	Off (DLY readout)
ΔREF OR DLY POS	Zero DLY readout
TRIGGER	
MODE	AUTO
HOLDOFF	Minimum (CCW)

b. Connect a test oscilloscope to the A GATE OUT connector (located on the 2465 rear panel) via a 50 Ω BNC cable.

c. CHECK—Test oscilloscope displays a signal with a high level between 2.4 V and 5 V and a low level between 0 V and 0.4 V.

d. VERIFY—Duration of the high level is between 1 ms and 1.2 ms.

e. VERIFY—Duration of the low level is between 80 μs and 150 μs.

f. VERIFY—Duration of the low level increases to at least 10 times the time measured in part e when the 2465 HOLDOFF control is rotated to the maximum CW position (but not in the detent).

g. Move the 50 Ω BNC cable from the A GATE OUT connector to the B GATE OUT connector.

h. CHECK—Test oscilloscope displays a signal with a high level between 2.4 V and 5 V and a low level between 0 V and 0.4 V.

i. VERIFY—Duration of the high portion of the signal is between 500 μs and 600 μs.

j. Disconnect the test setup.

ADDITIONAL FUNCTIONAL VERIFICATION

Equipment Required (see Table 4-1)

10X Probe supplied with Oscilloscope (Item 7)

Initial Control Settings.

Control settings not listed do not affect the procedure.

Set:

VERTICAL MODE	
CH 1, CH 2, CH 3, CH 4, ADD, and INVERT	Off (buttons out)
CHOP/ALT	ALT (button out)
20 MHz BW LIMIT	Off (button out)
VOLTS/DIV	
CH 1 and CH 2	0.1 V
CH 1 and CH 2 VAR	In detent
CH 3 and CH 4	0.1 V (buttons out)
Input Coupling	
CH 1 and CH 2	1 MΩ DC
A and B SEC/DIV	1 ms (knobs locked)
A and B SEC/DIV VAR	In detent
X10 MAG	Off (button out)
ΔV and Δt	Off (press and release until associated readout is off)
TRACKING	Off (button out)
TRACE SEP	Fully CW
TRIGGER	
HOLDOFF	B ENDS A (fully CW)
LEVEL	Midrange
SLOPE	+ (plus)
A/B TRIG Select	A
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC

1. Verify ALT, CHOP, and ADD Modes and TRACE SEP.

a. VERIFY—CH 1 trace is visible with no VERTICAL MODE buttons selected (all out).

b. Press the CH 2 VERTICAL MODE button in.

c. VERIFY—CH 1 trace is not displayed and the CH 2 trace is displayed.

d. Press the CH 1 VERTICAL MODE button in.

NOTE

Separate the traces by approximately 1 division using the VERTICAL POSITION controls. Do not position either trace precisely at graticule center.

e. VERIFY—Both the CH 1 and the CH 2 traces are displayed.

f. Press in the ADD button.

g. VERIFY—A third trace (ADD) is displayed.

h. Press in the CH 3 VERTICAL MODE button.

i. VERIFY—The CH 3 trace is added to the display.

j. Press in the CH 4 VERTICAL MODE button.

k. VERIFY—The CH 4 trace is added to the display.

l. Set the A and B SEC/DIV controls to 50 ms (knobs locked).

m. VERIFY—5 traces are alternately displayed in the following sequence: CH 1, CH 2, ADD, CH 3, CH 4.

n. Set the TRIGGER MODE switch to SGL SEQ.

o. VERIFY—After the current sequence of traces is complete, no further traces are displayed.

p. Set the TRIGGER SOURCE switch to LINE.

q. Press down and release the TRIGGER MODE switch.

r. VERIFY—Each time the TRIGGER MODE switch is pressed down and released, the 5 signal traces appear once (in sequence), the readout display flashes once and the scale illumination flashes on and off.

s. Set the TRIGGER MODE switch to AUTO LVL and press the CHOP button in.

t. VERIFY—The 5 traces appear to be displayed simultaneously.

u. Set:

TRIGGER SOURCE	CH 4
A SEC/DIV	20 μs
B SEC/DIV	10 μs (knob out and rotated)
CHOP/ALT	ALT (button out)
TRACE SEP	CCW until traces are separated

v. VERIFY—An alternate B sweep trace appears for each A sweep trace (10 traces total).

2. Verify BEAM FIND Operation.

a. Set:

A and B SEC/DIV	1 ms (knobs locked)
VERTICAL MODE	
CH 1	On (button in)
CH 2, CH 3, CH 4 and ADD	Off (buttons out)
X10 MAG	On (button in)
Horizontal POSITION	Midrange
Vertical POSITION	Midrange

b. Press and hold the BEAM FIND button in.

c. VERIFY—The trace is less than 10 divisions long and remains in the graticule area as the CH 1 POSITION control and the Horizontal POSITION control are rotated through their complete ranges.

d. Release the BEAM FIND button and set the VERTICAL POSITION and Horizontal POSITION controls to midrange.

3. Check Probe Encoding.

NOTE

Refer to Figure 2-8, Readout Display Locations, for the positioning of the readout display information.

a. Set:

VOLTS/DIV	
CH 1, CH 2, CH 3, and CH 4	0.1 V

b. Connect the standard accessory 10X probe (encoded) to the CH 1 input connector.

c. CHECK—CH 1 readout changes from 100 mV to 1 V.

d. Move the probe to CH 2 and repeat part c for that channel.

e. Move the probe to CH 3.

f. CHECK—Readout changes from 0.1 to 1.

g. Move the probe to CH 4 and repeat part f for that channel.

h. Disconnect test setup.