Instruction Manual

Tektronix

TDS 510A
Digitizing Oscilloscope
Performance Verification and Specifications

070-9706-00

CE

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Tektronix, Inc., P.O. Box 1000, Wilsonville, OR 97070–1000

WARRANTY

Tektronix warrants that this product will be free from defects in materials and workmanship for a period of three (3) years from the date of shipment. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; or c) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

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General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

Injury Precautions

Use Proper Power Cord. To avoid fire hazard, use only the power cord specified for this product.

Avoid Electric Overload. To avoid electric shock or fire hazard, do not apply a voltage to a terminal that is outside the range specified for that terminal.

Avoid Overvoltage. To avoid electric shock or fire hazard, do not apply potential to any terminal, including the common terminal, that varies from ground by more than the maximum rating for that terminal.

Avoid Electric Shock. To avoid injury or loss of life, do not connect or disconnect probes or test leads while they are connected to a voltage source.

Ground the Product. This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Do Not Operate Without Covers. To avoid electric shock or fire hazard, do not operate this product with covers or panels removed.

Use Proper Fuse. To avoid fire hazard, use only the fuse type and rating specified for this product.

Do Not Operate in Wet/Damp Conditions. To avoid electric shock, do not operate this product in wet or damp conditions.

Do Not Operate in an Explosive Atmosphere. To avoid injury or fire hazard, do not operate this product in an explosive atmosphere.

Product Damage Precautions

Use Proper Power Source. Do not operate this product from a power source that applies more than the voltage specified.

Use Proper Voltage Setting. Before applying power, ensure that the line selector is in the proper position for the power source being used.

Provide Proper Ventilation. To prevent product overheating, provide proper ventilation.

Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

Symbols and Terms

Terms in this Manual. These terms may appear in this manual:

WARNING. *Warning statements identify conditions or practices that could result in injury or loss of life.*

CAUTION. *Caution statements identify conditions or practices that could result in damage to this product or other property.*

Terms on the Product. These terms may appear on the product:

DANGER indicates an injury hazard immediately accessible as you read the marking.

WARNING indicates an injury hazard not immediately accessible as you read the marking.

CAUTION indicates a hazard to property including the product.

Symbols on the Product. The following symbols may appear on the product:

DANGER High Voltage | Protective Ground (Earth) Terminal | ATTENTION Refer to Manual | Double Insulated

Certifications and Compliances

Refer to the specifications section for a listing of certifications and compliances that apply to this product.

Preface

This is the Performance Verification for the TDS 510A Digitizing Oscilloscope. It contains procedures suitable for determining if the instrument functions, was adjusted properly, and meets the performance characteristics as warranted.

Also contained in this document are technical specifications for these oscilloscopes:

The following documents are related to the use or service of the digitizing oscilloscope.

- The TDS 420A, 430A, 460A, & 510A User Manual provides information on using your digitizing oscilloscope.
- The TDS 420A, 430A, 460A & 510A Reference gives you a quick overview of how to operate your digitizing oscilloscope.
- The TDS 510A Service Manual provides information for maintaining and servicing your digitizing oscilloscope to the module level.

Performance Verification

Performance Verification Procedures

Two types of Performance Verification procedures can be performed on this product; *Brief Procedures* and *Performance Tests*. You may not need to perform all of these procedures, depending on what you want to accomplish.

- To rapidly confirm that the oscilloscope functions and was adjusted properly, just do the brief procedures under *Self Tests*, which begin on page 1–5.

  Advantages: These procedures are quick to do, require no external equipment or signal sources, and perform extensive functional and accuracy testing to provide high confidence that the oscilloscope will perform properly. They can be used as a quick check before making a series of important measurements.

- To further check functionality, first do the *Self Tests* just mentioned; then do the brief procedures under *Functional Tests* that begin on page 1–7.

  Advantages: These procedures require minimal additional time to perform, require no additional equipment other than a standard-accessory probe, and more completely test the internal hardware of the oscilloscope. They can be used to quickly determine if the oscilloscope is suitable for putting into service, such as when it is first received.

- If more extensive confirmation of performance is desired, do the *Performance Tests*, beginning on page 1–15, after doing the *Functional* and *Self Tests* just referenced.

  Advantages: These procedures add direct checking of warranted specifications. They require more time to perform and suitable test equipment is required. (See *Equipment Required* beginning on page 1–16.)

If you are not familiar with operating this oscilloscope, read the user manual. These contain instructions that will acquaint you with the use of the front-panel controls and the menu system.

Conventions

Throughout these procedures the following conventions apply:

- Each test procedure uses the following general format:

  Title of Test

  Equipment Required

  Prerequisites

  Procedure

- Each procedure consists of as many steps, substeps, and subparts as required to do the test. Steps, substeps, and subparts are sequenced as follows:

  1. First Step

  a. First Substep

  - First Subpart

  - Second Subpart

  b. Second Substep

  2. Second Step

- In steps and substeps, the lead-in statement in italics instructs you what to do, while the instructions that follow tell you how to do it, as in the example step below, *"Initialize the oscilloscope"* by doing "Press save/recall **SETUP**. Now, press the main-menu button...".

  Initialize the oscilloscope: Press save/recall **SETUP**. Now, press the main-menu button **Recall Factory Setup**; then the side-menu button **OK Confirm Factory Init**.

- Where instructed to use a front-panel button or knob, or select from a main or side menu, or verify a readout or status message, the name of the button or knob appears in boldface type: "press **SHIFT**; then **UTILITY**, press the main-menu button **System** until **Cal** is highlighted in the pop-up menu. Verify that the status message is ***Pass*** in the main menu under the **Voltage Reference** label."

STOP*. The symbol at the left is accompanied by information you must read to do the procedure properly.*

- Refer to Figure 1–1: "Main menu" refers to the menu that labels the seven menu buttons under the display; "side menu" refers to the menu that labels the five buttons to the right of the display. "Pop-up menu" refers to a menu that pops up when a main-menu button is pressed.

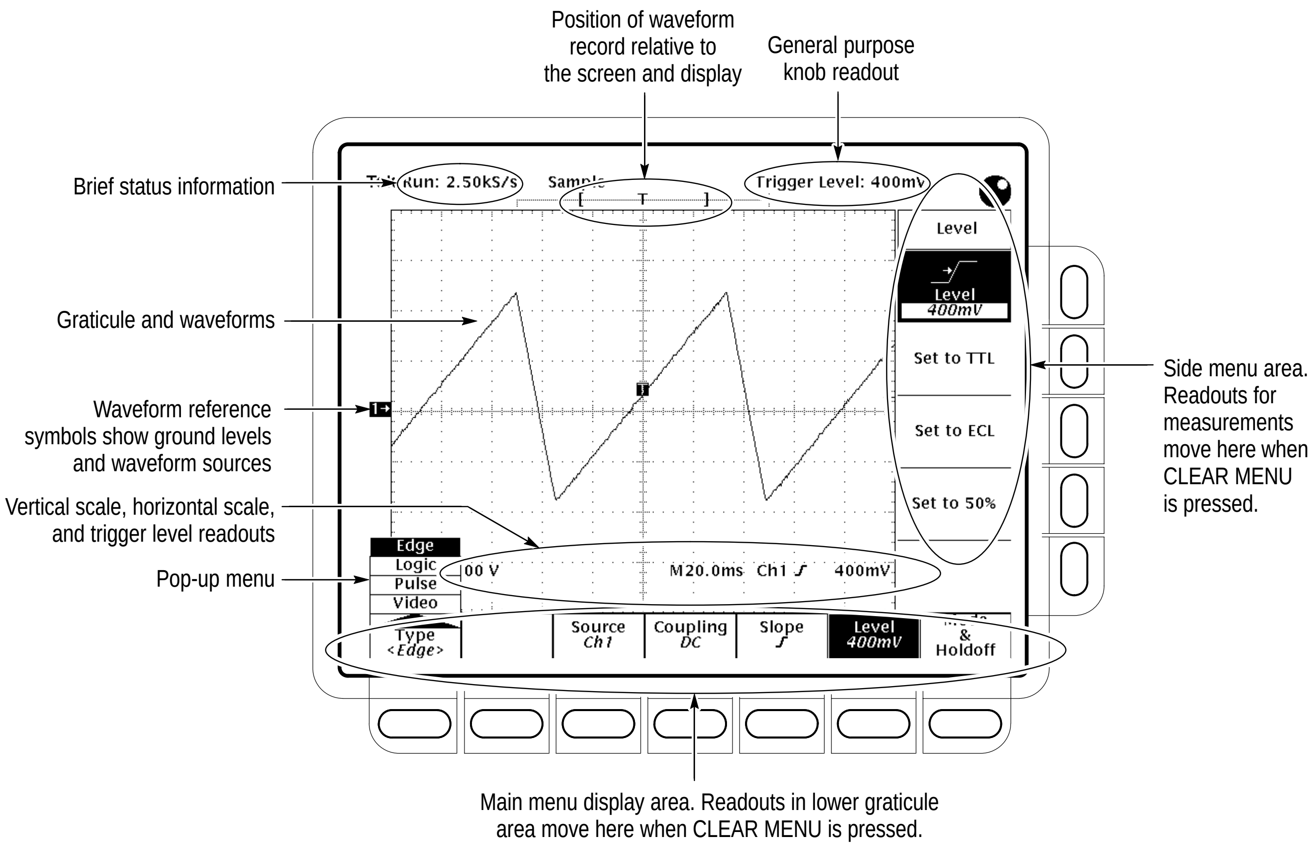


Figure 1–1: Map of Display Functions

Brief Procedures

The *Self Tests* use internal routines to confirm basic functionality and proper adjustment. No test equipment is required to do these test procedures.

The *Functional Tests* utilize the probe-compensation output at the front panel as a test-signal source for further verifying that the oscilloscope functions properly. A probe, such as the P6139A, is required to do these test procedures.

Self Tests

This procedure uses internal routines to verify that the oscilloscope functions and was adjusted properly. No test equipment or hookups are required.

Verify Internal Adjustment, Self Compensation, and Diagnostics

Equipment Required	None
Prerequisites	See page 1–15.

1. *Verify that internal diagnostics pass:* Do the following substeps to verify passing of internal diagnostics.

   a. *Display the System diagnostics menu:*

      - Press **SHIFT**; then press **UTILITY**.
      - Repeatedly press the main-menu button **System** until **Diag/Err** is highlighted in the pop-up menu.

   b. *Run the System Diagnostics:*

      - First disconnect any input signals from all four channels.
      - Press the main-menu button **Execute**; then press the side-menu button **OK Confirm Run Test**.

   c. *Wait:* The internal diagnostics do an exhaustive verification of proper oscilloscope function. This verification will take up to three and a half minutes. At some time during the wait, a “clock” icon (shown at left) will appear on-screen. When the verification is finished, the resulting status will appear on the screen.

   d. *Confirm no failures are found:* Verify that no failures are found and reported on-screen.

   e. *Confirm the three adjustment sections have passed status:*

- Press **SHIFT**; then press **UTILITY**.
- Highlight **Cal** in the pop-up menu by repeatedly pressing the main-menu button **System**. See Figure 1–2.
- Verify that the word ***Pass*** appears in the main menu under the following menu labels: **Voltage Reference**, **Frequency Response**, and **Pulse Trigger**. See Figure 1–2.

f. *Run the signal-path compensation:* Press the main-menu button **Signal Path**; then press the side-menu button **OK Compensate Signal Paths**.

g. *Wait:* Signal-path compensation may take five minutes to run. While it progresses, a “clock” icon (shown at left) is displayed on-screen. When compensation completes, the status message will be updated to *Pass* or *Fail* in the main menu. See step h.

h. *Confirm signal-path compensation returns passed status:* Verify that the word ***Pass*** appears under **Signal Path** in the main menu. See Figure 1–2.

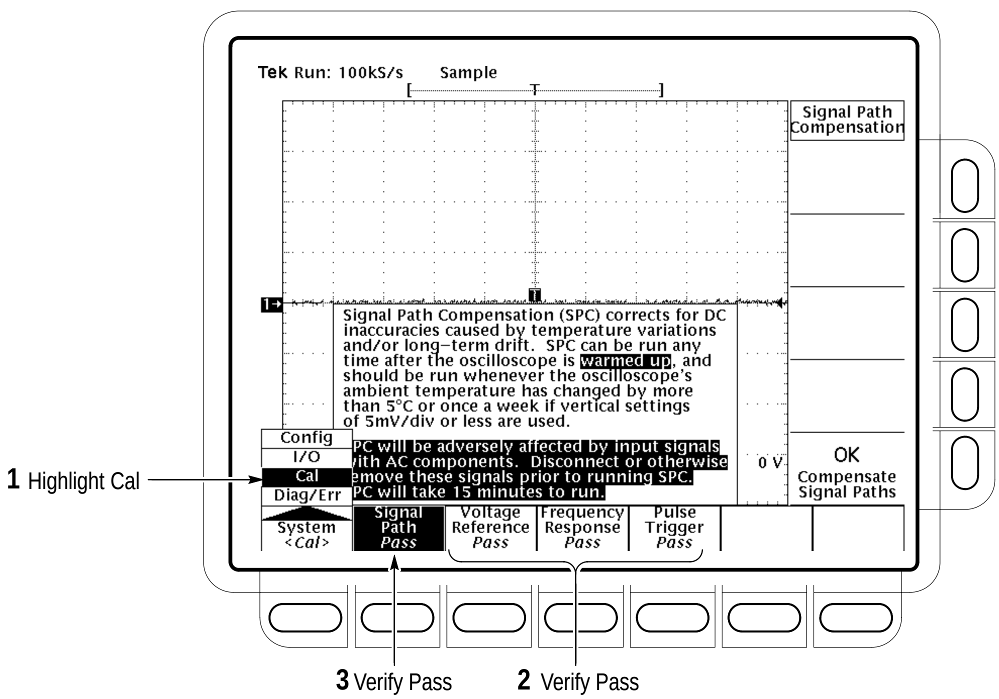


Figure 1–2: Verifying Adjustments and Signal-Path Compensation

2. *Return to regular service:* Press **CLEAR MENU** to exit the system menus.

Functional Tests

The purpose of these procedures is to confirm that the oscilloscope functions properly. The only equipment required is one of the standard-accessory probes and, to check the file system, a 3.5 inch, 720 K or 1.44 Mbyte floppy disk.

***STOP**. These procedures verify functions; that is, they verify that the oscilloscope features operate. They do not verify that they operate within limits.*

Therefore, when the instructions in the functional tests that follow call for you to verify that a signal appears on-screen "that is about five divisions in amplitude" or "has a period of about six horizontal divisions," etc., do NOT interpret the quantities given as limits. Operation within limits is checked in Performance Tests, which begin on page 1–15.

***STOP**. DO NOT make changes to the front-panel settings that are not called out in the procedures. Each verification procedure will require you to set the oscilloscope to certain default settings before verifying functions. If you make changes to these settings, other than those called out in the procedure, you may obtain invalid results. In this case, just redo the procedure from step 1.*

When you are instructed to press a menu button, the button may already be selected (its label will be highlighted). If this is the case, it is not necessary to press the button.

Verify All Input Channels

Equipment Required	One probe such as the P6243, P6245 or P6139A
Prerequisites	None

1. *Install the test hookup and preset the oscilloscope controls:*

   a. *Hook up the signal source:* Install the probe on **CH 1**. Connect the probe tip to **PROBE COMPENSATION SIGNAL** on the front panel; connect the probe ground (typically black) to **PROBE COMPENSATION GND**. If using a P6243 or P6245 probe, you may want to attach a Y-lead connector and two SMD KlipChips as shown in Figure 1–3.

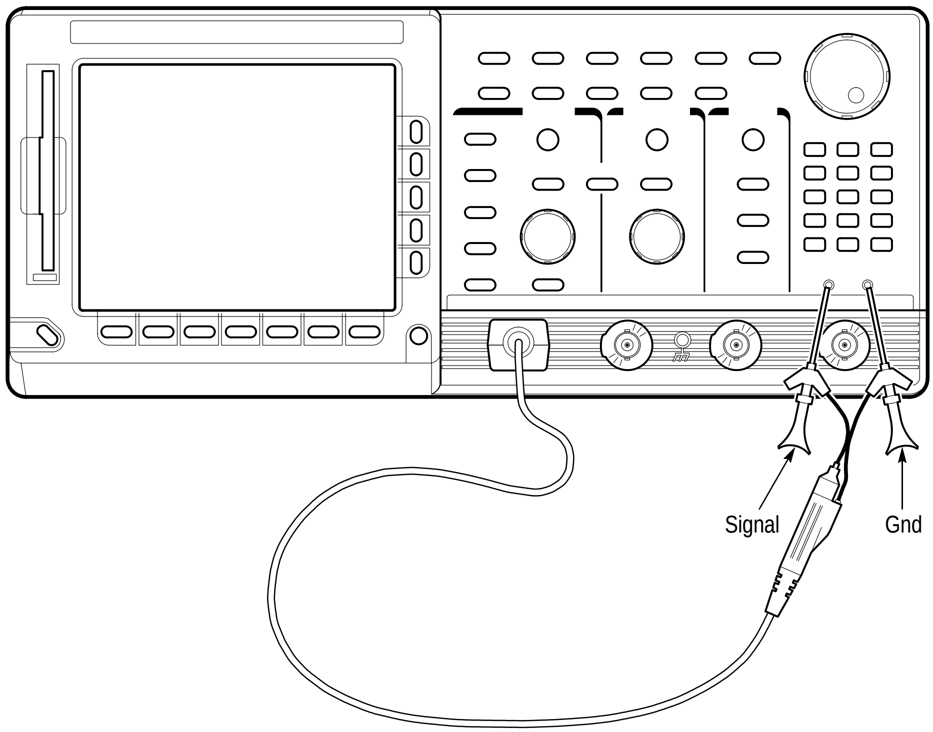


Figure 1–3: Universal Test Hookup for Functional Tests

b. *Initialize the oscilloscope:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

2. *Verify that all channels operate:* Do the following substeps — test CH 1 first, *skipping substep a and b since CH 1 is already set up for verification and as the trigger source from step 1.*

a. *Select an unverified channel:*

- Press **WAVEFORM OFF** to remove the channel just verified from display.
- Press the front-panel button that corresponds to the channel you are to verify.
- Move the probe to the channel you selected.

b. *Match the trigger source to the channel selected:*

- Press **TRIGGER MENU**.

- Press the main-menu button **Source**.
- Press the side-menu button that corresponds to the channel selected (**Ch2**, **Ch3**, or **Ch4**).

c. *Set up the selected channel:*

- Set the vertical **SCALE** to 200 mV.
- Set the horizontal **SCALE** to 200 μs. Press **CLEAR MENU** to remove any menu that may be on the screen.

d. *Verify that the channel is operational:* Confirm that the following statements are true.

- The vertical scale readout for the channel under test shows a setting of 200 mV, and a square-wave probe-compensation signal about 2.5 divisions in amplitude is on-screen. See Figure 1–1 on page 1–3 to locate the readout.
- The vertical **POSITION** knob moves the signal up and down the screen when rotated.
- Turning the vertical **SCALE** knob counterclockwise decreases the amplitude of the waveform on-screen, turning the knob clockwise increases the amplitude, and returning the knob to 200 mV returns the amplitude to about 2.5 divisions.

e. *Verify that the channel acquires in all acquisition modes:* Press **SHIFT**; then press **ACQUIRE MENU**. Use the side menu to select, in turn, each of the three hardware acquire modes and confirm that the following statements are true. Refer to the icons at the left of each statement as you confirm those statements.

- Sample mode displays an actively acquiring waveform on-screen. (Note that there is noise present on the peaks of the square wave.)

- Peak Detect mode displays an actively acquiring waveform on-screen with the noise present in Sample mode “peak detected.”

- Hi Res mode displays an actively acquiring waveform on-screen with the noise that was present in Sample mode reduced.

- Envelope mode displays an actively acquiring waveform on-screen with the noise displayed.

- Average mode displays an actively acquiring waveform on-screen with the noise reduced.

f. *Test all channels:* Repeat substeps a through e until all four input channels are verified.

3. *Remove the test hookup:* Disconnect the probe from the channel input and the probe-compensation terminals.

Verify the Time Base

Equipment Required	One probe such as the P6243, P6245 or P6139A
Prerequisites	None

1. *Install the test hookup and preset the oscilloscope controls:*
   a. *Hook up the signal source:* Install the probe on **CH 1**. Connect the probe tip to **PROBE COMPENSATION SIGNAL** on the front panel; connect the probe ground to **PROBE COMPENSATION GND**. See Figure 1–3 on page 1–8.
   b. *Initialize the oscilloscope:*
      - Press save/recall **SETUP**.
      - Press the main-menu button **Recall Factory Setup**; then press the side-menu button **OK Confirm Factory Init**.
   c. *Modify default settings:*
      - Set the vertical **SCALE** to 200 mV.
      - Set the horizontal **SCALE** to 200 μs.
      - Press **CLEAR MENU** to remove the menus from the screen.
2. *Verify that the time base operates:* Confirm the following statements.
   a. One period of the square-wave probe-compensation signal is about five horizontal divisions on screen for the 200 μs horizontal scale setting (set in step 1c).
   b. Rotating the horizontal **SCALE** knob clockwise expands the waveform on-screen (more horizontal divisions per waveform period), counter-clockwise rotation contracts it, and returning the horizontal scale to 200 μs returns the period to about five divisions.
   c. The horizontal **POSITION** knob positions the signal left and right on screen when rotated.
3. *Remove the test hookup:* Disconnect the probe from the channel input and the probe-compensation terminals.

Verify the Main and Delayed Trigger Systems

Equipment Required	One probe such as the P6243, P6245, or P6139A
Prerequisites	None

1. *Install the test hookup and preset the oscilloscope controls:*

   a. *Hook up the signal source:* Install the probe on **CH 1**. Connect the probe tip to **PROBE COMPENSATION SIGNAL** on the front panel; connect the probe ground to **PROBE COMPENSATION GND**. See Figure 1–3 on page 1–8.

   b. *Initialize the oscilloscope:*

      - Press save/recall **SETUP**.
      - Press the main-menu button **Recall Factory Setup**.
      - Press the side-menu button **OK Confirm Factory Init**.

   c. *Modify default settings:*

      - Set the vertical **SCALE** to 200 mV.
      - Set the horizontal **SCALE** for the **M** (main) time base to 200 μs.
      - Press **TRIGGER MENU**.
      - Press the main-menu button **Mode & Holdoff**.
      - Press the side-menu button **Normal**.
      - Press **CLEAR MENU** to remove the menus from the screen.

2. *Verify that the main trigger system operates:* Confirm that the following statements are true:

   - The trigger level readout for the main trigger system changes with the trigger-**LEVEL** knob.
   - The trigger-**LEVEL** knob can trigger and untrigger the square-wave signal as you rotate it. (Leave the signal *un*triggered, which is indicated by the display not updating.)
   - Pressing **SET LEVEL TO 50%** triggers the signal that you just left untriggered. (Leave the signal triggered.)

3. *Verify that the delayed trigger system operates:*

a. *Select the delayed time base:*

- Press **HORIZONTAL MENU**.
- Press the main-menu button **Time Base**.
- Press the side-menu button **Delayed Triggerable**; then press the side-menu button **Delayed Only**.
- Set the horizontal **SCALE** for the **D** (delayed) time base to 200 μs.

b. *Select the delayed trigger level menu:*

- Press **SHIFT**; then press **DELAYED TRIG**.
- Press the main-menu button **Level**; then press the side-menu button **Level**.

c. *Confirm that the following statements are true*:

- The trigger-level readout for the delayed trigger system changes as you turn the general purpose knob.
- As you rotate the general purpose knob, the square-wave probe-compensation signal can become triggered and untriggered. (Leave the signal *un*triggered, which is indicated by the display not updating.)
- Pressing the side-menu button **Set to 50%** triggers the probe-compensation signal that you just left untriggered. (Leave the signal triggered.)

d. *Verify the delayed trigger counter:*

- Press the main-menu button **Delay by *Time***.
- Use the keypad to enter a delay time of 1 second. Press **1**, then press **ENTER**.
- Verify that the trigger **READY** indicator on the front panel flashes about once every second as the waveform is updated on-screen.

4. *Remove the test hookup:* Disconnect the probe from the channel input and the probe-compensation terminals.

Verify the File System

Equipment Required	One probe such as the P6243, P6245 or P6139A One 720 K or 1.44 Mbyte, 3.5 inch DOS-compatible disk.
Prerequisites	None

1. *Install the test hookup and preset the oscilloscope controls:*

a. *Hook up the signal source:* Install the probe on **CH 1**. Connect the probe tip to **PROBE COMPENSATION SIGNAL** on the front panel; connect the probe ground to **PROBE COMPENSATION GND**. See Figure 1–3 on page 1–8.

b. *Insert the test disk:* Insert the disk in the disk drive to the left of the monitor.

- Position the disk so the metal shutter faces the drive.
- Position the disk so the stamped arrow is on the top right side. In other words, place the angled corner in the front bottom location.
- Push the disk into the drive until it goes all the way in and clicks into place.

c. *Initialize the oscilloscope:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

d. *Modify default settings:*

- Set the vertical **SCALE** to 200 mV.
- Set the horizontal **SCALE** for the **M** (main) time base to 200 μs. Notice the waveform on the display now shows two cycles instead of five.
- Press **CLEAR MENU** to remove the menus from the screen.

e. *Save the settings:*

- Press **SETUP**.
- Press the main-menu button **Save Current Setup**; then press the side-menu button **To File**.
- Turn the general purpose knob to select the file to save. Choose `TEK?????.SET` (or `fdo:`). With this choice, you will save a file starting with `TEK`, then containing 5-numbers, and a `.SET` extension.

For example, the first time you run this on a blank, formatted disk or on the Example Programs Disk, the oscilloscope will assign the name `TEK00000.SET` to your file. If you ran the procedure again, the oscilloscope would increment the name and call the file `TEK00001.SET`.

- Press the side-menu button **Save To Selected File**.

2. *Verify the file system works:*

- Press the main-menu button **Recall Factory Setup** and the side-menu button **OK Confirm Factory Init** to restore the 500 μs time base and the five cycle waveform.
- Press the main-menu button **Recall Saved Setup**; then press the side-menu button **From File**.
- Turn the general purpose knob to select the file to recall. For example, if you followed the instructions above and used a blank disk, you had the oscilloscope assign the name TEK00000.SET to your file.
- Press the side-menu button **Recall From Selected File**.
- Verify that oscilloscope retrieved the saved setup from the disk. Do this by noticing the horizontal **SCALE** for the **M** (main) time base is again 200 μs and the waveform shows only two cycles just as it was when you saved the setup.

3. *Remove the test hookup:*

- Disconnect the probe from the channel input and the probe-compensation terminals.
- Remove the disk from the disk drive. Do this by pushing in the tab of the disk drive.

Performance Tests

This section contains a collection of procedures for checking that the TDS 510A Digitizing Oscilloscope performs as warranted.

The procedures are arranged in four logical groupings: *Signal Acquisition System Checks*, *Time Base System Checks*, *Triggering System Checks*, and *Output Ports Checks*. They check all the characteristics that are designated as checked in *Specifications.* (The characteristics that are checked appear in **boldface** type under *Warranted Characteristics* in *Specifications*.)

STOP. *These procedures extend the confidence level provided by the basic procedures described on page 1–5. The basic procedures should be done first, then these procedures performed if desired.*

Prerequisites

The tests in this section comprise an extensive, valid confirmation of performance and functionality when the following requirements are met:

- The cabinet must be installed on the oscilloscope.
- You must have performed and passed the procedures under *Self Tests,* found on page 1–5, and those under *Functional Tests,* found on page 1–7.
- A signal-path compensation must have been done within the recommended calibration interval and at a temperature within ±5° C of the present operating temperature. (If at the time you did the prerequisite *Self Tests*, the temperature was within the limits just stated, consider this prerequisite met.)
- The oscilloscope must have been last adjusted at an ambient temperature between +20° C and +30° C, must have been operating for a warm-up period of at least 20 minutes, and must be operating at an ambient temperature between +5° C and +50° C. (The warm-up requirement is usually met in the course of meeting the Self Tests and Functional Tests prerequisites listed above.)

Equipment Required

These procedures use external, traceable signal sources to directly check warranted characteristics. The required equipment list follows this introduction.

Table 1–1: Test Equipment

Item Number and Description	Minimum Requirements	Example	Purpose
1. Attenuator,10X (two required)	Ratio: 10X; impedance 50 Ω; connectors: female BNC input, male BNC output	Tektronix part number 011-0059-02	Signal Attenuation
2. Attenuator, 5X	Ratio: 5X; impedance 50 Ω; connectors: female BNC input, male BNC output	Tektronix part number 011-0060-02	Signal Attenuation
3. Adapter, BNC female to Clip Leads	BNC female to Clip Leads	Tektronix part number 013-0076-00	Signal Coupling for Probe Compensator Output Check
4. Terminator, 50 Ω	Impedance 50 Ω; connectors: female BNC input, male BNC output	Tektronix part number 011-0049-01	Signal Termination for Channel Delay Test
5. Cable, Precision 50 Ω Coaxial (two required)	50 Ω, 36 in, male to male BNC connectors	Tektronix part number 012-0482-00	Signal Interconnection
6. Connector, Dual-Banana (two required)	Female BNC to dual banana	Tektronix part number 103-0090-00	Various Accuracy Tests
7. Connector, BNC “T”	Male BNC to dual female BNC	Tektronix part number 103-0030-00	Checking Trigger Sensitivity
8. Coupler, Dual-Input	Female BNC to dual male BNC	Tektronix part number 067-0525-02	Checking Delay Between Channels
9. Generator, DC Calibration	Variable amplitude to ±104 V; accuracy to 0.1%	Data Precision 8200	Checking DC Offset, Gain, and Measurement Accuracy
10. Generator, Calibration	500 mV square wave calibrator amplitude; accuracy to 0.25%	Wavetek 9100 with options 100 and 250 (or, optionally, Tektronix PG 506A[1])	To check accuracy of CH 3 Signal Out
11. Generator, Time Mark	Variable marker frequency from 10 ms to 10 ns; accuracy within 2 ppm	Wavetek 9100 with options 100 and 250 (or, optionally, Tektronix TG 501A Time Mark Generator[1)]	Checking Sample-Rate and Delay-time Accuracy
12. Probe, 10X	A P6139A, P6243, or P6245 probe[2]	Tektronix part number P6139A or P6245	Signal Interconnection
13. 3.5 inch, 720 K or 1.44 Mbyte, DOS-compatible floppy disk	3.5 inch, 720 K or 1.44 Mbyte, DOS-compatible floppy disk		Checking File System Basic Functionality
14. Generator, Video Signal	Provides PAL compatible outputs	Tektronix TSG 121	Used to Test Video Option 05 Equipped Instruments Only
15. Oscillator, Leveled Sine wave Generator	60 Hz Sine wave	Wavetek 9100 with options 100 and 250 (or, optionally, Tektronix SG 502)	Used to Test Video Option 05 Equipped Instruments Only

Table 1–1: Test Equipment (Cont.)

Item Number and Description	Minimum Requirements	Example	Purpose
16. Pulse Generator		Tektronix CFG280 (or, optionally, PG 502)	Used to Test Video Option 05 Equipped Instruments Only
17. Cable, Coaxial (two required)	75 Ω, 36 in, male to male BNC connectors	Tektronix part number 012-1338-00	Used to Test Video Option 05 Equipped Instruments Only
18. Terminator, 75 Ω (two required)	Impedance 75 Ω; connectors: female BNC input, male BNC output	Tektronix part number 011-0102-01	Used to Test Video Option 05 Equipped Instruments Only
19. Generator, Sine Wave	100 kHz to at least 400 MHz. Variable amplitude from 12 mV to 2 V_{p-p}. Frequency accuracy >2.0%	Rohde & Schwarz SMY[3]	Checking Analog Bandwidth, Trigger Sensitivity, Sample-rate, External Clock, and Delay-Time Accuracy
20. Meter, Level and Power Sensor	Frequency range:10 MHz to 400MHz. Amplitude range: 6 mVp-p to 2 V_{p-p}	Rohde & Schwarz URV 35, with NRV-Z8 power sensor[3]	Checking Analog Bandwidth and Trigger Sensitivity
21. Splitter, Power	Frequency range: DC to 1 GHz. Tracking: >2.0%	Rohde & Schwarz RVZ[3]	Checking Analog Bandwidth
22. Generator, Function	Frequency range 5 MHz to 10 MHz. Square wave transition time ≤ 25 ns. Amplitude range: 0 to 10 V_{p-p} into 50 Ω	Tektronix CFG280	Checking External Clock
23. Adapter (four required)	Male N to female BNC	Tektronix 103–0045–00	Checking Analog Bandwidth
24. Adapter	Female N to male BNC	Tektronix 103–0058–00	Checking Analog Bandwidth
25. Generator, Leveled Sine Wave, Medium-Frequency (optional)	200 kHz to 250 MHz; Variable amplitude from 5 mV to 4 V_{p-p} into 50 Ω	Tektronix SG 503 Leveled Sine Wave Generator[1, 3]	Checking Trigger Sensitivity at low frequencies
26. Generator, Leveled Sine Wave, High-Frequency (optional)	250 MHz to 1 GHz; Variable amplitude from 500 mV to 4 V_{p-p} into 50 Ω; 6 MHz reference	Tektronix SG 504 Leveled Sine Wave Generator[1] with SG 504 Output Head[3]	Checking Analog Bandwidth and Trigger Sensitivity at high frequencies

[1] **Requires a TM 500 or TM 5000 Series Power Module Mainframe.**

[2] **Warning: The optional P6243 and P6245 probes that may be used with this oscilloscope provide an extremely low loading capacitance (<1 pF) to ensure the best possible signal reproduction. These probes should not be used to measure signals exceeding ±8 V, or errors in signal measurement will be observed. Above 40 V, damage to the probe may result. To make measurements beyond ±8 V, use either the P6139A probe (good to 500 V), or refer to the catalog for a recommended probe.**

[3] **You can replace items 19, 20, or 21 with a Tektronix SG503 (item 25) or SG504 (item 26) – if available.**

TDS 510A Test Record

Photocopy this and the next three pages and use them to record the performance test results for your TDS 510A Digitizing Oscilloscope.

Test Record

Instrument Serial Number:	__________	Certificate Number:	__________
Temperature:	__________	RH %:	__________
Date of Calibration:	__________	Technician:	__________

Performance Test		Minimum	Incoming	Outgoing	Maximum
Offset Accuracy					
CH1 Offset	+1 mV +101 mV +1.01 V	– 1.6 mV – 25.1 mV – 251 mV	__________ __________ __________	__________ __________ __________	+ 1.6 mV + 25.1 mV + 251 mV
CH2 Offset	+1 mV +101 mV +1.01 V	– 1.6 mV – 25.1 mV – 251 mV	__________ __________ __________	__________ __________ __________	+ 1.6 mV + 25.1 mV + 251 mV
CH3 Offset	+1 mV +101 mV +1.01 V	– 1.6 mV – 25.1 mV – 251 mV	__________ __________ __________	__________ __________ __________	+ 1.6 mV + 25.1 mV + 251 mV
CH4 Offset	+1 mV +101 mV +1.01 V	– 1.6 mV – 25.1 mV – 251 mV	__________ __________ __________	__________ __________ __________	+ 1.6 mV + 25.1 mV + 251 mV
DC Voltage Measurement Accuracy (Averaged)					
CH1	5 mV Vert scale setting, –5 Div position setting, +1 V offset	+ 1.0355 V	__________	__________	+ 1.0445 V
CH1	5 mV Vert scale setting, +5 Div position setting, –1 V offset	– 1.0445 V	__________	__________	– 1.0355 V
CH1	200 mV Vert scale setting, –5 Div position setting, +10 V offset	+ 11.5085 V	__________	__________	+ 11.6915 V
CH1	200 mV Vert scale setting, +5 Div position setting, –10 V offset	– 11.6915 V	__________	__________	– 11.5085 V
CH1	1 V Vert scale setting, –5 Div position setting, +10 V offset	+ 17.6075 V	__________	__________	+ 18.3925 V
CH1	1 V Vert scale setting, +5 Div position setting, –10 V offset	– 18.3925 V	__________	__________	– 17.6075 V
CH2	5 mV Vert scale setting, –5 Div position setting, +1 V offset	+ 1.0355 V	__________	__________	+ 1.0445V
CH2	5 mV Vert scale setting, +5 Div position setting, –1 V offset	– 1.0445 V	__________	__________	– 1.0355 V
CH2	200 mV Vert scale setting, –5 Div position setting, +10 V offset	+ 11.5085 V	__________	__________	+ 11.6915 V

Test Record (Cont.)

Instrument Serial Number: __________	Certificate Number: __________
Temperature: __________	RH %: __________
Date of Calibration: __________	Technician: __________

Performance Test		Minimum	Incoming	Outgoing	Maximum
CH2	200 mV Vert scale setting, +5 Div position setting, –10 V offset	– 11.6915 V	__________	__________	– 11.5085 V
CH2	1 V Vert scale setting, –5 Div position setting, +10 V offset	+ 17.6075 V	__________	__________	+ 18.3925 V
CH2	1 V Vert scale setting, +5 Div position setting, –10 V offset	– 18.3925 V	__________	__________	– 17.6075 V
CH3	5 mV Vert scale setting, –5 Div position setting, +1 V offset	+ 1.0355 V	__________	__________	+ 1.0445 V
CH3	5 mV Vert scale setting, +5 Div position setting, –1 V offset	– 1.0445 V	__________	__________	– 1.0355 V
CH3	200 mV Vert scale setting, –5 Div position setting, +10 V offset	+ 11.5085 V	__________	__________	+ 11.6915 V
CH3	200 mV Vert scale setting, +5 Div position setting, –10 V offset	– 11.6915 V	__________	__________	– 11.5085 V
CH3	1 V Vert scale setting, –5 Div position setting, +10 V offset	+ 17.6075 V	__________	__________	+ 18.3925 V
CH3	1 V Vert scale setting, +5 Div position setting, –10 V offset	– 18.3925 V	__________	__________	– 17.6075 V
CH4	5 mV Vert scale setting, –5 Div position setting, +1 V offset	+ 1.0355 V	__________	__________	+ 1.0445 V
CH4	5 mV Vert scale setting, +5 Div position setting, –1 V offset	– 1.0445 V	__________	__________	– 1.0355 V
CH4	200 mV Vert scale setting, –5 Div position setting, +10 V offset	+ 11.5085 V	__________	__________	+ 11.6915 V
CH4	200 mV Vert scale setting, +5 Div position setting, –10 V offset	– 11.6915 V	__________	__________	– 11.5085 V
CH4	1 V Vert scale setting, –5 Div position setting, +10 V offset	+ 17.6075 V	__________	__________	+ 18.3925 V
CH4	1 V Vert scale setting, +5 Div position setting, –10 V offset	– 18.3925 V	__________	__________	– 17.6075 V
Analog Bandwidth					
CH1	100 mV	424 mV	__________	__________	N/A
CH2	100 mV	424 mV	__________	__________	N/A
CH3	100 mV	424 mV	__________	__________	N/A
CH4	100 mV	424 mV	__________	__________	N/A

Test Record (Cont.)

Instrument Serial Number: __________	Certificate Number: __________
Temperature: __________	RH %: __________
Date of Calibration: __________	Technician: __________

Performance Test	Minimum	Incoming	Outgoing	Maximum
Delay Between Channels				
Delay Between Channels	N/A	________	________	250 ps
Time Base System				
Long Term Sample Rate/ Delay Time @ 100 ns/10.0 ms	–2.5 Div	________	________	+2.5 Div
Trigger System Accuracy				
Pulse-Glitch or Pulse-Width, Hor. scale ≤ 1 µs Lower Limit Upper Limit	 2.5 ns 2.5 ns	 ________ ________	 ________ ________	 7.5 ns 7.5 ns
Pulse-Glitch or Pulse-Width, Hor. scale > 1 µs Lower Limit Upper Limit	 1.0 µs 1.0 µs	 ________ ________	 ________ ________	 3.0 µs 3.0 µs
Main Trigger, DC Coupled, Positive Slope	9.940 V	________	________	10.060 V
Main Trigger, DC Coupled, Negative Slope	9.940 V	________	________	10.060 V
Delayed Trigger, DC Coupled, Positive Slope	9.940 V	________	________	10.060 V
Delayed Trigger, DC Coupled, Negative Slope	9.940 V	________	________	10.060 V
CH1 Sensitivity, 50 MHz, Main	Pass/Fail	________	________	Pass/Fail
CH1 Sensitivity, 50 MHz, Delayed	Pass/Fail	________	________	Pass/Fail
CH1 AUX Trigger Input	Pass/Fail	________	________	Pass/Fail
CH1 Sensitivity, full bandwidth, Main	Pass/Fail	________	________	Pass/Fail
CH1 Sensitivity, full bandwidth, Delayed	Pass/Fail	________	________	Pass/Fail
Output Signal Checks				
MAIN TRIGGER OUTPUT, 1 MΩ High Low	 High ≥ 2.5 V	 ________ ________	 ________ ________	 Low ≤ 0.7 V
MAIN TRIGGER OUTPUT, 50 Ω High Low	 High ≥ 1.0 V	 ________ ________	 ________ ________	 Low ≤ 0.25 V
DELAYED TRIGGER OUTPUT, 50 Ω High Low	 High ≥ 1.0 V	 ________ ________	 ________ ________	 Low ≤ 0.25 V
DELAYED TRIGGER OUTPUT, 1 MΩ High Low	 High ≥ 2.5 V	 ________ ________	 ________ ________	 Low ≤ 0.7 V

Test Record (Cont.)

Instrument Serial Number: __________	Certificate Number: __________
Temperature: __________	RH %: __________
Date of Calibration: __________	Technician: __________

Performance Test	Minimum	Incoming	Outgoing	Maximum
CH 3 or AX 1 SIGNAL OUTPUT, 1 MΩ	Pk-Pk ≥ 90 mV	__________	__________	Pk-Pk ≤ 110 mV
CH 3 or AX 1 SIGNAL OUTPUT, 50 Ω	Pk-Pk ≥ 45 mV	__________	__________	Pk-Pk ≤ 55 mV
Probe Compensator Output Signal				
Frequency (CH1 Freq.)	950 Hz	__________	__________	1.050 kHz
Voltage (difference)	495 mV	__________	__________	505 mV

Signal Acquisition System Checks

These procedures check those characteristics that relate to the signal-acquisition system and are listed as checked under *Warranted Characteristics* in *Specifications.*

Check Offset Accuracy (Zero Setting)

Equipment Required	None
Prerequisites	See page 1–15.

1. *Preset the instrument controls:*

   a. *Initialize the oscilloscope:*

      - Press save/recall **SETUP**.
      - Press the main-menu button **Recall Factory Setup**.
      - Press the side-menu button **OK Confirm Factory Init**.
      - Press **CLEAR MENU** to remove the menus from the screen.

   b. *Modify the default settings:*

      - Press **SHIFT**; then press **ACQUIRE MENU**.
      - Press the main-menu button **Mode**; then press the side-menu button **Hi Res**.
      - Press **CURSOR**.
      - Press the main-menu button **Function**; then press the side-menu button **H Bars**.
      - Press **CLEAR MENU**.
      - Be sure to disconnect any input signals from all four channels.

2. *Confirm input channels are within limits for offset accuracy at zero offset:* Do the following substeps — test CH 1 first, *skipping substep a. since CH 1 is already set up to be checked from step 1.*

   a. *Select an unchecked channel:* Press **WAVEFORM OFF** to remove the channel just confirmed from the display. Then, press the front-panel button that corresponds to the channel you are to confirm.

   b. *Set the vertical scale:* Set the vertical **SCALE** to one of the settings listed in Table 1–2 that is not yet checked. (Start with the first setting listed.)

- Press **VERTICAL MENU**. Press the main-menu button **Fine Scale**.
- Use the keypad to enter the vertical scale. For the 1 mV setting, press **1**, **SHIFT**, **m**, then **ENTER**. For the 101 mV setting, press **101**, **SHIFT**, **m**, and then **ENTER**. For the 1.01 V setting, press **1.01** and then **ENTER**.
- Press **CLEAR MENU**.

Table 1–2: DC Offset Accuracy (Zero Setting)

Vertical Scale Setting	Vertical Position and Offset Setting[1]	Offset Accuracy Limits
1 mV	0	±1.6 mV
101 mV	0	±25.1 mV
1.01 V	0	±251 mV

[1] Vertical position is set to 0 divisions and vertical offset to 0 V when the oscilloscope is initialized in step 1.

c. *Display the test signal:* The waveform position and offset were initialized for all channels in step 1 and are displayed as you select each channel and its vertical scale.

d. *Measure the test signal:* Align the active cursor over the waveform by rotating the general purpose knob. Ignore the other cursor. See Figure 1–4.

e. Read the measurement results at the absolute (**@:**) cursor readout, not the delta (**Δ:**) readout on screen. That is, read the offset relative to the ground reference. See Figure 1–4.

f. *Check against limits:* Do the following subparts in the order listed.

- CHECK that the measurement results are within the limits listed for the current vertical scale setting.
- Enter voltage on test record.
- Repeat substeps b through f until all vertical scale settings listed in Table 1–2, are checked for the channel under test.

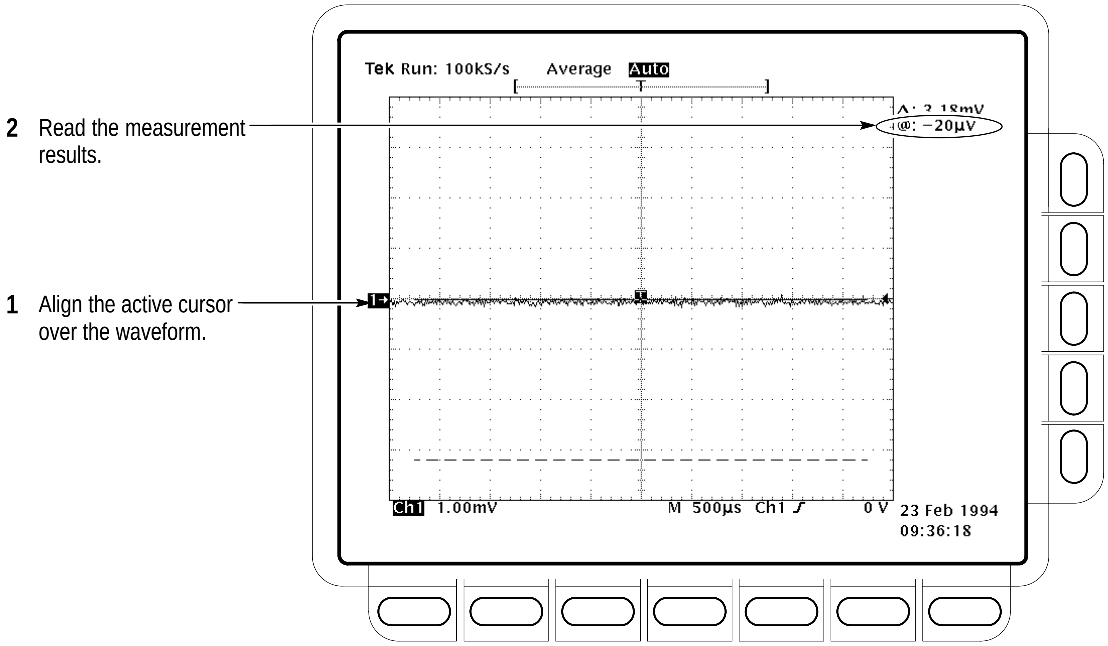


Figure 1–4: Measurement of DC Offset Accuracy at Zero Setting

g. *Test all channels:* Repeat substeps a through f for all input channels.

3. *Disconnect the hookup:* No hookup was required.

Check DC Voltage Measurement Accuracy

WARNING. *The generator is capable of outputting dangerous voltages. Be sure to set the DC calibration generator to 0 volts before connecting, disconnecting, and/or moving the test hookup during the performance of this procedure.*

Equipment Required	Two dual-banana connectors (Item 6) One BNC T connector (Item 7) One DC calibration generator (Item 9) Two precision coaxial cables (Item 5)
Prerequisites	The oscilloscope must meet the prerequisites listed on page 1–15

1. *Install the test hookup and preset the instrument controls:*

a. *Hook up the test-signal source:*

- Set the output of a DC calibration generator to 0 volts.
- Connect the output of a DC calibration generator through a dual-banana connector followed by a 50 Ω precision coaxial cable to one side of a BNC T connector. See Figure 1–5.
- Connect the Sense output of the generator through a second dual-banana connector followed by a 50 Ω precision coaxial cable to the other side of the BNC T connector. Now connect the BNC T connector to **CH 1**. See Figure 1–5.

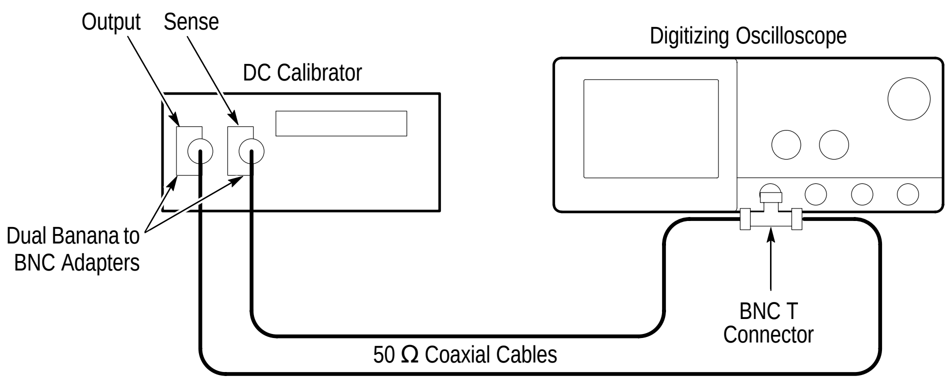


Figure 1–5: Initial Test Hookup

b. *Initialize the oscilloscope:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

c. *Modify the default settings:*

- Press **SHIFT**; then press **ACQUIRE MENU**.
- Press the main-menu button **Mode**; then press the side-menu button **Average 16**.

2. *Confirm input channels are within limits for DC accuracy at maximum offset and position:* Do the following substeps — test CH 1 first, *skipping substep 2a since CH 1 is already selected from step 1.*

a. *Select an unchecked channel:*

- Press **WAVEFORM OFF** to remove the channel just confirmed from the display.
- Press the front-panel button that corresponds to the channel you are to confirm.
- *Set the generator output to 0 V.*
- Move the test hookup to the channel you selected.

b. *Turn on the measurement Mean for the channel:*

- Press **MEASURE**, then press the main-menu button **Select Measrmnt for *CHx***.

- Press the side-menu button **more** until the menu label **Mean** appears in the side menu (its icon is shown at the left). Press the side-menu button **Mean**.
- Press **CLEAR MENU**.

c. *Set the vertical scale:* Set the vertical **SCALE** to one of the settings listed in Table 1–3 that is not yet checked. (Start with the first setting listed.)

Table 1–3: DC Voltage Measurement Accuracy

Scale Setting	Position Setting (Divs)	Offset Setting	Generator Setting	Accuracy Limits
5 mV	–5	+1 V	+1.040 V	+1.0355 V to +1.0445 V
	+5 V	–1 V	–1.040 V	–1.0445 V to –1.0355 V
200 mV	–5	+10 V	+11.6 V	+11.5085 V to +11.6915 V
	+5	–10 V	–11.6 V	–11.6915 V to –11.5085 V
1 V	–5	+10 V	+18V	+17.6075 V to +18.3925 V
	+5	–10 V	–18 V	–18.3925 V to –17.6075 V

d. *Display the test signal:*

- Press **VERTICAL MENU**. Press the main-menu button **Position**.
- Use the keypad to set vertical position to –5 divisions (press **–5**, then **ENTER**, on the keypad). The baseline level will move off screen.
- Press the main-menu button **Offset**.

- Use the keypad to set vertical offset to the positive-polarity setting listed in the table for the current vertical scale setting. The baseline level will remain off screen.
- Set the generator to the level and polarity indicated in the table for the vertical scale, position, and offset settings you have made. The DC test level should appear on screen. (If it doesn't return, the DC accuracy check is failed for the current vertical scale setting of the current channel.)

e. *Measure the test signal:* Press **CLEAR MENU**. Read the measurement results at the **Mean** measurement readout. See Figure 1–6.

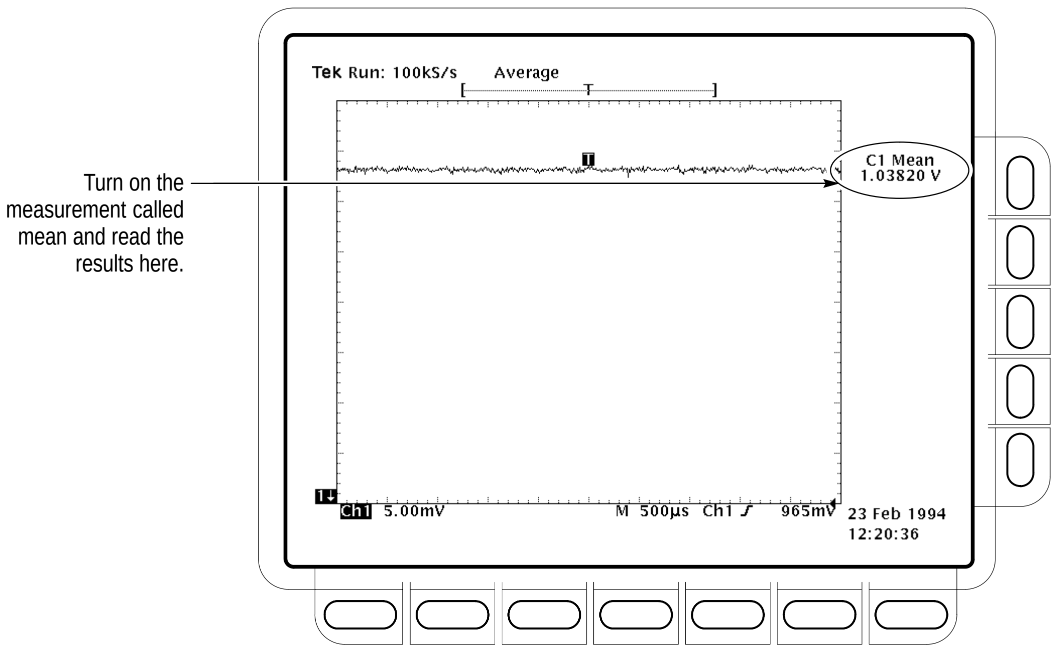


Figure 1–6: Measurement of DC Accuracy at Maximum Offset and Position

f. *Check against limits:*

- CHECK that the readout for the measurement **Mean** readout on screen is within the limits listed for the current vertical scale and position/offset/generator settings. Enter value on test record.
- Repeat substep d, reversing the polarity of the position, offset, and generator settings as is listed in the table.
- CHECK that the **Mean** measurement readout on screen is within the limits listed for the current vertical scale setting and position/offset/generator settings. Enter the value on test record.

- Repeat substeps c through f until all vertical scale settings, listed in Table 1–3, are checked for the channel under test.

g. *Test all channels:* Repeat substeps a through f for all four channels.

3. *Disconnect the hookup:*

a. *Set the generator output to 0 V.*

b. Disconnect the cable from the generator output at the input connector of the channel last tested.

Check Analog Bandwidth

Equipment Required	One sine wave generator (Item 19) One level meter and power sensor (Item 20) One power splitter (Item 21) One female N to male BNC adapter (Item 24) Four male N to female BNC adapters (Item 23) Two 50 Ω precision cables (Item 5) Two 10X attenuators (Item 1). Optional: One high-frequency leveled sine wave generator and its leveling head (Item 26) – replaces items 19, 20, 21, 23, 24, and 5
Prerequisites	See page 1–15.

1. *Install the test hookup and preset the instrument controls:*

a. *Initialize the oscilloscope:*

- Press save/recall **SETUP**. Press the main-menu button **Recall Factory Setup**; then press the side-menu button **OK Confirm Factory Init**.

b. *Modify the default settings:*

- Press **TRIGGER MENU**.
- Press the main-menu button **Coupling**. Then press the side menu button **Noise Rej**.
- Turn the horizontal **SCALE** knob to 50 ns. Press **SHIFT**; then press **ACQUIRE MENU**.
- Press the main-menu button **Mode**; then press the side-menu button **Average 16**.
- Press **MEASURE**. Press the main-menu button **High–Low Setup**; then press the side-menu button **Min–Max**.

NOTE. *Refer to the* Sine Wave Generator Leveling Procedure *on page 1–78 if your sine wave generator does not have automatic output amplitude leveling.*

c. *Hook up the test-signal source:* Connect the sine wave output of a leveled sine wave generator to **CH 1**. Set the output of the generator to a reference frequency of 10 MHz or less. See Figure 1–7.

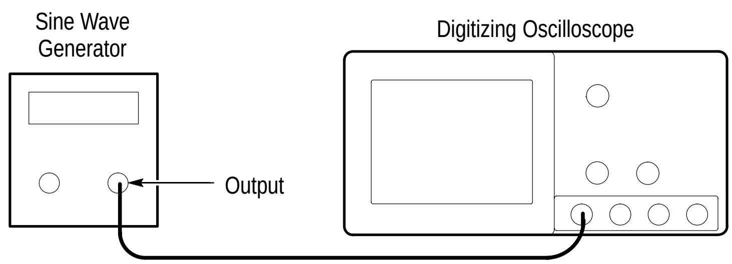


Figure 1–7: Initial Test Hookup

2. *Confirm the input channels are within limits for analog bandwidth:* Do the following substeps — test CH 1 first, *skipping substeps* a *and b since CH 1 is already set up for testing from step 1.*

a. *Select an unchecked channel:*

- Press **WAVEFORM OFF** to remove the channel just confirmed from display.
- Press the front-panel button that corresponds to the channel you are to confirm.
- Move the leveling output of the sine wave generator to the channel you selected.

b. *Match the trigger source to the channel selected:*

- Press **TRIGGER MENU**. Press the main-menu button **Source**; then press the side-menu button that corresponds to the channel selected.

c. *Set its input impedance:*

- Press **VERTICAL MENU**; then press the main-menu button **Coupling**.
- Press the side-menu **Ω** button to toggle it to the **50 Ω** setting.

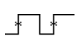
d. *Set the vertical scale:* Set the vertical **SCALE** to one of the settings listed in Table 1–4 not yet checked. (Start with the 100 mV setting.)

Table 1–4: Analog Bandwidth

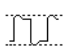
Vertical Scale	Reference Amplitude	Horizontal Scale	Test Frequency	Limits
100 mV	600 mV (6 divisions)	1 ns	500 MHz	≥424 mV
1 V	5 V (5 divisions)	1 ns	500 MHz	≥3.535 V
500 mV	3 V (6 divisions)	1 ns	500 MHz	≥2.121 V
200 mV	1.2 V (6 divisions)	1 ns	500 MHz	≥848 mV
50 mV	300 mV (6 divisions)	1 ns	500 MHz	≥212 mV
20 mV	120 mV (6 divisions)	1 ns	500 MHz	≥84.8 mV
10 mV	60 mV (6 divisions)	1 ns	500 MHz	≥42.4 mV
5 mV	30 mV (6 divisions)	1 ns	500 MHz	≥21.2 mV
2 mV	12 mV (6 divisions)	1 ns	350 MHz	≥8.48 mV
1 mV	6 mV (6 divisions)	1 ns	250 MHz	≥4.24 mV

e. *Display the test signal:* Do the following subparts to first display the reference signal and then the test signal.

- Press **MEASURE**; then press the main-menu button **Select Measrmnt for *CHx***.



- Press the side-menu button **more**, if needed, until the menu label **Frequency** appears in the side menu (its icon is shown at the left). Press the side-menu button **Frequency**.



- Press the side-menu button **more** until the menu label **Pk-Pk** appears in the side menu (its icon is shown at the left). Press the side-menu button **Pk-Pk**.
- Press **CLEAR MENU**.
- Set the generator output so the CHx Pk-Pk readout equals the reference amplitude in Table 1–4 that corresponds to the vertical scale set in substep d.
- Press the front-panel button **SET LEVEL TO 50%** as necessary to trigger a stable display. At full bandwidth, you may also want to make small, manual adjustments to the trigger level. You can use the **TRIGGER LEVEL** knob to do this.

f. *Measure the test signal:*

- Set the frequency of the generator, as shown on screen, to the test frequency in Table 1–4 that corresponds to the vertical scale set in substep d. See Figure 1–8.

- Set the horizontal **SCALE** to the horizontal scale setting in Table 1–4 that corresponds to the vertical scale set in substep d. Press **SET LEVEL TO 50%** as necessary to trigger the signal.
- Read the results at the CHx Pk-Pk readout, which will automatically measure the amplitude of the test signal. See Figure 1–8.

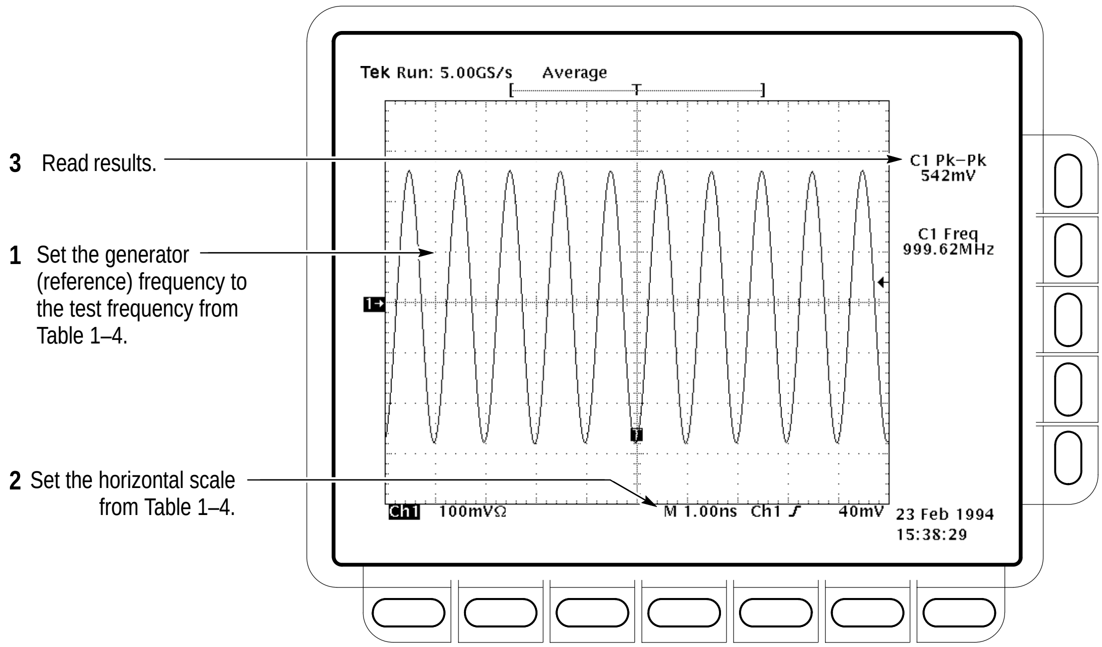


Figure 1–8: Measurement of Analog Bandwidth

g. *Check against limits:*

- CHECK that the **Pk-Pk** readout on screen is within the limits listed in Table 1–4 for the current vertical scale setting.
- Enter the voltage on the test record.
- When finished checking, set the horizontal **SCALE** back to the 50 ns setting.

STOP*. Checking the bandwidth at all vertical scale settings is time consuming and unnecessary. You may skip checking the remaining vertical scale settings in Table 1–4 (that is, skip the following substep, h) if this oscilloscope has passed the 100 mV vertical scale setting just checked in this procedure and the* Verify Internal Adjustment, Self Compensation, and Diagnostics *procedure found under* Self Tests, *on page 1–5.*

NOTE. Passing the signal path compensation confirms the signal path for all vertical scale settings for all channels. Passing the internal diagnostics ensures that the factory-set adjustment constants that control the bandwidth for each vertical scale setting have not changed.

h. *Check remaining vertical scale settings against limits (optional):*

- If desired, finish checking the remaining vertical scale settings for the channel under test by repeating substeps d through g for each of the remaining scale settings listed in Table 1–4 for the channel under test.
- When doing substep e, skip the subparts that turn on the CHx Pk-Pk measurement until you check a new channel.
- Install/remove 10X attenuators between the generator leveling head and the channel input as needed to obtain the six division reference signals listed in the table.

i. *Test all channels:* Repeat substeps a through g for all four channels.

3. *Disconnect the hookup:* Disconnect the test hook up from the input connector of the channel last tested.

Check Delay Between Channels

Equipment Required	One sine wave generator (Item 19, or optionally, item 25) One precision coaxial cable (Item 5) One 50 Ω terminator (Item 4) One dual-input coupler (Item 8)
Prerequisites	See page 1–15.

STOP. DO NOT use the vertical position knob to reposition any channel while doing this check. To do so invalidates the test.

1. *Install the test hookup and preset the instrument controls:*

a. *Initialize the front panel:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

b. *Modify the initialized front-panel control settings:*

- Do *not* adjust the vertical position of any channel during this procedure.
- Set the horizontal **SCALE** to 500 ps.
- Press **SHIFT**; then press **ACQUIRE MENU**.
- Press the main-menu button **Mode**, and then press the side-menu button **Average 16**.

c. *Hook up the test-signal source:*

- Connect the sine wave output of a sine wave generator (item 19 or, optionally, 25) to a 50 Ω precision coaxial cable followed by a 50 Ω termination, and a dual-input coupler. See Figure 1–9.
- Connect the coupler to both **CH 1** and **CH 2**. See Figure 1–9.

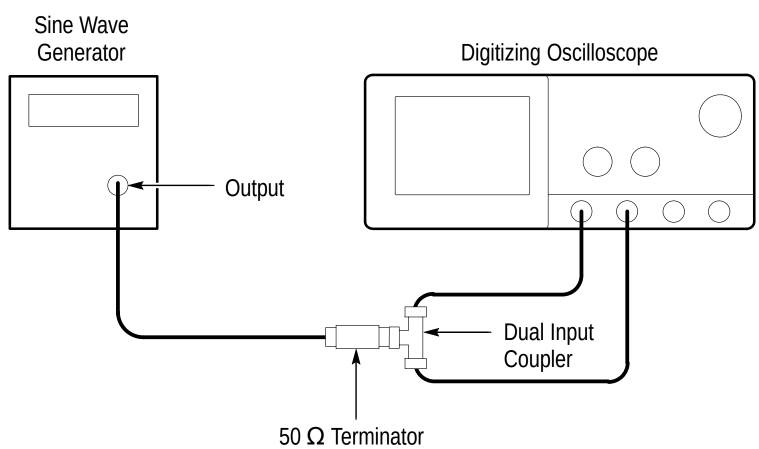


Figure 1–9: Initial Test Hookup

2. *Confirm all four channels are within limits for channel delay:*

a. *Set up the generator:* Set the generator frequency to 250 MHz and the amplitude for about six divisions in CH 1.

Hint: As you are adjusting the generator amplitude, push **SET LEVEL TO 50%** frequently to speed up the updating of the waveform amplitude on screen.

b. The horizontal **SCALE** should already be set to 500 ps. Push the front-panel **ZOOM** button, press the side-menu **On** button, set the horizontal **SCALE** to 250 ps, and be sure the vertical scale factor is kept at 1.0X and the horizontal scale factor is 2.0X.

c. *Save a CH 2 waveform:* Press **CH 2**. Be sure the vertical scale factor is kept at 1.0X. Then press save/recall **WAVEFORM**. Now, press the main-menu button **Save Wfm**; then press the side-menu button **To Ref 2**.

d. *Save CH 3 waveform:*

- Move the coupler from **CH 2** to **CH 3**, so that **CH 1** and **CH 3** are driven. Press **WAVEFORM OFF**. Press **CH 3**. Be sure the vertical scale factor is kept at 1.0X. Then press the side-menu button **To Ref 3**.

e. *Display all test signals:*

- Press **WAVEFORM OFF** to remove CH 3 from the display.
- Display the live waveform. Move the coupler from **CH 3** to **CH 4**, so that CH 1 and CH 4 are driven. Press **CH 4** to display. Be sure the vertical scale factor is kept at 1.0X. See Figure 1–10 on page 1–36.
- Display the reference waveforms. To do this, press the front-panel button **MORE**. Press the main-menu buttons **Ref 2** and **Ref 3**. You may notice their overlapping ground reference indicators. See Figure 1–10 on page 1–36.

f. *Measure the test signal:*

- Locate the time reference points for these waveforms. Do this by first identifying the point where the rising edge of the left-most waveform crosses the center horizontal graticule line. Next, note the corresponding *time reference point* for the right-most waveform. See Figure 1–10 on page 1–36.
- Press **CURSOR**.
- Press the main-menu button **Function**; then press the side-menu button **V Bars**.
- Press **CLEAR MENU**.
- Align one V bar cursor to the *time reference point* of the left-most waveform edge and the other cursor to the *time reference point* of the right-most waveform edge by rotating the General Purpose knob. (Press **SELECT** to switch between the two cursors.) See Figure 1–10 on page 1–36.

- Read the measurement results at the **Δ:** cursor readout, not the **@:** readout on screen.

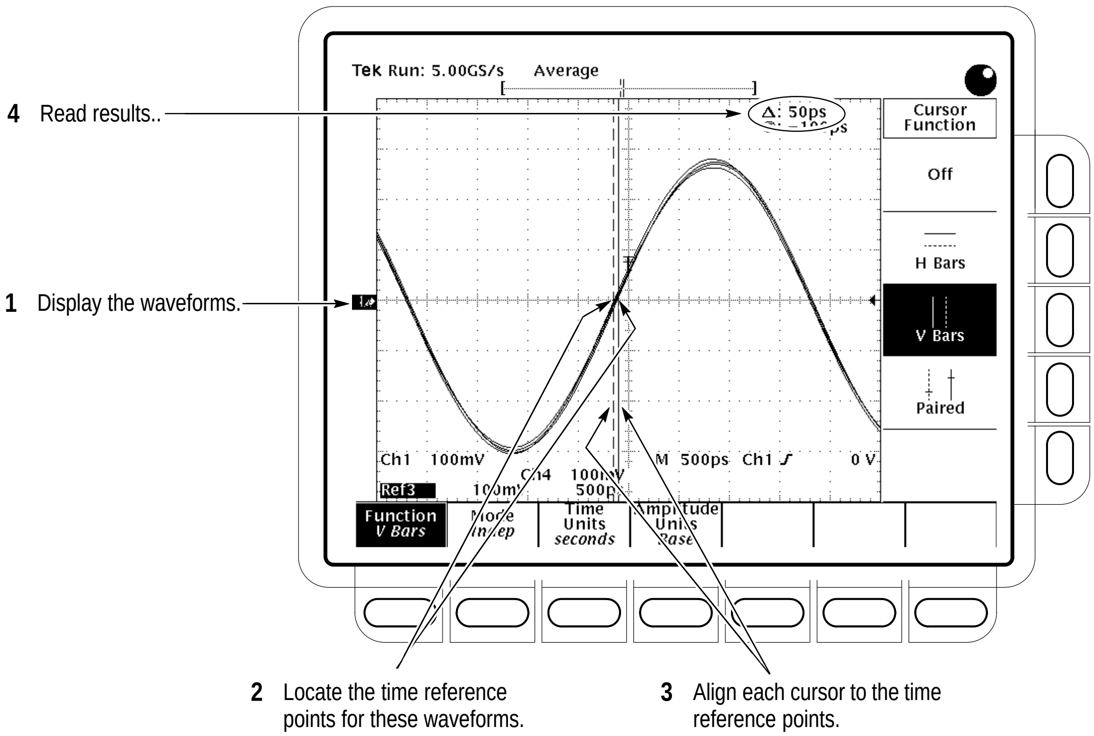


Figure 1–10: Measurement of Channel Delay

g. *Check against limits:* CHECK that the cursor readout on screen is ≤250 ps.

h. If the channel skew is within the limits, enter the time on the test record and proceed to step 3. Otherwise, proceed with steps i through p.

i. Use the cursors to measure the skew from CH1 to CH2, CH1 to CH3, and CH1 to CH4. Write down these three numbers in the first measurement column of Table 1–5. Note that these numbers may be either positive or negative.

j. Repeat the procedure from step 1.c through 2.e.

k. Again use the cursors to measure the skew from CH1 to CH2, CH1 to CH3, and CH1 to CH4. Write down these numbers in the second measurement column of Table 1–5. Note that these numbers may be either positive or negative.

l. Add the first CH1 to CH2 skew measurement to the second CH1 to CH2 skew measurement and divide the result by 2. Use Table 1–5.

m. Add the first CH1 to CH3 skew measurement to the second CH1 to CH3 skew measurement and divide the result by 2. Use Table 1–5.

n. Add the first CH1 to CH4 skew measurement to the second CH1 to CH4 skew measurement and divide the result by 2. Use Table 1–5.

o. Check against limits: CHECK that the largest of the three results from steps l, m, and n is between –250 ps and + 250 ps.

p. Enter the time on the test record.

Table 1–5: Delay Between Channels Worksheet

Coupling	First Measurement	Second Measurement	Add First and Second Measurements	Divide Sum by 2
CH1 to CH2 skew				
CH1 to CH3 skew				
CH1 to CH4 skew				

3. *Disconnect the hookup:* Disconnect the cable from the generator output at the input connectors of the channels.

Time Base System Checks

These procedures check those characteristics that relate to the Main and Delayed time base system and are listed as checked under *Warranted Characteristics* in *Specifications.*

Check Accuracy for Long-Term Sample Rate and Delay Time Measurements

Equipment Required	One time-mark generator (Item 11) One 50 Ω, precision coaxial cable (Item 5)
Prerequisites	See page 1–15.

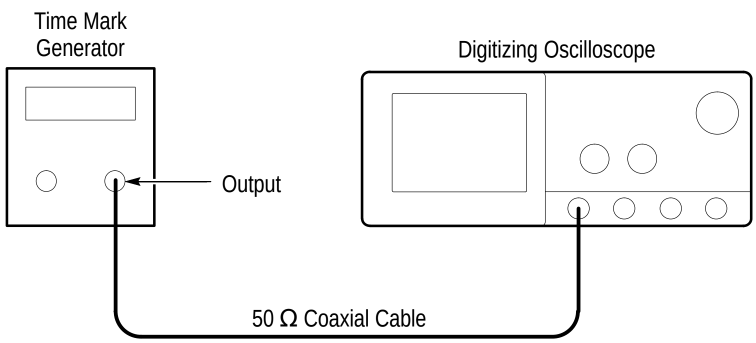


Figure 1–11: Initial Test Hookup

1. *Install the test hookup and preset the instrument controls:*

a. *Hook up the test-signal source*: Connect, through a 50 Ω precision coaxial cable, the time-mark output of a time-mark generator to **CH 1**. Set the output of the generator for 10 ms markers. See Figure 1–11.

b. *Initialize the oscilloscope:*

- Press save/recall **SETUP**. Press the main-menu button **Recall Factory Setup**. Press the side-menu button **OK Confirm Factory Init**.

c. *Modify the initialized front-panel control settings:*

- Set the vertical **SCALE** to 200 mV (or 500 mV with the optional Tektronix TG 501A Time Mark Generator)
- Press **VERTICAL MENU**; then press the main-menu button **Coupling**. Press the side-menu button **Ω** to toggle it to the **50 Ω** setting.
- Press **SET LEVEL TO 50%**.

- Use the vertical **POSITION** knob to center the test signal on screen.
- Set the horizontal **SCALE** of the Main time base to 1 ms.
- Press **TRIGGER MENU**; then press the main-menu button **Mode & Holdoff**. Press the side-menu button **Normal**.

2. *Confirm Main and Delayed time bases are within limits for accuracies:*

a. *Display the test signal:*

- Align the trigger **T** to the center vertical graticule line by adjusting the horizontal **POSITION**. See Figure 1–12 on page 1–40.
- Press **HORIZONTAL MENU**.
- Set horizontal modes. To do this, press the main-menu button **Time Base**. Press the side-menu buttons **Delayed Only** and **Delayed Runs After Main**. See Figure 1–12.

b. *Measure the test signal*:

- Set the horizontal **SCALE** of the **D** (delayed) time base to 100 ns.
- Set delayed time to 10 ms. Do this on the keypad by pressing **10**, then **SHIFT**, then **m** followed by **ENTER**.)

c. *Check long-term sample rate and delay time accuracies against limits:*

- CHECK that the rising edge of the marker crosses the center horizontal graticule line at a point within ±2.5 divisions of the center graticule. See Figure 1–12.
- Enter number of divisions on the test record.

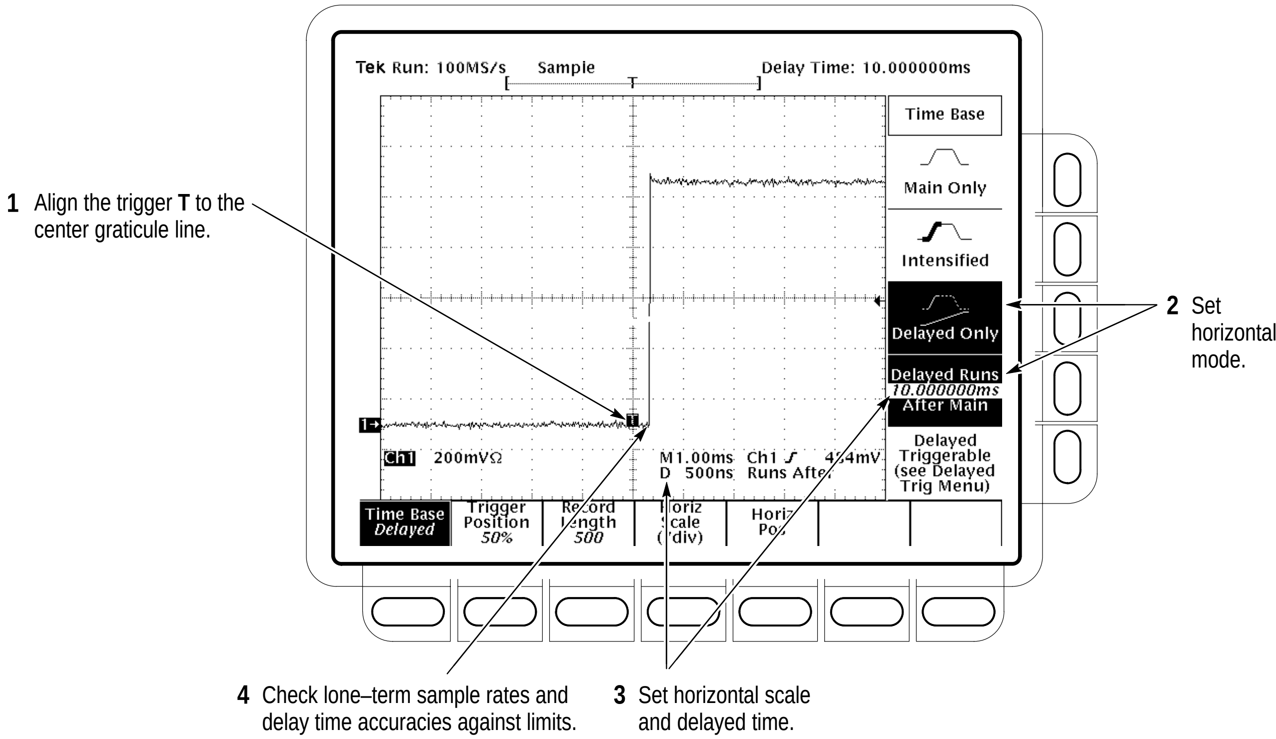


Figure 1–12: Measurement of Accuracy — Long-Term and Delay Time

3. *Disconnect the hookup:* Disconnect the cable from the generator output at the input connector of **CH 1**.

Trigger System Checks

These procedures check those characteristics that relate to the Main and Delayed trigger systems and are listed as checked in *Specifications.*

Check Accuracy (Time) for Pulse-Glitch or Pulse-Width Triggering

Equipment Required	One medium-frequency sine wave generator (Item 19 or, optionally, Item 25) One 10X attenuator (Item 1) One 50 Ω, precision coaxial cable (Item 5)
Prerequisites	See page 1–15.

1. *Install the test hookup and preset the instrument controls:*

a. *Initialize the instrument:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

b. *Modify the default setup:*

- Press **VERTICAL MENU**.
- Press the main-menu button **Coupling**; then press the side-menu **Ω** button to select **50 Ω** coupling.
- Set the horizontal **SCALE** to 10 ns.

c. *Hook up the test-signal source:* Connect the output of a medium-frequency leveled sine wave generator (Item 25) to CH 1. Do this through a 50 Ω precision coaxial cable, followed by a 10X attenuator. See Figure 1–13.

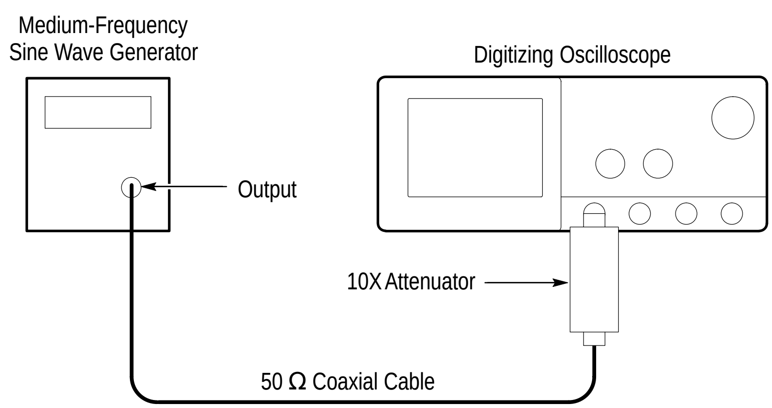


Figure 1–13: Initial Test Hookup

2. *Confirm the trigger system is within time-accuracy limits for pulse-glitch or pulse-width triggering (Horizontal Scale ≤1 μs):*

a. *Display the test signal:* Set the output of the sine wave generator for a 100 MHz, five-division sine wave on screen. Press **SET LEVEL TO 50%**.

b. *Set the trigger mode:* Press **TRIGGER MENU**. Now press the main-menu button **Mode & Holdoff**; then press the side-menu button **Normal**.

c. *Set upper and lower limits that ensure triggering:* See Figure 1–14.

- Press the main-menu button **Type**; then repeatedly press the same button until **Pulse** is highlighted in the menu that pops up.
- Press the main-menu button **Class**; then repeatedly press the same button until **Width** is highlighted in the menu that pops up.
- Press the main-menu button **Trig When**; then press the side-menu button **Within Limits.**
- Press the side-menu button **Upper Limit**. Use the keyboard to set the upper limit to 10 ns: press **10**, then **SHIFT**, then **n**, and **ENTER**.
- Press the side-menu button **Lower Limit**. Use the keypad to set the lower limit to 2 ns.

d. *Change limits until triggering stops:*

- Press **SET LEVEL TO 50%**.
- While doing the following subparts, monitor the display (it will stop acquiring) and the front-panel light **TRIG** (it will extinguish) to determine when triggering is lost.
- Press the side-menu button **Lower Limit**.
- Use the general purpose knob to *increase* the **Lower Limit** readout until triggering is lost.
- CHECK that the **Lower Limit** readout, after the oscilloscope loses triggering, is within 2.5 ns to 7.5 ns, inclusive.
- Enter the time on test record.
- Use the keypad to return the **Lower Limit** to 2 ns and reestablish triggering.
- Press the side-menu button **Upper Limit**; then use the general purpose knob to slowly *decrease* the **Upper Limit** readout until triggering is lost.
- CHECK that the **Upper Limit** readout, after the oscilloscope loses triggering, is within 2.5 ns to 7.5 ns, inclusive.
- Enter the time on test record.

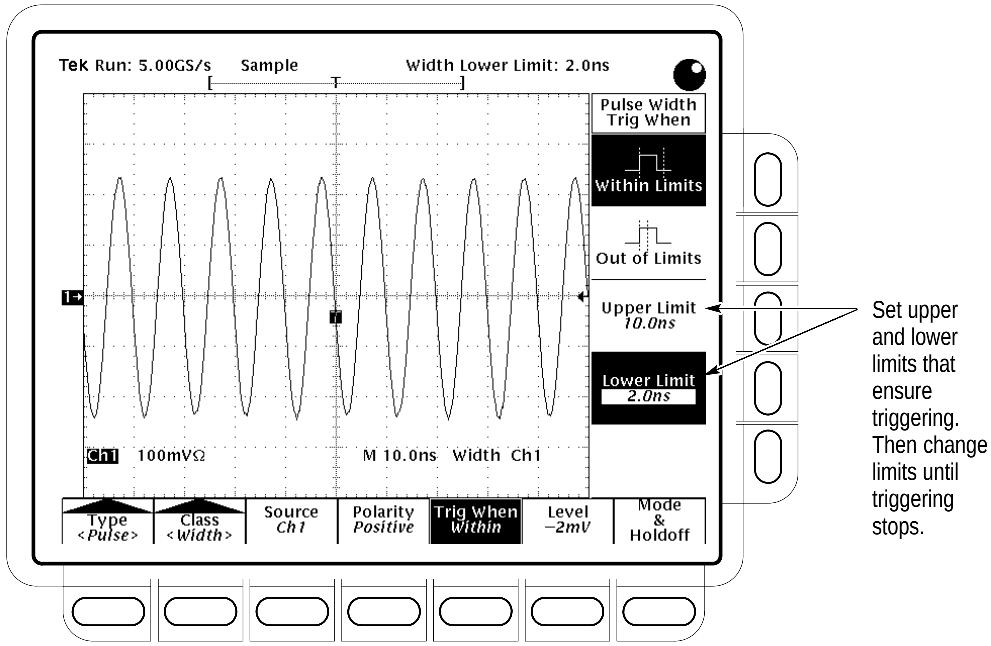


Figure 1–14: Measurement of Time Accuracy for Pulse and Glitch Triggering

3. *Confirm the trigger system is within time-accuracy limits for pulse-glitch or pulse-width triggering (horizontal scale >1 μs):*

a. *Set upper and lower limits that ensure triggering at 250 kHz:*

- Press the side-menu button **Upper Limit**. Use the keyboard to set the upper limit to 4 μs.
- Press the side-menu button **Lower Limit**. Use the keypad to set the lower limit to 500 ns.

b. *Display the test signal:*

- Set the horizontal **SCALE** to 5 μs.
- Set the output of the sine wave generator for a 250 kHz, five-division sine wave on screen. Set the vertical **SCALE** to 20 mV (the waveform will overdrive the display).
- Press **SET LEVEL TO 50%**.

c. *Check against limits:* Do the following subparts in the order listed.

- Press the side-menu button **Lower Limit**.
- Use the general purpose knob to *increase* **Lower Limit** readout until triggering is lost.

- CHECK that the **Lower Limit** readout, after the oscilloscope stops triggering, is within 1 μs to 3 μs, inclusive.
- Enter time on test record.
- Use the keypad to return the **Lower Limit** to 500 ns and reestablish triggering.
- Press the side-menu button **Upper Limit**; then use the general purpose knob to slowly *decrease* the **Upper Limit** readout until triggering stops.
- CHECK that the **Upper Limit** readout, after the oscilloscope loses triggering, is within 1 μs to 3 μs, inclusive.
- Enter the time on test record.

4. *Disconnect the hookup:* Disconnect the cable from the generator output at the input connector of **CH 1**.

Check Accuracy, Trigger-Level or Threshold, DC Coupled

Equipment Required	One DC calibration generator (Item 9) One BNC T connector (Item 7) Two 50 Ω, precision coaxial cables (Item 5)
Prerequisites	See page 1–15.

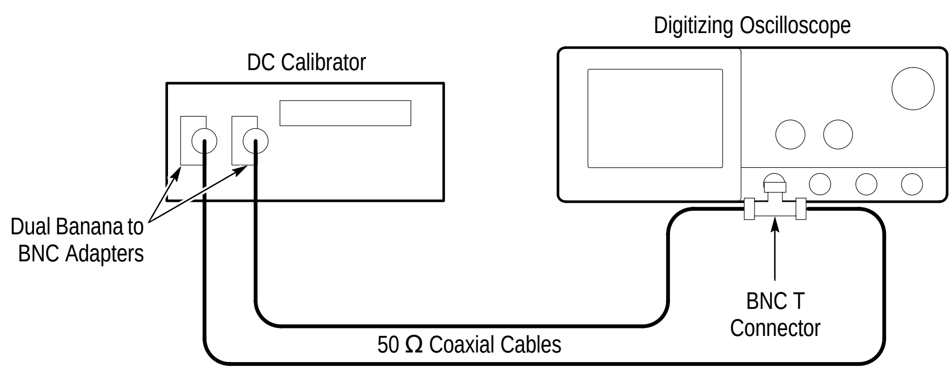


Figure 1–15: Initial Test Hookup

1. *Install the test hookup and preset the instrument controls:*

a. *Hook up the test-signal source:*

- Set the output of the DC calibration generator to 0 volts.

- Connect the output of the DC calibration generator, through a dual-banana connector followed by a 50 Ω precision coaxial cable, to one side of a BNC T connector. See Figure 1–15.
- Connect the Sense output of the generator, through a second dual-banana connector followed by a 50 Ω precision coaxial cable, to other side of the BNC T connector. Now connect the BNC T connector to **CH 1**. See Figure 1–15.

b. *Initialize the oscilloscope:*

- Press save/recall **Setup**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

2. *Confirm Main trigger system is within limits for Trigger-level/Threshold accuracy:*

a. *Display the test signal:*

- Set the vertical **SCALE** to 200 mV.
- Press **VERTICAL MENU**, then press the main-menu button **Position**.
- Set vertical position to –3 divisions (press **–3**, then **ENTER**, on the keypad.) The baseline level will move down three divisions. See Figure 1–16 on page 1–46.
- Press the main-menu button **Offset**.
- Set vertical offset to +10 volts with the keypad. The baseline level will move off screen.
- Set the standard output of the DC calibration generator equal to the offset (+10 volts). The DC test level will appear on screen. See Figure 1–16.

b. *Measure the test signal:*

- Press **SET LEVEL TO 50%**.
- Press **TRIGGER MENU**.
- Read the measurement results from the readout below the label **Level** in the main menu, not the trigger readout in the graticule area.

c. *Read results (Check against limits):* See Figure 1–16.

- CHECK that the **Level** readout in the main menu is within 9.940 V to 10.060 V, inclusive.

- Enter the voltage on test record.

- Press the main-menu button **Slope**; then press the side-menu button for negative slope. See icon at left. Repeat substep b.
- CHECK that the **Level** readout in the main menu is within 9.940 V to 10.060 V, inclusive.
- Enter the voltage on the test record.

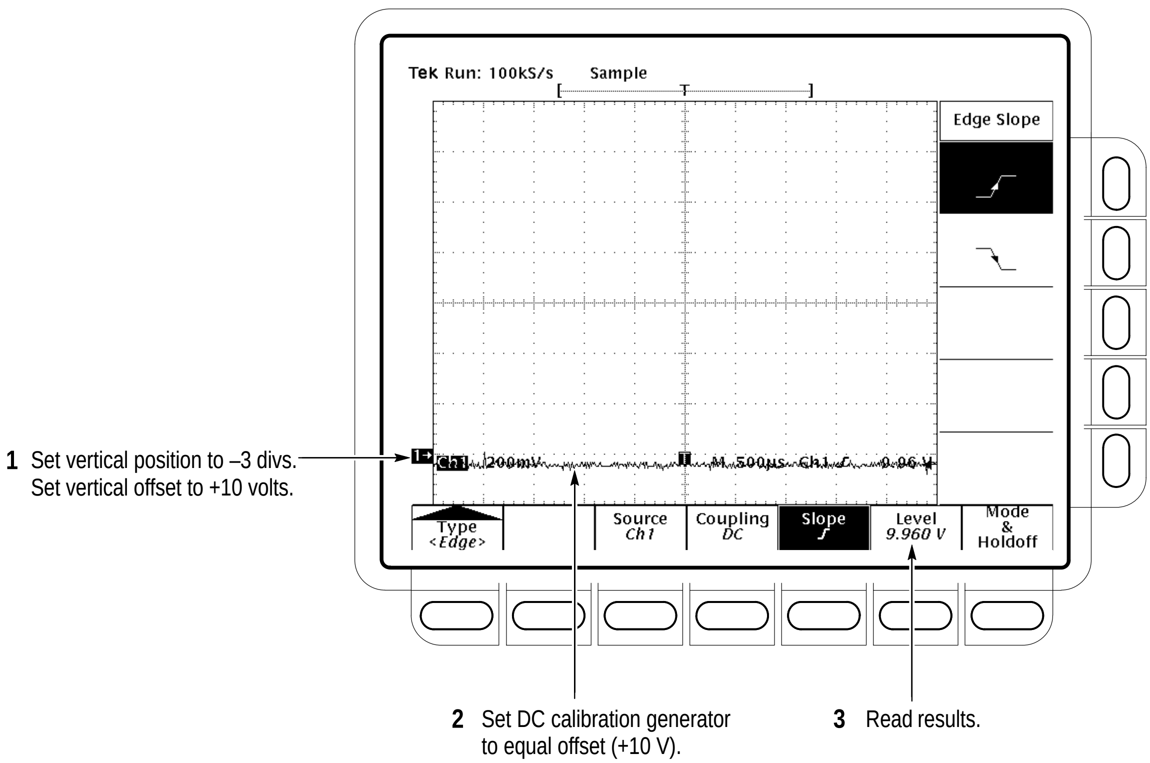


Figure 1–16: Measurement of Trigger-Level Accuracy

3. *Confirm Delayed trigger system is within limits for Trigger-level/Threshold accuracy:*

   a. *Select the Delayed time base:*

   - Press **HORIZONTAL MENU**.
   - Press the main-menu button **Time Base**.
   - Press the side-menu buttons **Delayed Only** and **Delayed Trigger-able**.
   - Set **D** (delayed) horizontal **SCALE** to 500 μs.

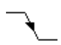
b. *Select the Delayed trigger system:*

- Press **SHIFT**; then press the front-panel **DELAYED TRIG** button.
- Press the main-menu button **Level**.

c. *Measure the test signal:* Press the side-menu button **SET TO 50%**. Read the measurement results in the side (or main) menu below the label **Level**.

d. *Check against limits:* Do the following subparts in the order listed.

- CHECK that the **Level** readout in the side menu is within 9.940 V to 10.060 V, inclusive.
- Enter the voltage on the test record.



- Press the main-menu button **Slope**; then press the side-menu button for negative slope. See icon at left. Press the main-menu button **Level**. Repeat substep c.
- CHECK that the **Level** readout in the side menu is within 9.940 V to 10.060 V, inclusive.
- Enter the voltage on the test record.

4. *Disconnect the hookup:*

a. *First set the output of the DC calibration generator to 0 volts.*

b. Disconnect the cable from the generator output at the input connector of **CH 1**.

Sensitivity, Edge Trigger, DC Coupled

Equipment Required	One sine wave generator (Item 19 or, optionally, items 25 and 26) Two precision 50 Ω coaxial cables (Item 5) One 10X attenuator (Item 1) One BNC T connector (Item 7) One 5X attenuator (Item 2)
Prerequisites	See page 1–15.

1. *Install the test hookup and preset the instrument controls:*

a. *Initialize the oscilloscope:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.

- Press the side-menu button **OK Confirm Factory Init**.

b. *Modify the initialized front-panel control settings:*

- Set the horizontal **SCALE** for the **M** (main) time base to 20 ns.
- Press **HORIZONTAL MENU**; then press the main-menu button **Time Base**.
- Press the side-menu button **Delayed Only**; then press the side-menu button **Delayed Triggerable**.
- Set the horizontal **SCALE** for the **D** (delayed) time base to 20 ns; then press the side-menu button **Main Only**.
- Press **TRIGGER MENU**; then press the main-menu button **Mode & Holdoff**. Press the side-menu button **Normal**.
- Press **VERTICAL MENU**; then press the main-menu button **Coupling**. Press the side-menu button **Ω** to select the 50 Ω setting.
- Press **SHIFT**; then press **ACQUIRE MENU**. Press the main-menu button **Mode**; then press the side-menu button **Average 16**.

c. *Hook up the test-signal source:*

- Connect the signal output of a medium-frequency sine wave generator (item 19 or, optionally, item 25) to a BNC T connector. Connect one output of the T connector to **CH 1** through a 50 Ω precision coaxial cable. Connect the other output of the T connector to the **AUX TRIG INPUT** at the rear panel. See Figure 1–17.

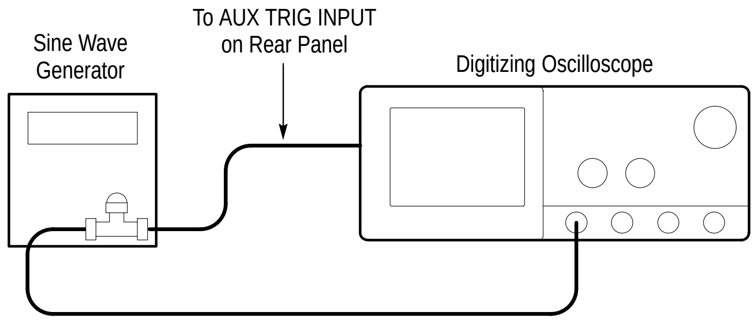
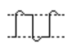


Figure 1–17: Initial Test Hookup

2. *Confirm Main and Delayed trigger systems are within sensitivity limits (50 MHz):*

   a. *Display the test signal:*

      - Set the generator frequency to 50 MHz.
      - Press **MEASURE**.
      - Press the main-menu button **High-Low Setup**; then press the side-menu button **Min-Max**.
      - Press the main-menu button **Select Measrmnt for *Ch1***.



      - Press the side-menu button **–more–** until **Amplitude** appears in the side menu (its icon is shown at the left). Press the side-menu button **Amplitude**.
      - Press **SET LEVEL TO 50%**.
      - Press **CLEAR MENU**.
      - Set the test signal amplitude for about three and a half divisions on screen. Now fine adjust the generator output until the **CH 1 Amplitude** readout indicates the amplitude is 350 mV. Readout may fluctuate around 350 mV.
      - Disconnect the 50 Ω precision coaxial cable at **CH 1** and reconnect it to **CH 1** through a 10X attenuator.

   b. *Check the Main trigger system for stable triggering at limits:*

      - Read the following definition: A stable trigger is one that is consistent; that is, one that results in a uniform, regular display triggered on the selected slope (positive or negative). This display should *not* have its trigger point switching between opposite slopes, nor should it roll across the screen. At horizontal scale settings of 2 ms/division and faster, **TRIG'D** will remain constantly lighted. It will flash for slower settings.
      - Press **TRIGGER MENU**; then press the main-menu button **Slope**.
      - Press **SET LEVEL TO 50%**. Adjust the **TRIGGER LEVEL** knob so that the **TRIG'D** light is on. Set the level to near the middle of the range where the **TRIG'D** light is on. CHECK that the trigger is stable for the test waveform on both the positive and negative slopes. Use the side menu to switch between trigger slopes.
      - Enter the pass/fail result for the main trigger on the test record.
      - Leave the Main trigger system triggered on the positive slope of the waveform before continuing to the next step.

c. *Check Delayed trigger system for stable triggering at limits:* Do the following subparts in the order listed.

- Press **HORIZONTAL MENU**; then press the main-menu button **Time Base**. Press the side-menu button **Delayed Only**; then press **Delayed Triggerable** in the same menu.
- Press **SHIFT**; then press **DELAYED TRIG**. Press the main-menu button **Level**.
- Press the side-menu button **SET TO 50%**.

  CHECK that a stable trigger is obtained for the test waveform for both the positive and negative slopes of the waveform. Use the **TRIGGER LEVEL** knob to stabilize the Main trigger. Use the general purpose knob to stabilize the Delayed trigger. Press the main-menu button **Slope**; then use the side menu to switch between trigger slopes. See Figure 1–18.

- Enter the pass/fail result for the delayed trigger on the test record.
- Leave the Delayed trigger system triggered on the positive slope of the waveform before continuing to the next step. Also, return to the main time base: Press **HORIZONTAL MENU**; then press the main-menu button **Time Base**. Press the side-menu button **Main Only**.
- Press **CLEAR MENU**.

3. *Confirm the AUX Trigger input:*

a. *Display the test signal:*

- Remove the 10X attenuator and reconnect the cable to **CH 1**.
- Set the test signal amplitude for about 2.5 divisions on screen.
- Now fine adjust the generator output until the **CH 1 Amplitude** readout indicates the amplitude is 250 mV. (Readout may fluctuate around 250 mV.)

b. *Check the AUX trigger source for stable triggering at limits:* Do the following in the order listed.

- Use the definition for stable trigger from step 2.
- Press **TRIGGER MENU**; then press the main-menu button **Source**.
- Press the side-menu button **–more–** until the side-menu label **DC Aux** appears; then press **DC Aux**.

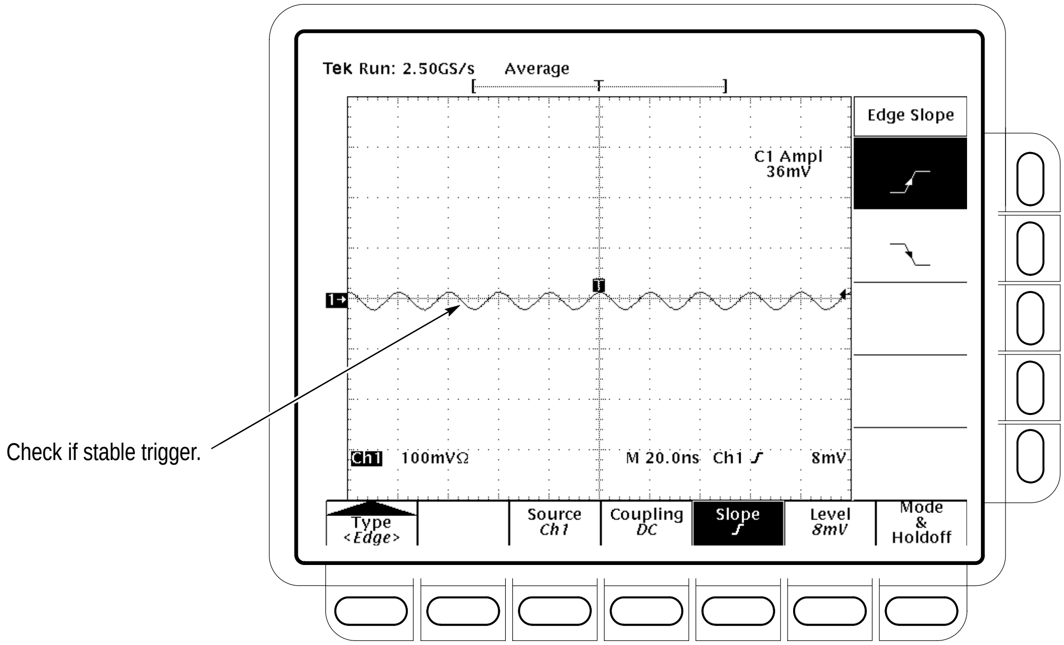


Figure 1–18: Measurement of Trigger Sensitivity — 50 MHz Results

- Press **SET LEVEL TO 50%**. CHECK that a stable trigger is obtained for the test waveform on both the positive and negative slopes. Press the main-menu button **Slope**; then use the side menu to switch between trigger slopes. Use the **TRIGGER LEVEL** knob to stabilize the trigger if required.
- Enter the pass/fail result on the test record.
- Leave the Main trigger system triggered on the positive slope of the waveform before proceeding to the next check.
- Press the main-menu button **Source**; then press the side-menu button **–more–** until **CH 1** appears. Press **CH 1**.

4. *Confirm that the Main and Delayed trigger systems are within sensitivity limits (500 MHz):*

a. *Hook up the test-signal source:* Disconnect the hookup installed in step 1. Connect the signal output of a high-frequency sine wave generator (Item 19 or, optionally, Item 26) to **CH 1**.

b. *Set the Main and Delayed Horizontal Scales:*

- Set the horizontal **SCALE** to 500 ps for the **M** (Main) time base.

- Press **HORIZONTAL MENU**. Now press the main-menu button **Time base**; then press the side-menu button **Delayed Triggerable**.
- Press the side-menu button **Delayed Only**.
- Set the horizontal **SCALE** to 500 ps for the **D** (Delayed) time base. Press the side-menu button **Main Only**.

c. *Display the test signal:*

- Set the generator frequency to full bandwidth (500 MHz).
- Set the test signal amplitude for about five divisions on screen. Now fine adjust the generator output until the **CH 1 Amplitude** readout indicates the amplitude is 500 mV. (Readout may fluctuate around 500 mV.)
- Disconnect the leveling head at **CH 1** and reconnect it to **CH 1** through a 5X attenuator.

d. Repeat step 2, substeps b and c only, since only the full bandwidth (500 MHz) is to be checked here.

***NOTE**. You just checked the trigger sensitivity. If desired, you may repeat steps 1 through 4 for the other channels (CH2, CH3, and CH4).*

5. *Disconnect the hookup:* Disconnect the cable from the channel last tested.

Output Signal Checks

The procedure that follows checks those characteristics of the output signals that are listed as checked under *Warranted Characteristics* in *Specifications.* The oscilloscope outputs these signals at its front and rear panels.

Check Outputs — CH 3 Main and Delayed Trigger

Equipment Required	Two 50 Ω precision cables (Item 5) One calibration generator (Item 10)
Prerequisites	See page 1–15. Also, the oscilloscope must have passed *Check DC Voltage Measurement Accuracy* on page 1–25.

1. *Install the test hookup and preset the instrument controls:*

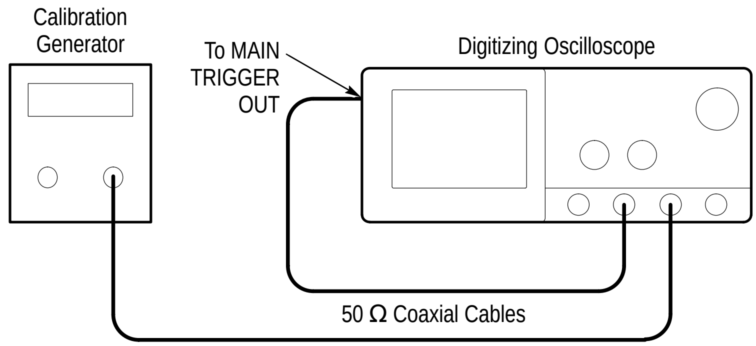


Figure 1–19: Initial Test Hookup

a. *Hook up test-signal source 1:*

- Connect the standard amplitude output of a calibration generator through a 50 Ω precision coaxial cable to **CH 3**. See Figure 1–19.
- Set the output of the calibration generator to 0.500 V.

b. *Hook up test-signal source 2:* Connect the **Main Trigger Out** at the rear panel to **CH 2** through a 50 Ω precision cable.

c. *Initialize the oscilloscope:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

d. *Modify the initialized front-panel control settings:*

- Set the horizontal **SCALE** to 200 μs.
- Press **SHIFT**; then press **ACQUIRE MENU**.
- Press the main-menu button **Mode**; then press the side-menu button **Average**.
- Select **64** averages. Do this with the keypad or the general purpose knob.

2. *Confirm Main and Delayed Trigger outputs are within limits for logic levels:*

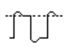
a. *Display the test signal:*

- Press **WAVEFORM OFF** to turn off CH 1.

- Press **CH 2** to display that channel.
- Set the vertical **SCALE** to 1 V.
- Press **TRIGGER MENU**.
- Press the main-menu button **Source**; then press the side-menu button **CH 3**. Press **SET LEVEL TO 50%**.
- Use the vertical **POSITION** knob to center the display on screen.

b. *Measure logic levels:*

- Press **MEASURE**; then press the main-menu button **Select Measurement for Ch2**.



- Select high and low measurements. To do this, repeatedly press the side-menu button **–more–** until **High** and **Low** appear in the side menu (their icons are shown at the left). Press both side-menu buttons **High** and **Low**.

c. *Check Main Trigger output against limits:*

- CHECK that the **Ch2 High** readout is ≥2.5 volts and that the **Ch2 Low** readout is ≤0.7 volts. See Figure 1–20.
- Enter the high and low voltages on the test record.
- Press **VERTICAL MENU**; then press the main-menu button **Coupling**. Now press the side-menu button **Ω** to toggle it to the 50 Ω setting.
- CHECK that the **Ch2 High** readout is ≥1.0 volt and that the **Ch2 Low** readout ≤0.25 volts.
- Enter the high and low voltages on the test record.

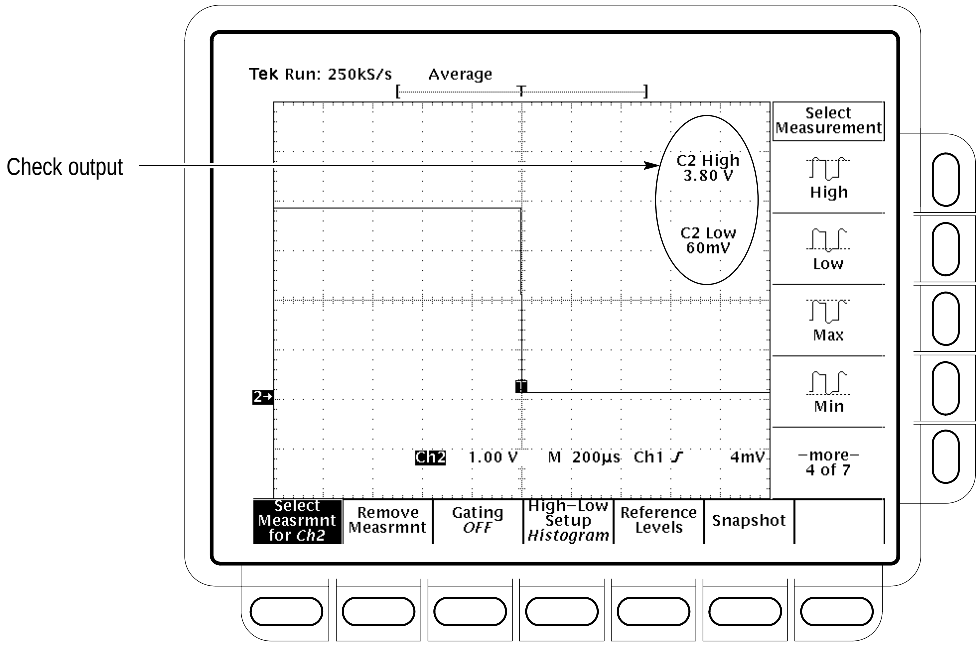


Figure 1–20: Measurement of Main Trigger Out Limits

d. *Check Delayed Trigger output against limits:* See Figure 1–20.

- Move the precision 50 Ω cable from the rear-panel **Main Trigger Output** BNC to the rear-panel **Delayed Trigger Output** BNC.
- CHECK that the **Ch2 High** readout is ≥1.0 volt and that the **Ch2 Low** readout ≤0.25 volts.
- Enter high and low voltages on test record.
- Press the side-menu button **Ω** to select the 1 MΩ setting.
- Press **CLEAR MENU**.
- CHECK that the **Ch2 High** readout is ≥2.5 volts and that the **Ch2 Low** readout is ≤0.7 volts.
- Enter high and low voltages on test record.

3. *Confirm CH 3 output is within limits for gain:*

a. *Measure gain:*

- Move the precision 50 Ω cable from the rear-panel **DELAYED TRIGGER OUTPUT** BNC to the rear-panel **SIGNAL OUT** BNC.
- Push **TRIGGER MENU**.

- Press the main-menu button **Source**.
- Press the side-menu button **Ch3**.
- Set vertical **SCALE** to 100 mV.
- Press **SET LEVEL TO 50%**.
- Press **MEASURE**; then press the main-menu button **Select Measrmnt for Ch2**.

- Repeatedly press the side-menu button **–more–** until **Pk-Pk** appears in the side menu (its icon is shown at the left). Press the side-menu button **Pk-Pk**.
- Press **CLEAR MENU**.

b. *Check against limits:*

- CHECK that the readout **Ch2 Pk-Pk** is between 90 mV and 110 mV, inclusive.
- Enter voltage on test record.
- Press **VERTICAL MENU**; then press the side-menu button **Ω** to toggle to the 50 Ω setting.
- Press **CLEAR MENU**.
- CHECK that the readout **Ch2 Pk-Pk** is between 45 mV and 55 mV, inclusive.
- Enter the voltage on the test record.

4. *Disconnect the hookup:* Disconnect the cables from the channel inputs and the rear panel outputs.

Check Probe Compensator Output

Equipment Required	One female BNC to clip adapter (Item 3) Two dual-banana connectors (Item 6) One BNC T connector (Item 7) Two 50 Ω precision cables (Item 5) One DC calibration generator (Item 9)
Prerequisites	See page 1–15. Also, the oscilloscope must have passed *Check Accuracy For Long-Term Sample Rate and Delay Time Measurements* on page 1–38.

1. *Install the test hookup and preset the instrument controls:*

   a. *Hook up test signal:*

   - Connect one of the 50 Ω cables to **CH 1**. See Figure 1–21.
   - Connect the other end of the cable just installed to the female BNC-to-clips adapter. See Figure 1–21.
   - Connect the red clip on the adapter just installed to the **PROBE COMPENSATION SIGNAL** on the front panel; connect the black clip to **PROBE COMPENSATION GND**. See Figure 1–21.

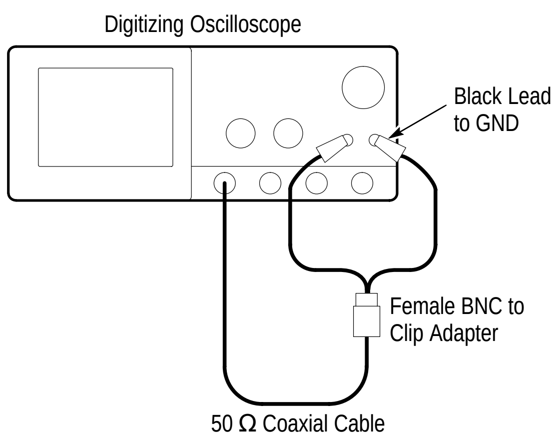


Figure 1–21: Initial Test Hookup

   b. *Initialize the oscilloscope:*

   - Press save/recall **SETUP**.
   - Press the main-menu button **Recall Factory Setup**.
   - Press the side-menu button **OK Confirm Factory Init**.

   c. *Modify the initialized front-panel control settings:*

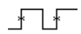
   - Set the horizontal **SCALE** to 200 μs.
   - Press **SET LEVEL TO 50%**.
   - Use the vertical **POSITION** knob to center the display on screen.
   - Press **SHIFT**; then press **ACQUIRE MENU**.
   - Press the main-menu button **Mode**; then press the side-menu button **Average**.

- Select **128** averages with the keypad or the general purpose knob.

2. *Confirm that the Probe Compensator signal is within limits for frequency and amplitude:*

   a. *Measure the frequency of the probe compensation signal:*

   - Press **MEASURE**; then press the main-menu button **Select Measrmnt for *Ch1***.



   - Repeatedly press the side-menu button **–more–** until **Frequency** appears in the side menu (its icon is shown at the left). Press the side-menu button **Frequency**.

   b. *Check against limits:*

   - CHECK that the **CH 1 Freq** readout is within 950 Hz to 1.050 kHz, inclusive. See Figure 1–22.
   - Enter the frequency on the test record.
   - Press **MEASURE**; then press the main-menu button **Remove Measrmnt for *Ch1***. Press the side–menu **Measurement 1**.

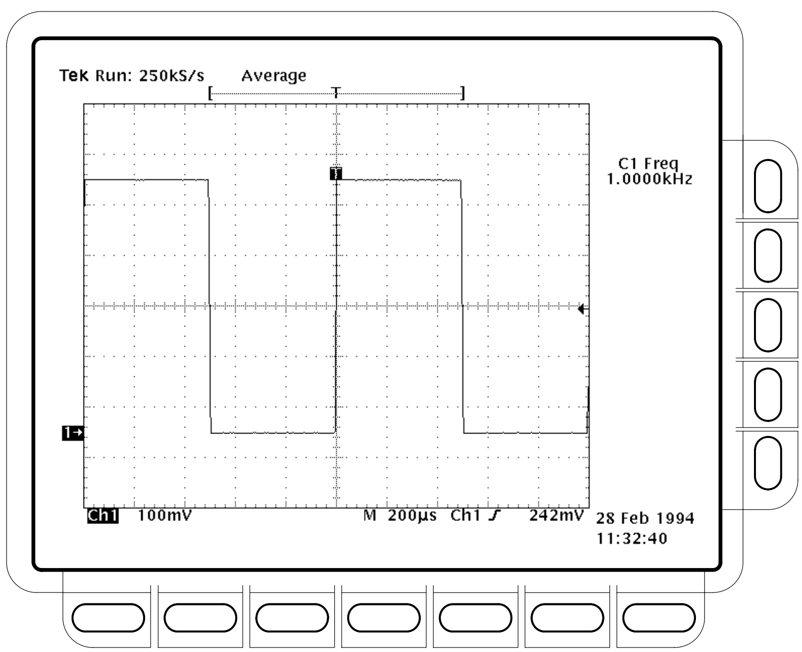


Figure 1–22: Measurement of Probe Compensator Frequency

c. *Save the probe compensation signal in reference memory:*

- Press **SAVE/RECALL WAVEFORM**; then press the main-menu button **Save Wfm *Ch 1***.
- Press the side-menu button **To Ref 1** to save the probe compensation signal in reference 1.
- Disconnect the cable from **CH 1** and the clips from the probe compensation terminals.
- Press **MORE**; then press the main-menu button **Ref 1** to displayed the stored signal.
- Press **CH 1**.

d. *Hook up the DC standard source:*

- Set the output of a DC calibration generator to 0 volts.
- Connect the output of a DC calibration generator through a dual-banana connector followed by a 50 Ω precision coaxial cable to one side of a BNC T connector. See Figure 1–23.
- Connect the Sense output of the generator through a second dual-banana connector followed by a 50 Ω precision coaxial cable to the other side of the BNC T connector. Now connect the BNC T connector to **CH 1**. See Figure 1–23.

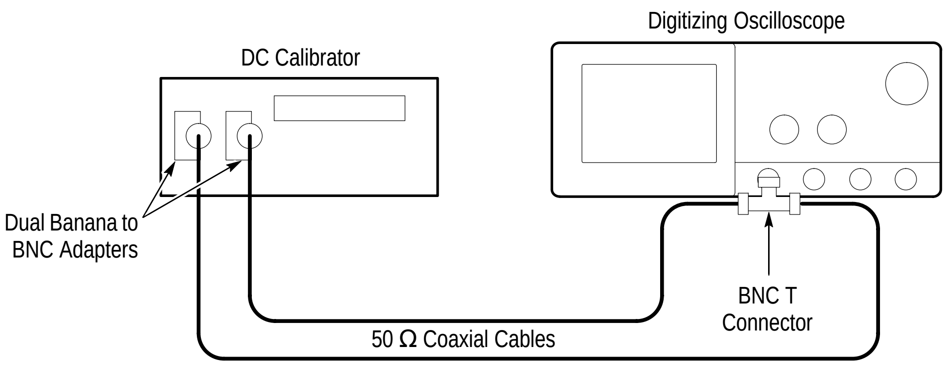


Figure 1–23: Subsequent Test Hookup

e. *Measure amplitude of the probe compensation signal:*

- Press **SHIFT**; then press **ACQUIRE MENU**. Press the side-menu button **AVERAGE** then enter 16 using the keypad or the general purpose knob.

- Adjust the output of the DC calibration generator until it precisely overlaps the top (upper) level of the stored probe compensation signal. (This value will be near 500 mV.)
- Record the setting of the DC generator.
- Adjust the output of the DC calibration generator until it precisely overlaps the base (lower) level of the stored probe compensation signal. (This value will be near zero volts.)
- Record the setting of the DC generator.

f. Press **CLEAR MENU** to remove the menus from the display. See Figure 1–24.

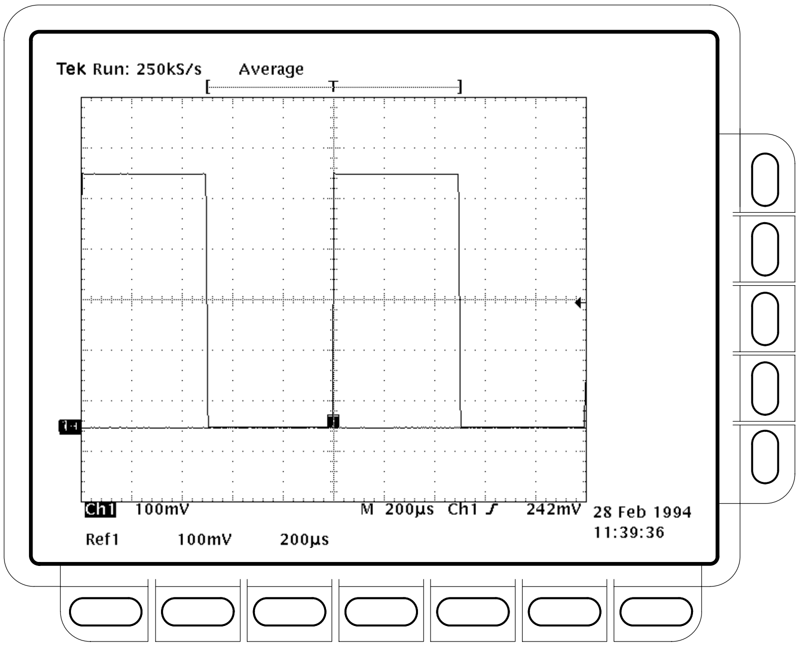


Figure 1–24: Measurement of Probe Compensator Amplitude

g. *Check against limits:*

- Subtract the value just obtained (base level) from that obtained previously (top level).
- CHECK that the difference obtained is within 495 mV to 505 mV, inclusive.
- Enter the voltage difference on the test record.

3. *Disconnect the hookup:* Disconnect the cable from **CH 1**.

Option 05 Video Trigger Checks

Check Video Trigger

Equipment Required	PAL signal source (Item 14) 60 Hz. sine wave generator (Item 15) Pulse generator (Item 16) Two 75 Ω cables (Item 17) Two 75 Ω terminators (Item 18) One BNC T connector (Item 7) 50 Ω cable (Item 5) 50 Ω terminator (Item 4)
Prerequisites	See page 1–15. These prerequisites include running the signal path compensation routine.

1. *Set up the oscilloscope to factory defaults by completing the following steps:*
   - **a.** Press save/recall **SETUP**.
   - **b.** Press the main-menu **Recall Factory Setup**.
   - **c.** Press the side-menu **OK Confirm Factory Init**.
   - **d.** Wait for the Clock Icon to leave the screen.
2. *Set up the oscilloscope for TV triggers by completing the following steps:*
   - **a.** Press **TRIGGER MENU**.
   - **b.** Press the main-menu **Type** pop-up until you select **Video**.
   - **c.** Press the main-menu **Standard** pop-up until you select **625/PAL**.
   - **d.** Press the main-menu **Line**.
   - **e.** Use the keypad to set the line number to 7 (press **7**, then **ENTER**).
   - **f.** Press **VERTICAL MENU**.
   - **g.** Press the main-menu **Bandwidth**.
   - **h.** Select **100 MHz** from the side menu.
   - **i.** Press the main-menu **Fine Scale**.
   - **j.** Use the keypad to set the fine scale to 282mV (press **282**, **SHIFT**, **m**, then **ENTER**).
   - **k.** Press **HORIZONTAL MENU**.

l. Press the main-menu **Horiz Scale**.

m. Use the keypad to set the horizontal scale to 200 ns (press **200**, **SHIFT**, **n,** then **ENTER**).

3. *Check Jitter vs. Signal Amplitude:*

a. Set up equipment for Jitter Test. See Figure 1–25.

- Connect one of the rear panel composite outputs marked **COMPST** on the TSG121 through a 75 Ω cable and a 75 Ω terminator to the CH1 input of the oscilloscope.
- Press the **100% FIELD** control of the PAL signal source.

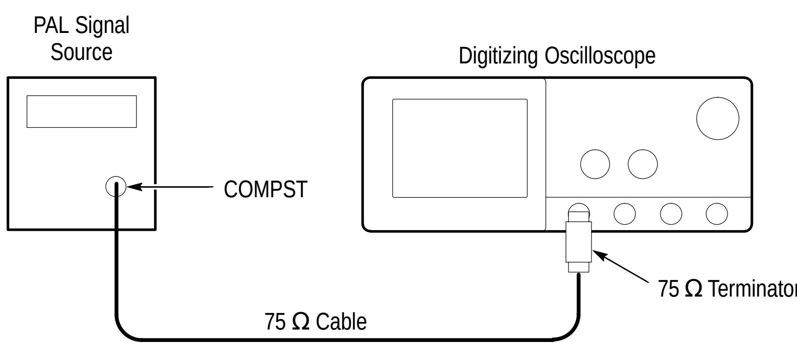


Figure 1–25: Jitter Test Hookup

b. CHECK that the oscilloscope lights up its front panel **TRIG'D** LED and it displays the waveform on screen. See Figure 1–26.

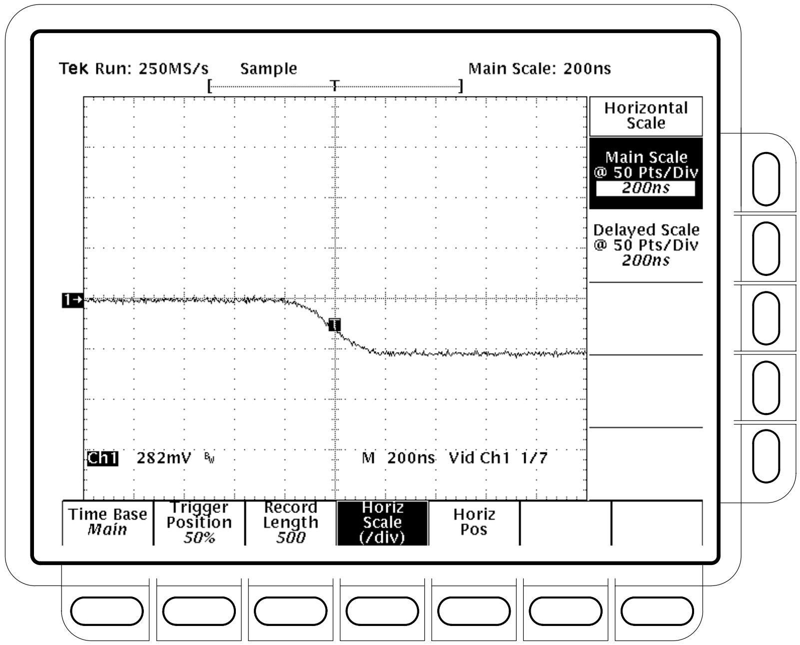


Figure 1–26: Jitter Test Displayed Waveform

- **c.** Press **SHIFT**; then press **ACQUIRE MENU**.
- **d.** Press the main-menu **Mode**.
- **e.** Select the side-menu **Average**. It should be already set to 16.
- **f.** Press the main-menu **Create Limit Test Template.**
- **g.** Press the side-menu **V Limit**.
- **h.** Use the keypad to set V Limit to 180 mdiv (press **180**, **SHIFT**, **m**, then **ENTER**)
- **i.** Press the side-menu **OK Store Template**.
- **j.** Press **MORE**.
- **k.** Press the main-menu **Ref1**.
- **l.** Press **CH1**.
- **m.** Press **SHIFT**; then press **ACQUIRE MENU**.
- **n.** Press the main-menu **Limit Test Setup**.
- **o.** Toggle the side-menu **Limit Test** to **ON**.
- **p.** Toggle the side-menu **Ring Bell if Condition Met** to **ON**.

q. Press the main-menu **Mode**.

r. Press the side-menu **Envelope**.

s. Use the keypad to set envelope to use 100 acquisitions (press **100**, then **ENTER**).

t. Press the main-menu **Stop After** button.

u. Press the side-menu **Single Acquisition Sequence.**

v. CONFIRM that the oscilloscope successfully makes 100 acquisitions. If not successful, the oscilloscope bell will ring. When the word **Run** in the top left corner of the display changes to **STOP**, the test is complete. See Figure 1–27.

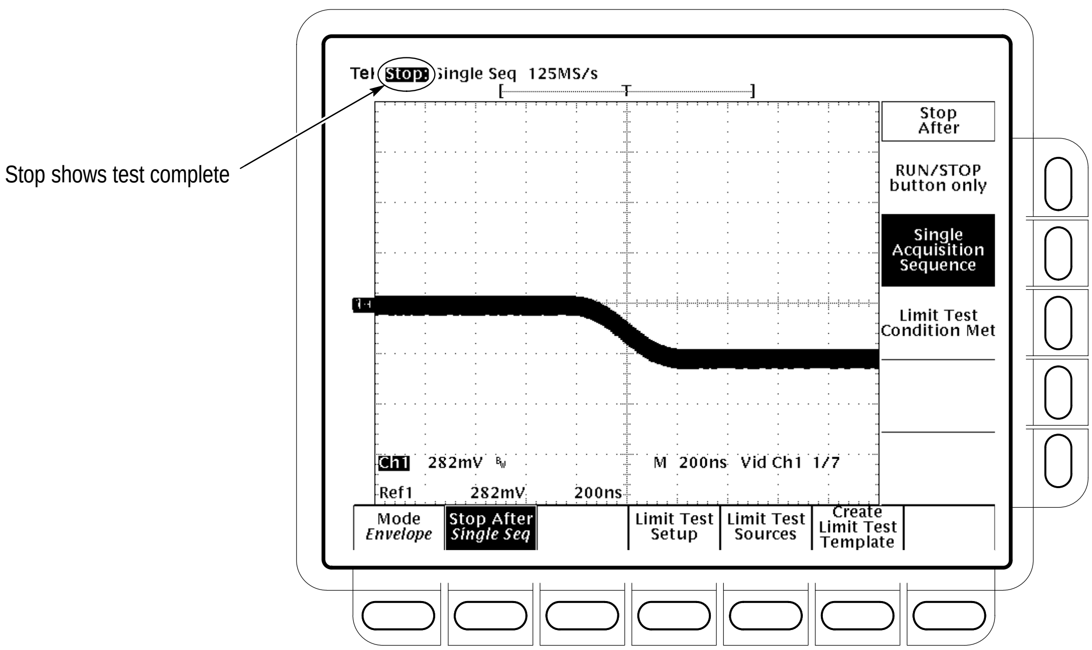


Figure 1–27: Jitter Test When Completed

w. Press the main-menu **Limit Test Setup**.

x. Toggle the side-menu **Ring Bell if Condition Met** to **OFF**.

y. Toggle the side-menu **Limit Test** to **OFF**.

4. *Check Triggered Signal Range:*

Set up oscilloscope for Triggered Signal Test:

a. Press **MORE**.

b. Press **WAVEFORM OFF**.

c. Press **HORIZONTAL MENU**.

d. Use the keypad to set horizontal scale (/div) to 50 μs (press **50**, **SHIFT**, **μ**, then **ENTER**).

e. Press **SHIFT**; then press **ACQUIRE MENU**.

f. Press the main-menu **Stop After**.

g. Press the side-menu **RUN/STOP button only**.

h. Press the main-menu **Mode**.

i. Press the side-menu **Sample**.

j. Press **RUN/STOP**.

k. Press **VERTICAL MENU**.

l. Use the keypad to set fine scale to 300 mV (press **300**, **SHIFT**, **m,** then **ENTER**).

m. CONFIRM that the **TRIG'D** LED stays lighted and that the waveform on screen is stable. That is, it does not move horizontally or vertically. Also, CONFIRM that the waveform on the screen has one positive pulse and a number of negative pulses. See Figure 1–28.

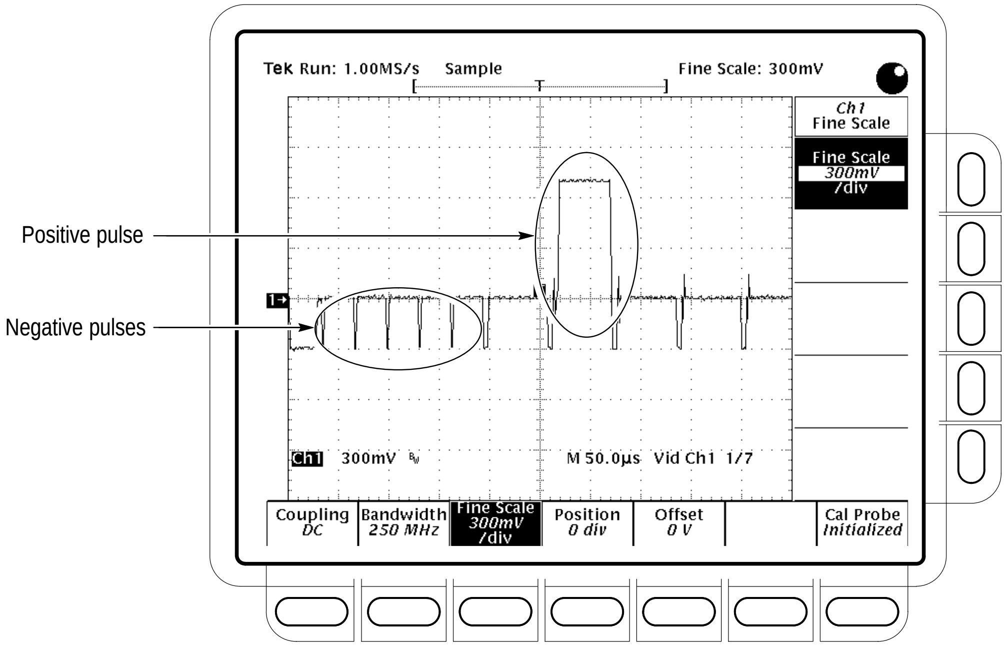


Figure 1–28: Triggered Signal Range Test – 300 mV

n. Use the keypad to set the fine scale to 75 mV (press **75**, **SHIFT**, **m**, and then **ENTER**).

o. CONFIRM that the **TRIG'D** LED stays lighted and that the waveform on screen is stable. That is, it does not move horizontally or vertically. Also, CONFIRM that the waveform on the screen has one positive pulse and a number of negative pulses. See Figure 1–29.

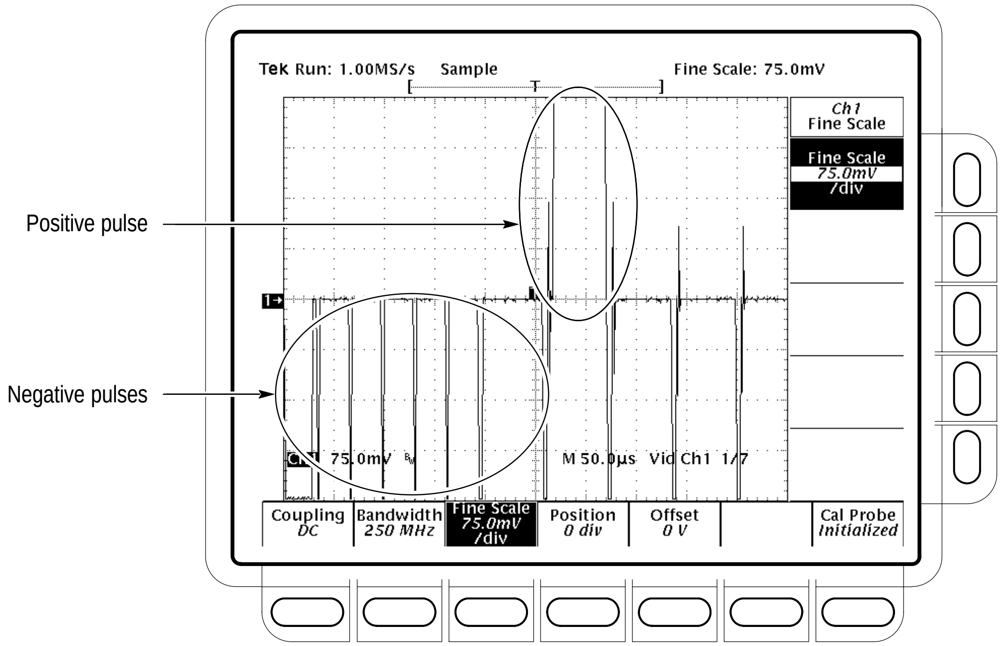


Figure 1–29: Triggered Signal Range Test – 75 mV

p. Disconnect all test equipment from the oscilloscope.

5. *Check 60 Hz Rejection:*

a. Set up oscilloscope for 60 Hz Rejection Test:

- Use the keypad to set the Ch1 Fine Scale to 282 mV (press **282**, **SHIFT m**, and then **ENTER**)**.**
- Press **WAVEFORM OFF**.
- Press **CH2**.
- Press **VERTICAL MENU**.
- Use the keypad set the fine scale to 2 V (press **2**, then **ENTER**).
- Press **HORIZONTAL MENU**.
- Use the keypad to set the horizontal scale (/div) to 5 ms (press **5**, **SHIFT**, **m**, and then **ENTER**).

b. Set up 60 Hz signal generator:

- Connect the output of the signal generator to the CH2 input through a 50 Ω cable. See Figure 1–30.

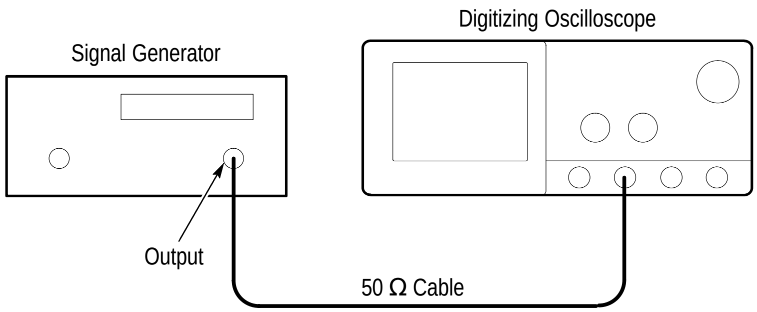


Figure 1–30: 60 Hz Rejection Test Hookup

- Adjust the signal generator for three vertical divisions of 60 Hz signal. See Figure 1–31. The signal will not be triggered. That is, it will run free.

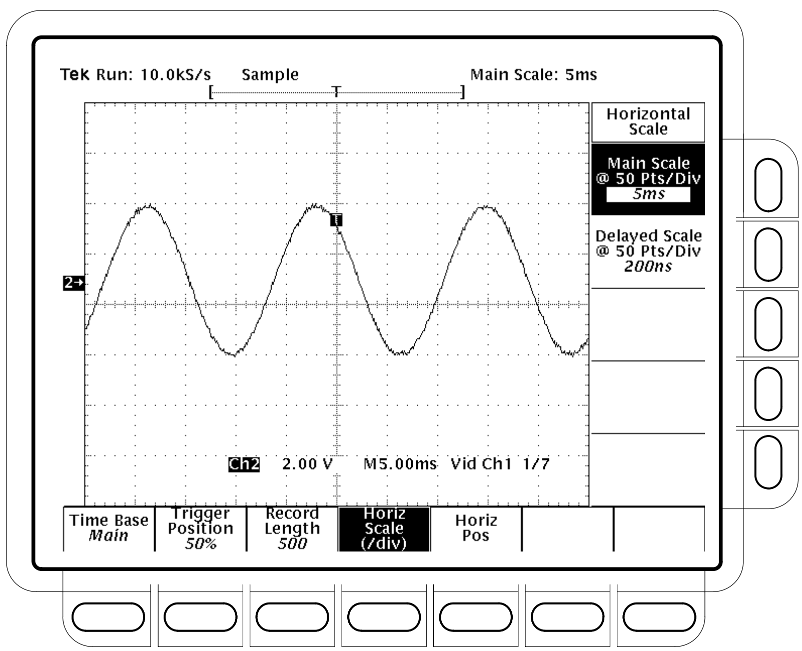


Figure 1–31: 60 Hz Rejection Test Setup Signal

c. Check 60 Hz rejection:

- Use the keypad to set the horizontal scale (/div) to 50 μs (press **50**, **SHIFT**, **μ**, and then **ENTER**).
- Reconnect the output of the signal generator. Connect the composite signal connector of the PAL signal source (labeled **COMPST** on the

TSG 121) to a 75 Ω cable and a 75 Ω terminator. Connect both signals to the CH1 input through a BNC T. See Figure 1–32.

- Press **VERTICAL MENU**.
- If needed, press the main-menu **Fine Scale**.
- Use the keypad to set fine scale to 500 mV (press **500**, **SHIFT**, **m**, then **ENTER**).
- Connect another composite signal connector of the PAL signal source (labeled **COMPST** on the TSG 121) through a 75 Ω cable and a 75 Ω terminator to the CH2 input. See Figure 1–32.

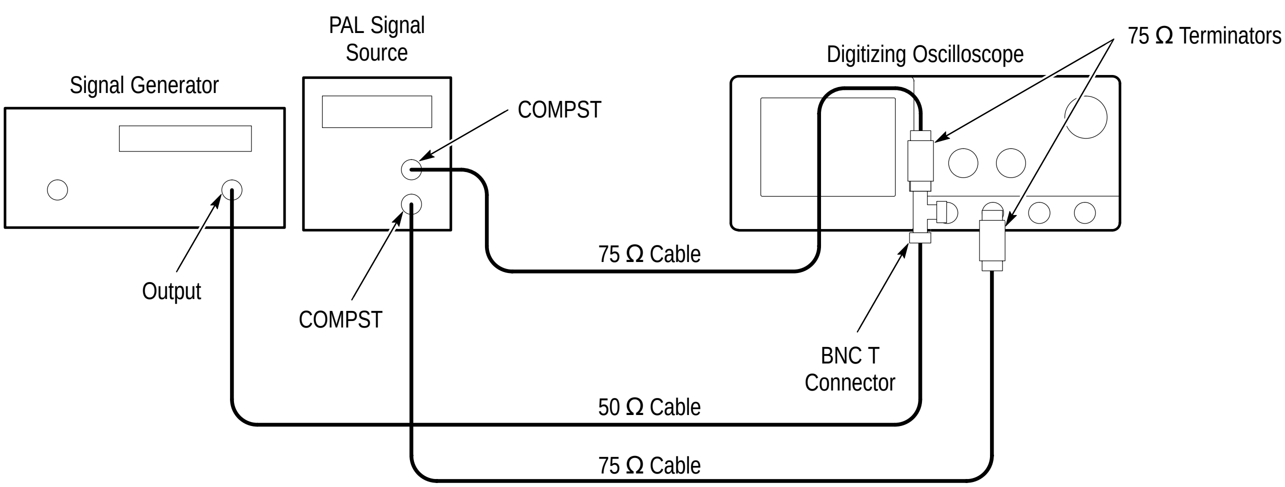


Figure 1–32: Subsequent 60 Hz Rejection Test Hookup

- CONFIRM that the **TRIG'D** LED stays lighted and that the waveform on screen is stable. In other words, be sure the waveform does not move horizontally or vertically. Also, confirm that the waveform on the screen has one positive pulse and a number of negative pulses. See Figure 1–33.
- Disconnect all test equipment from the oscilloscope.

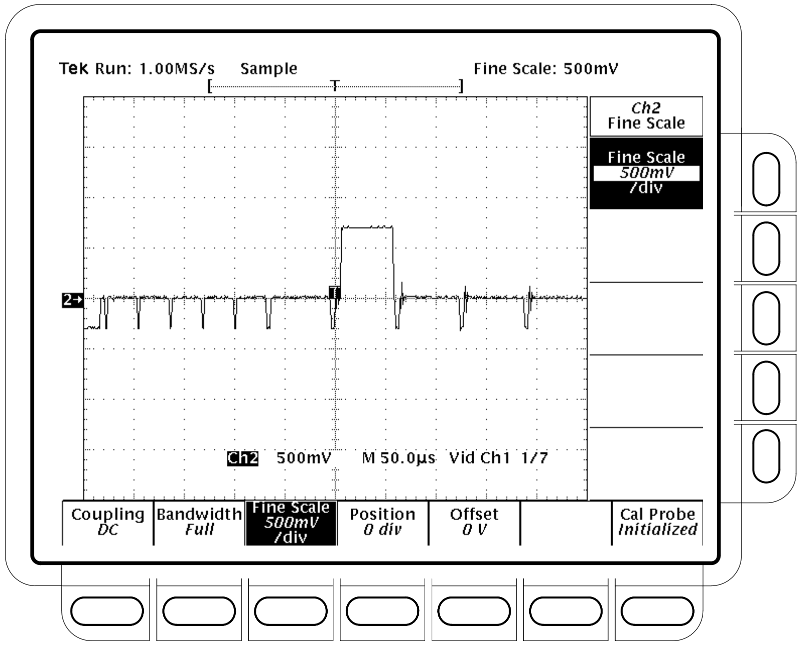


Figure 1–33: 60 Hz Rejection Test Result

6. *Check Line Count Accuracy:*

   a. Set up oscilloscope for Line Count Accuracy Test:

      - Press **WAVEFORM OFF**.
      - Press **CH1**.
      - Press **HORIZONTAL MENU**.
      - Press the main-menu **Record Length**.
      - Press the side-menu **–more–** until you see the appropriate menu.
      - Press the side-menu **5000 points in 100divs**.
      - Press the main-menu **Horiz Scale (/div)**.
      - Use the keypad to set the horizontal scale to 200 ns (press **200**, **SHIFT**, **n**, then **ENTER)**.

   b. Check Line Count Accuracy:

      - Connect a composite output signal from the rear of the PAL signal source (labeled **COMPST** on the TSG 121) to the CH1 input through a 75 Ω cable and a 75 Ω terminator. See Figure 1–34.

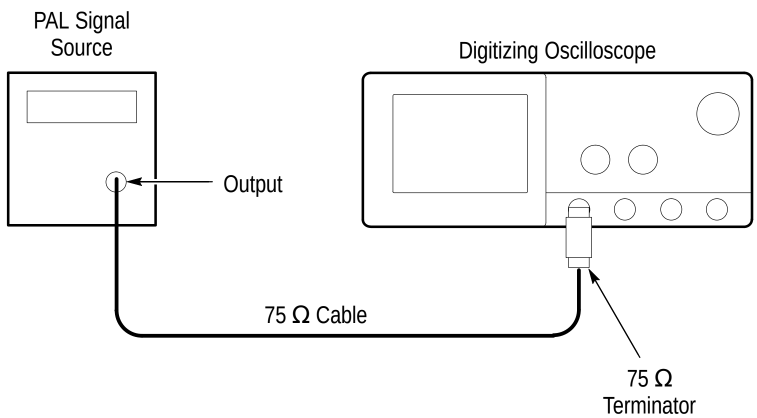


Figure 1–34: Line Count Accuracy Test Hookup

- Press the main-menu **Trigger Position**.
- Press the side-menu to **Set to 50%**.
- Press the main-menu to **Horiz Pos**.
- Press the side-menu to **Set to 50%**.
- Use the **HORIZONTAL POSITION** knob to move the falling edge of the sync pulse to two divisions to the left of center screen. See Figure 1–35.

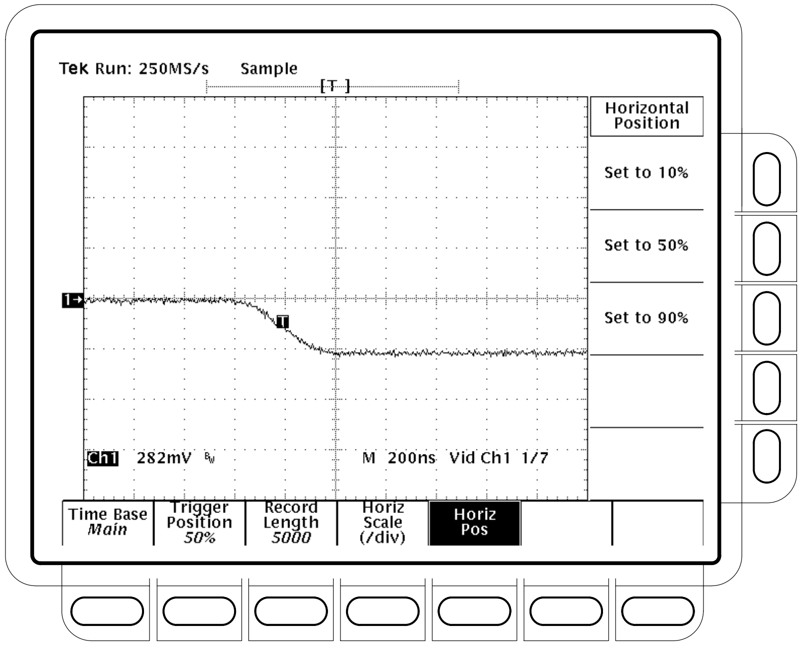


Figure 1–35: Line Count Accuracy Test Setup Waveform

- Press **CURSOR**.
- Press the main-menu **Function**.
- Press the side-menu **V Bars**.
- Using the General Purpose knob, place the left cursor directly over the trigger ‘T’ icon.
- Press **SELECT**.
- Turn the General Purpose knob to adjust the right cursor for a cursor delta reading of **6.780us**.
- Use the **HORIZONTAL POSITION** knob to position the right cursor to center screen.
- Verify that the cursor is positioned on a positive slope of the burst signal. See Figure 1–36.

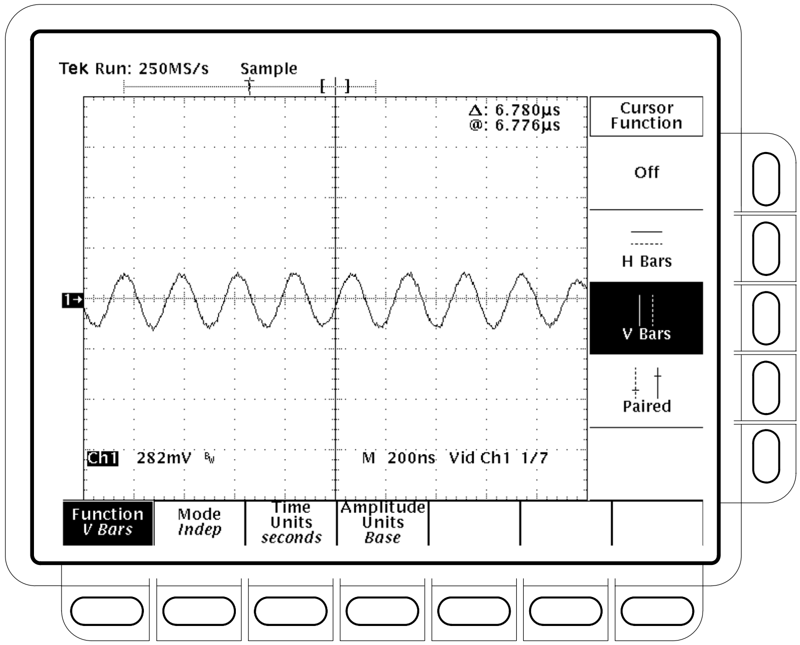


Figure 1–36: Line Count Accuracy Correct Result Waveform

- Disconnect all test equipment from the oscilloscope.
- Turn off cursors by pressing **CURSOR**, then the main-menu **Function** button, and, finally, **Off** from the side menu.

7. *Check the Sync Duty Cycle:*

a. Set up oscilloscope for Sync Duty Cycle Test:

- Press **TRIGGER MENU**.
- Press the **Standard** pop-up to select **FlexFmt**. Trigger **Type** should already be set to **Video**.
- Press the main-menu **Setup**.
- Press the side-menu **Field Rate**.
- Use the keypad to set the field rate to 60.05 Hz (press **60.05**, then **ENTER**).
- Press the side-menu **Lines**.
- Use the keypad to set the field rate to 793 lines (press **793**, then **ENTER**).
- Press the side-menu **Fields**.

- Use the keypad to set the number of fields to 1 (press **1**, then **ENTER**).
- Press the side-menu **Sync Width**.
- Use the keypad to set the width to 400 ns (press **400**, **SHIFT**, **n**, then **ENTER**).
- Press the side-menu **–more– 1 of 2**. Then press **V1 Start Time**.
- Use the keypad to set V1 start time to 10.10 μs (press **10.10**, **SHIFT**, **μ**, then **ENTER**).
- Press the side-menu **V1 Stop Time**.
- Use the keypad to set V1 stop time to 10.50 μs (press **10.50**, **SHIFT**, **μ**, then **ENTER**).
- Press the main-menu **Type** pop-up to select **Edge**.
- Press **HORIZONTAL MENU**.
- Press the main-menu **Record Length**.
- Select the side-menu **1000 points in 20div**. If needed, first press the side-menu **–more–** until you see the appropriate side-menu item.
- Turn the **HORIZONTAL POSITION** knob to position the trigger 'T' two divisions to the left of the center screen.
- Press **MEASURE**.
- If needed, press the main-menu **Select Measrmnt**.
- Press the side-menu **Negative Width**.
- Press the side-menu **Period**.

b. Set up the pulse generator for Sync Duty Cycle Test:

- Set **PULSE DURATION** to 50 ns.
- Set **PERIOD** to 10 μs.
- Set **OUTPUT (VOLTS)** to **–1** for **LOW LEVEL** and **+1** for **HIGH LEVEL**.
- Depress the **COMPLEMENT** button.
- Be sure **BACK TERM** is depressed (in).

c. Check Sync Duty Cycle:

- Connect the pulse generator through a 50 Ω cable and a 50 Ω terminator to the oscilloscope CH1 input. See Figure 1–37.

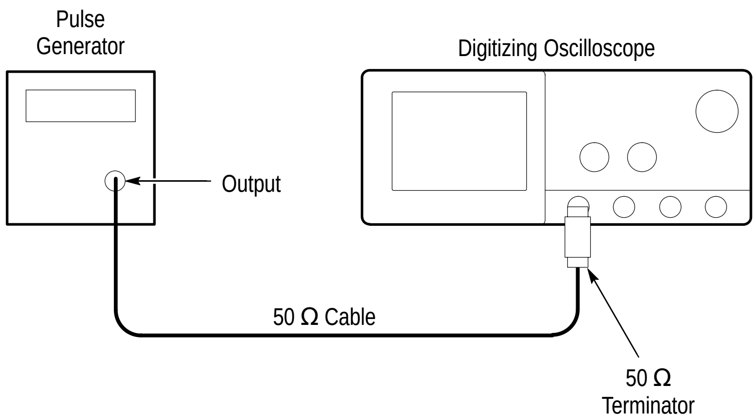


Figure 1–37: Setup for Sync Duty Cycle Test

- Turn the pulse generator **OUTPUT (VOLTS)** control until the signal on the oscilloscope shows a one division negative going pulse. See Figure 1–38.

***NOTE**. You may need to adjust the trigger level control to obtain a stable trigger.*

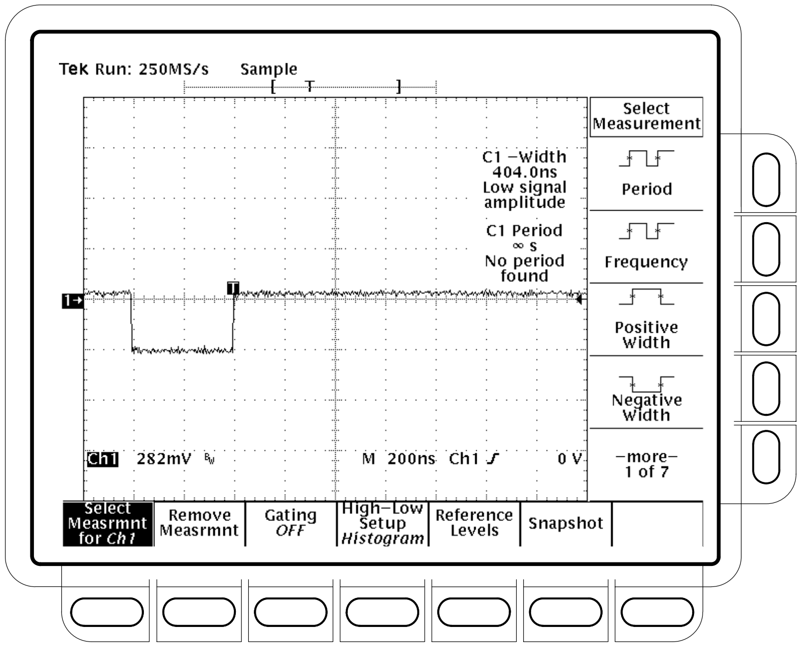


Figure 1–38: Sync Duty Cycle Test: One-Div Neg Pulse Waveform

- Turn the pulse generator **PULSE DURATION** variable control to adjust the negative pulse so the oscilloscope **CH1 – Width** measurement displays **400ns +/–10 ns**.
- Turn the **HORIZONTAL SCALE** knob to set the oscilloscope time base to **5µs/div**.
- Turn the pulse generator PERIOD variable control to adjust the period until the oscilloscope **CH1 Period** measurement reads **21.000µs –25/+50 ns**. See Figure 1–39. Read note shown below.

***NOTE**. The pulse duration and period adjustments are critical in making this measurement. If the pulse duration and/or the duty cycle are not stable, the FLEXFMT function may not function. You must take care when making these adjustments.*

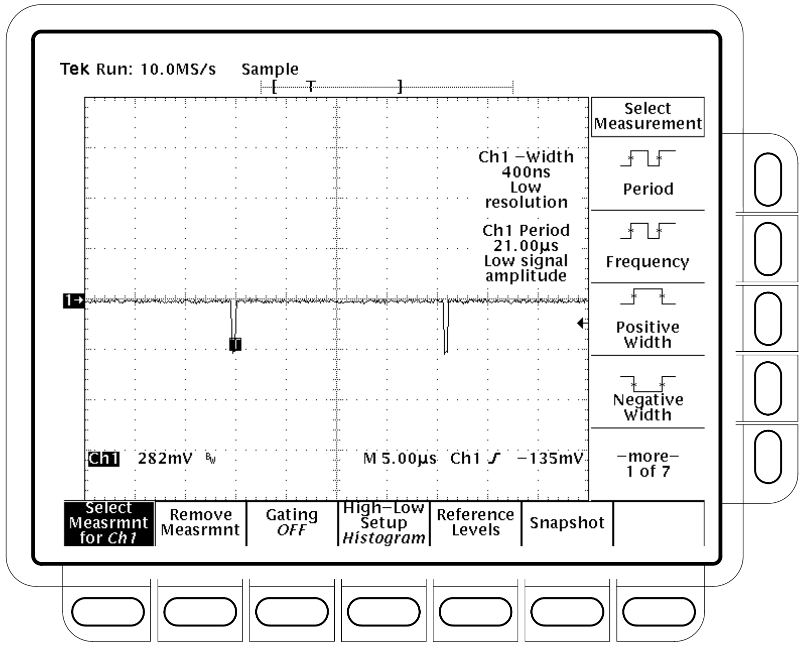


Figure 1–39: Sync Duty Cycle Test: Critically Adjusted Pulse

- Press **TRIGGER MENU**.
- Press the main-menu **Type** pop-up until you select **Video**.

  If the **TRIG'D** LED is not lighted, check that the **CH1 – Width** and **CH1 Period** measurements are adjusted correctly. See note above. CONFIRM that the setup is correct and the oscilloscope will trigger.

- CONFIRM that the **TRIG'D** LED is lighted and the waveform is stable.
- Disconnect the signal source from CH1, wait a few seconds, then reconnect the signal.
- CONFIRM that the **TRIG'D** LED is lighted and the waveform is stable.
- Press **Sync Polarity**.
- Press **Pos Sync**.
- Push the pulse generator **COMPLEMENT** button out.
- CONFIRM that the **TRIG'D** LED is lighted and the waveform is stable.

- Disconnect the signal source from CH1, wait a few seconds, then reconnect the signal.
- CONFIRM that the **TRIG'D** LED is lighted and the waveform is stable.
- Disconnect all test equipment from the oscilloscope.
- Press save/recall **SETUP**, the main-menu button **Recall Factory Setup**, and the side-menu **OK Confirm Factory Init**.

Sine Wave Generator Leveling Procedure

Some procedures in this manual require a sine wave generator to produce the necessary test signals. If you do not have a leveled sine wave generator, use one of the following procedures to level the output amplitude of your sine wave generator.

Equipment Required	Sine wave generator (Item 19) Level meter and power sensor (Item 20) Power splitter (Item 21) Two male N to female BNC adapters (Item 23) One precision coaxial cable (Item 5)
Prerequisites	See page 1–15.

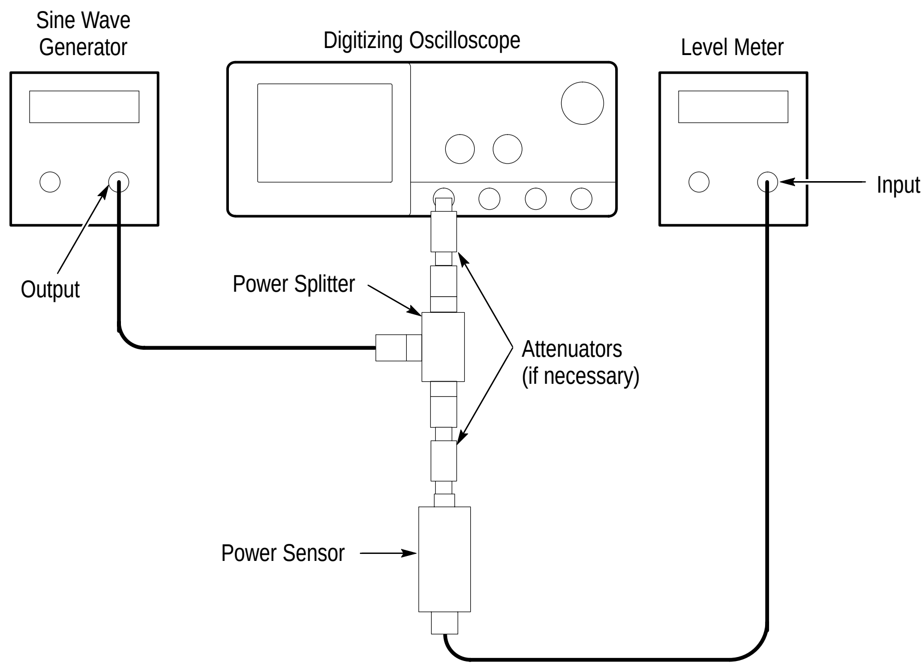


Figure 1–40: Sine Wave Generator Leveling Equipment Setup

1. *Install the test hookup:* Connect the equipment as shown in Figure 1–40.
2. *Set the Generator:*
   - Set the sine wave generator to a reference frequency of 10 MHz.
   - Adjust the sine wave generator amplitude to the required number of divisions as measured by the oscilloscope.
3. *Record the reference level:* Note the reading on the level meter.
4. *Set the generator to the new frequency and reference level:*
   - Change the sine wave generator to the desired new frequency.
   - Input the correction factor for the new frequency into the level meter.
   - Adjust the sine wave generator amplitude until the level meter again reads the value noted in step 3. The signal amplitude is now correctly set for the new frequency.

Equipment Required	Sine wave generator (Item 19) Level meter and power sensor (Item 20) Two male N to female BNC adapters (Item 23) Two precision coaxial cables (Item 5)
Prerequisites	See page 1–15.

1. *Install the test hookup:* Connect the equipment as shown in Figure 1–41 (start with the sine wave generator connected to the oscilloscope).

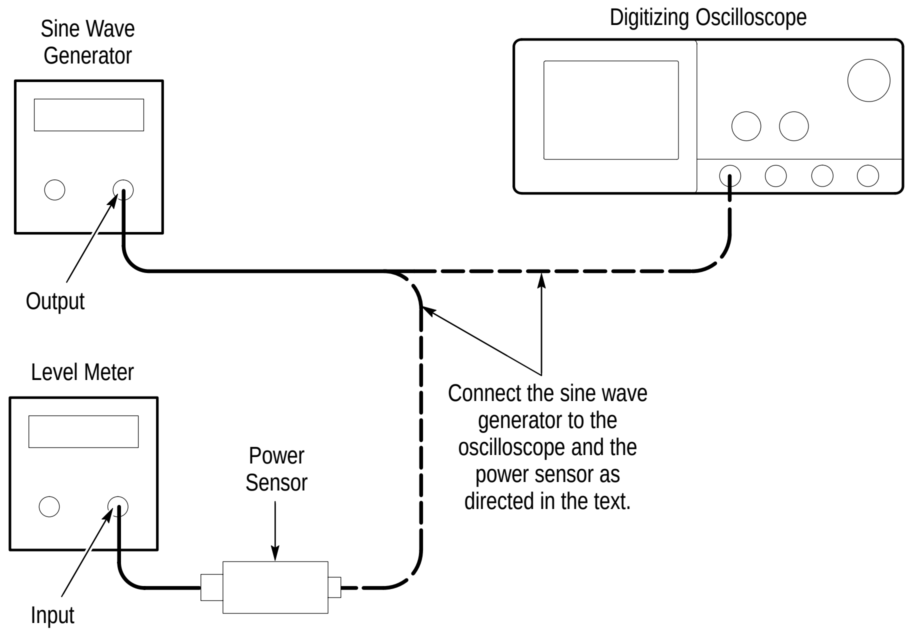


Figure 1–41: Equipment Setup for Maximum Amplitude

2. *Set the Generator:*
   - Set the sine wave generator to a reference frequency of 10 MHz.
   - Adjust the sine wave generator amplitude to the required number of divisions as measured by the oscilloscope.
3. *Record the reference level:*
   - Disconnect the sine wave generator from the oscilloscope.
   - Connect the sine wave generator to the power sensor.
   - Note the level meter reading.

4. *Set the generator to the new frequency and reference level:*

- Change the sine wave generator to the desired new frequency.
- Input the correction factor for the new frequency into the level meter.
- Adjust the sine wave generator amplitude until the level meter again reads the value noted in step 3. The signal amplitude is now correctly set for the new frequency.
- Disconnect the sine wave generator from the power sensor.
- Connect the sine wave generator to the oscilloscope.

Specifications

Specifications

This chapter begins with a general description of the traits of the TDS 510A Digitizing Oscilloscope. Three sections follow, one for each of three classes of traits: *nominal traits*, *warranted characteristics*, and *typical characteristics*.

General Product Description

The TDS 510A is a portable, four-channel oscilloscope suitable for use in a variety of test and measurement applications and systems. Key features include:

- 500 MHz maximum analog bandwidth
- 500 Megasamples/second maximum digitizing rate
- Four-channel acquisition
- Extensive triggering capabilities: including edge, logic, and glitch; optional NTSC, PAL, SECAM, HDTV, and FlexFormat™ (user definable format) video trigger modes
- Waveform Math — Invert a single waveform and add, subtract, and multiply two waveforms, and optionally integrate or differentiate a single waveform or perform an FFT (fast fourier transform) on a waveform to display its magnitude or phase versus its frequency
- Eight-bit digitizers
- Up to 50,000-point record length per channel
- Full GPIB software programmability; hardcopy output using GPIB, RS-232, or Centronics ports (RS-232 and Centronics are option 13)
- Complete measurement and documentation capability
- Intuitive graphic icon operation blended with the familiarity of traditional horizontal and vertical knobs
- On-line help at the touch of a button
- A full complement of advanced functions, like continuously updated measurement results and local pass/fail decision making
- Specialized display modes, including variable persistence, dot or vector mode, sin(x)/x or linear display filters, and Fit-to-Screen compression of the waveform record to fit on the screen

- A complement of advanced acquisition modes such as peak-detect, high-resolution, sample, envelope, and average
- A unique graphical user interface (GUI), an on-board help mode, and a logical front-panel layout
- VGA output for driving remote monitors
- NVRAM and an optional 1.44 Mbyte, DOS 3.3 or later, floppy disk drive for saving waveforms and oscilloscope setups

Nominal Traits

This section contains tables that list the electrical and mechanical *nominal traits* that describe the TDS 510A Digitizing Oscilloscope.

Nominal traits are described using simple statements of fact, such as "Four, all identical" for the trait "Input Channels, Number of," rather than in terms of limits that are performance requirements.

Table 2–1: Nominal Traits — Signal Acquisition System

Name	Description	
Bandwidth Selections	20 MHz, 100 MHz, and FULL (500 MHz)	
Digitizers, Number of	Four, all identical	
Digitized Bits, Number of	8 bits[1]	
Input Channels, Number of	Four, all identical, called CH1 – CH4	
Input Coupling	DC, AC, or GND[2]	
Input Impedance Selections	1 MΩ or 50 Ω	
Ranges, Offset	**Volts/Div Setting** 1 mV/div – 99.5 mV/div 100 mV/div – 995 mV/div 1 V/div – 10 V/div	**Offset Range** ±1 V ±10 V ±100 V
Range, Position	±5 divisions	
Range, Sensitivity	1 mV/div to 10 V/div[3]	

1 **Displayed vertically with 25 digitization levels (DLs) per division and 10.24 divisions dynamic range with zoom off. A DL is the smallest voltage level change that can be resolved by the 8-bit A-D Converter, with the input scaled to the volts/division setting of the channel used. Expressed as a voltage, a DL is equal to 1/25 of a division times the volts/division setting.**

2 **GND input coupling disconnects the input connector from the attenuator and connects a ground reference to the input of the attenuator.**

3 **The sensitivity ranges from 1 mV/div to 10 V/div in a 1–2–5 sequence of coarse settings. Between a pair of adjacent coarse settings, the sensitivity can be finely adjusted. The resolution of such a fine adjustment is 1% of the more sensitive coarse setting. For example, between 50 mV/div and 100 mV/div, the volts/division can be set with 0.5 mV resolution.**

Table 2–2: Nominal Traits — Time Base System

Name	Description	
Range, Sample-Rate[1,3]	**Number of Channels On**	**Sample-Rate Range**
	1 or 2	5 Samples/s – 500 MSamples/s
	3 or 4	5 Samples/s – 250 MSamples/s
Range, Equivalent Time or Interpolated Waveform Rate[2,3]	500 MSamples/s to 100 GSamples/s	
Range, Seconds/Division	500 ps/div to 10 s/div	
Record Length[4]	500 samples, 1000 samples, 2500 samples, 5000 samples, 15,000 samples, and 50,000 samples. Up to four 50 K waveform records may be saved in NVRAM.	
Range, Time Base Delay Time	16 ns to 250 seconds	

1 **The range of real-time rates, expressed in samples/second, at which a digitizer samples signals at its inputs and stores the samples in memory to produce a record of time-sequential samples.**

2 **The range of waveform rates for equivalent time or interpolated waveform records.**

3 **The Waveform Rate (WR) is the equivalent sample rate of a waveform record. For a waveform record acquired by real-time sampling of a single acquisition, the waveform rate is the same as the real-time sample rate; for a waveform created by interpolation of real-time samples from a single acquisition or by equivalent-time sampling of multiple acquisitions, the waveform rate is faster than the real time sample rate. For all three cases, the waveform rate is 1/(Waveform Interval) for the waveform record, where the waveform interval (WI) is the time between the samples in the waveform record.**

4 **The maximum record length of 50,000 samples is selectable with all acquisition modes except Hi Res. In Hi Res, the maximum record length is 15,000 samples.**

Table 2–3: Nominal Traits — Triggering System

Name	Description	
Range, Delayed Trigger Time Delay	16 ns to 250 s	
Range, Events Delay	2 to 10,000,000	
Range (Time) for Pulse-Glitch or Pulse-Width Triggering	2 ns to 1 s	
Ranges,Trigger Level or Threshold	**Source**	**Range**
	Any Channel	±12 divisions from center of screen
	Auxiliary	±4 V
	Line	±300 V
Video Trigger Modes of Operation (Option 05 Video Trigger)	Supports the following video standards: ■ NTSC (525/60) – 2 field mono or 4 field ■ PAL (625/50) – 2 field mono, 8 field ■ SECAM ■ HDTV – (787.5/60) (1050.60) (1125/60) (1250/60) ■ FlexFormat™ (user definable standards) User can specify: field rate, number of lines, sync pulse width and polarity, line rate, and vertical interval timing.	

Table 2–4: Nominal Traits — Display System

Name	Description
CRT Type	7 inch diagonal monochrome, magnetic deflection CRT with horizontal raster orientation. The phosphor is P4
Video Display Resolution	640 pixels horizontally by 480 pixels vertically in a display area of 5.04 inches horizontally by 3.78 inches vertically
Waveform Display Graticule	Single Graticule: 401 × 501 pixels, 8 × 10 divisions, where divisions are 1 cm by 1 cm
Waveform Display Grey Scale	Sixteen levels in infinite-persistence and variable persistence display styles.

Table 2–5: Nominal Traits — Interfaces, Output Ports, and Power Fuse

Name	Description
Interface, GPIB	GPIB interface complies with IEEE Std 488–1987
Interface, RS-232 (Option 13)	RS-232 interface complies with EIA/TIA 574 (talk only)
Interface, Centronics (Option 13)	Centronics interface complies with Centronics interface standard C332-44 Feb 1977, REV A
Interface, Video	VGA video output[1], non interlaced, with levels that comply with ANSI R5343A standard. DB-15 connector.
Logic Polarity for Main- and Delayed-Trigger Outputs	Negative TRUE. High to low transition indicates the trigger occurred.
Fuse Rating	Either of two fuses[2] may be used: a .25″ × 1.25″ (UL 198.6, 3AG): 6 A FAST, 250 V, or a 5 mm × 20 mm, (IEC 127): 5 A (T), 250 V.

1 **VGA compatible at 30.6 kHz line sync rate.**

2 **Each fuse type requires its own fuse cap.**

Table 2–6: Nominal Traits — Mechanical

Name	Description
Cooling Method	Forced-air circulation with no air filter
Construction Material	Chassis parts constructed of aluminum alloy; front panel constructed of plastic laminate; circuit boards constructed of glass-laminate. Cabinet is aluminum and is clad in Tektronix Blue vinyl material.
Finish Type	Tektronix Blue vinyl-clad aluminum cabinet
Weight	Standard oscilloscope 12.3 kg (27 lbs), with front cover. 20.0 kg (44 lbs), when packaged for domestic shipment. Rackmount oscilloscope 12.3 kg (27 lbs) plus weight of rackmount parts, for the rackmounted oscilloscope (Option 1R). 25.6 kg (56 lbs), when the rackmounted oscilloscope is packaged for domestic shipment. Rackmount conversion kit 2.3 kg (5 lbs), parts only; 3.6 kg (8 lbs), parts plus package for domestic shipping.

Table 2–6: Nominal Traits — Mechanical (Cont.)

Name	Description
Overall Dimensions	Standard oscilloscope Height: 193 mm (7.6 in), with the feet installed. Width: 445 mm (17.5 in), with handle. Depth: 434 mm (17.1 in), with front cover installed. Rackmount oscilloscope Height: 178 mm (7.0 in). Width: 483 mm (19.0 in). Depth: 558.8 mm (22.0 in).

Warranted Characteristics

This section lists the electrical and environmental *warranted characteristics* that describe the TDS 510A Digitizing Oscilloscope.

Warranted characteristics are described in terms of quantifiable performance limits which are warranted.

***NOTE**. In these tables, those warranted characteristics that are checked in the procedure* Performance Verification*, found in Section 4, appear in* **boldface type** *under the column* **Name**.

As stated above, this subsection lists only warranted characteristics. A list of *typical characteristics* starts on page 2–15.

Performance Conditions

The electrical characteristics found in these tables of warranted characteristics apply when the scope has been adjusted at an ambient temperature between +20° C and +30° C, has warmed-up for at least 20 minutes, and is operating at an ambient temperature between +4° C and +50° C (unless otherwise noted).

Table 2–7: Warranted Characteristics — Signal Acquisition System

Name	Description	
Accuracy, DC Gain	±1% (For all sensitivities from 1 mV/div to 10 V/div with offsets from 0 V to ±100 V.)	
Accuracy, Offset	**Volts/Div Setting**	**Offset Accuracy**
	1 mV/div – 99.5 mV/div	±(0.2% × | Net Offset[1] | + 1.5 mV + 0.1 div × volts/div setting)
	100 mV/div – 995 mV/div	±(0.35% × | Net Offset[1] | + 15 mV + 0.1 div × volts/div setting)
	1 V/div – 10 V/div	±(0.35% × | Net Offset[1] | + 150 mV + 0.1 div × volts/div setting)
Accuracy, DC Voltage Measurement, Averaged[3]	Average of ≥ 16 waveforms	±(1.0% × |(reading – Net Offset[1])| + Offset Accuracy + 0.06 div × volts/div setting)
	Delta Volts between any two averages[2] of ≥ 16	±(1.0% × | reading | + 0.3 mV + 0.1 div× volts/div setting)

Table 2–7: Warranted Characteristics — Signal Acquisition System (Cont.)

Name	Description	
Analog Bandwidth, DC-50 Ω Coupled or DC-1 MΩ Coupled	**Volts/Div**	**Bandwidth[4]**
	5 mV/div – 10 V/div	DC – 500 MHz
	2 mV/div – 4.98 mV/div	DC – 350 MHz
	1 mV/div – 1.99 mV/div	DC – 250 MHz
Cross Talk (Channel Isolation)	≥ 100:1 at 100 MHz and ≥ 30:1 at the derated bandwidth for any two channels having equal volts/division settings	
Input Impedance, DC-1 MΩ Coupled	1 MΩ ± 0.5% in parallel with 10 pF ±2 pF	
Input Impedance, DC-50 Ω Coupled	50 Ω ± 1% with VSWR ≤ 1.3:1 from DC – 500 MHz	
Input Voltage, Maximum, DC-1 MΩ, AC-1 MΩ, or GND Coupled	300 V CAT II; derate at 20 dB/decade above 1 MHz	
Input Voltage, Maximum, DC-50 Ω or AC-50 Ω Coupled	5 V_{RMS}, with peaks ≤ ±30 V	
Lower Frequency Limit, AC Coupled	≤ 10 Hz when AC–1 MΩ Coupled; ≤ 200 kHz when AC – 50 Ω Coupled[5]	
Delay Between Channels, Full Bandwidth, Equivalent Time	≤ 250 ps for any two channels with equal volts/division and coupling settings	

1 **Net Offset = Offset – (Position × Volts/Div). Net Offset is the nominal voltage level at the center of the A-D converter dynamic range. Offset Accuracy is the accuracy of this Voltage level.**

2 **The samples must be acquired under the same setup and ambient conditions.**

3 **To ensure the most accurate measurements possible, run an SPC calibration first. When using the oscilloscope at a Volts/Div setting ≤ 5 mV/div, an SPC calibration should be run once per week to ensure that instrument performance levels meet specifications.**

4 **The limits given are for the ambient temperature range of 0° C to +30° C. Reduce the upper bandwidth frequencies by 4.0 MHz for each ° C above +30° C.**

5 **The AC Coupled Lower Frequency Limits are reduced by a factor of 10 when 10X, passive probes are used.**

Table 2–8: Warranted Characteristics — Time Base System

Name	Description
Accuracy, Long Term Sample Rate and Delay Time	±25 ppm over any ≥ 1 ms interval

Table 2–9: Warranted Characteristics — Triggering System

Name	Description		
Accuracy (Time) for Pulse-Glitch or Pulse-Width Triggering	**Time Range**	**Accuracy**	
	2 ns to 1 μs	±(20% of setting + 0.5 ns)	
	1.02 μs to 1 s	±(100 ns + 0.0025% of setting)	
Sensitivity, Edge-Type Trigger, DC Coupled[1]	**Trigger Source**	**Sensitivity**	
	CH1 – CH4	0.35 division from DC to 50 MHz, increasing to 1 division at 500 MHz	
		0.55 division from DC to 50 MHz, increasing to 1.5 division at 500 MHz	
	Auxiliary	0.25 volts from DC to 50 MHz	
Width, Minimum Pulse and Rearm, for Pulse Triggering	**Pulse Class**	**Minimum Pulse Width**	**Minimum Rearm Width**
	Glitch	2 ns	2 ns + 5% of Glitch Width Setting
	Runt	2.5 ns	2.5 ns
	Width	2 ns	2 ns + 5% of Width Upper Limit Setting
Accuracy, Trigger Level or Threshold, DC Coupled	**Trigger Source**	**Accuracy**[2]	
	Any Channel	±(2% of |(Setting – Net Offset)| + 0.3 div × volts/div setting + Offset Accuracy)	
	Auxiliary	±(6% of |Setting| + 8% of p-p signal + 100 mV)	
Jitter (Option 05 Video Trigger)	17 ns_{p-p} on HDTV signal; 60 ns_{p-p} on NTSC or PAL signal		
Input Signal Sync Amplitude for Stable Triggering (Option 05 Video Trigger)	0.6 division to 4 division (1 division to 4 divisions in Numerical Field)		

1 **The minimum sensitivity for obtaining a stable trigger. A stable trigger results in a uniform, regular display triggered on the selected slope. The trigger point must not switch between opposite slopes on the waveform, and the display must not "roll" across the screen on successive acquisitions. The TRIG'D LED stays constantly lighted when the SEC/DIV setting is 2 ms or faster but may flash when the SEC/DIV setting is 10 ms or slower.**

2 **The waveform interval (WI) is the time between the samples in the waveform record. Also, see the footnote for the characteristics *Sample Rate Range* and *Equivalent Time or Interpolated Waveform Rate* on page 2–4 and net offset on page 2–10.**

Table 2–10: Warranted Characteristics — Interfaces, Output Ports and Power Requirements

Name	Description	
Logic Levels, Main- and Delayed-Trigger Outputs	**Characteristic**	**Limits**
	V_{out} (HI)	≥ 2.5 V open circuit; ≥ 1.0 V into a 50 Ω load to ground
	V_{out} (LO)	≤ 0.7 V into a load of ≤ 4 mA; ≤ 0.25 V into a 50 Ω load to ground
Output Voltage and Frequency, Probe Compensator	**Characteristic**	**Limits**
	Output Voltage	0.5 V (base-top) ±1% into a ≥ 50 Ω load
	Frequency	1 kHz ±5%
Output Voltage, Channel 3 Signal Out	20 mV/division ±10% into a 1 MΩ load; 10 mV/division ±10% into a 50 Ω load	
Source Voltage	90 to 250 VAC_{RMS} CAT II, continuous range	
Source Frequency	45 Hz to 440 Hz	
Power Consumption	≤ 300 W (450 VA)	

Table 2–11: Warranted Characteristics — Environmental, Safety, and Reliability

Name	Description
Atmospherics	Temperature: Operating: +0° C to +50° C (disk drive operation limited to +4° C minimum); Non-operating: –22° C to +60° C Relative humidity with floppy disk (optional): Operating: To 80%, at or below +29° C; Operating: To 20%, at or below +50° C Non-operating: To 90%, at or below +40° C; Non-operating: To 5%, at or below +50° C Relative humidity without floppy disk: Operating: To 95%, at or below +40° C; Operating: To 75%, from +41° C to +55° C Altitude: To 4570 m (15,000 ft.), operating; To 12190 m (40,000 ft.), non-operating
Dynamics	Random vibration without floppy disk installed: 0.31 g_{RMS}, from 5 to 500 Hz, 10 minutes each axis, operating; 3.07 g_{RMS}, from 5 to 500 Hz, 10 minutes each axis, non-operating
User-Misuse Simulation	Electrostatic Discharge Susceptibility: Up to 8 kV with no change to control settings or impairment of normal operation; up to 15 kV with no damage that prevents recovery of normal operation by the user

Table 2–12: Certifications and compliances

EC Declaration of Conformity	Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility and Low Voltage Directive 73/23/ECC for Product Safety. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities: EN 50081-1 Emissions: EN 55022 Class B Radiated and Conducted Emissions EN 60555-2 AC Power Line Harmonic Emissions EN 50082-1 Immunity: IEC 801-2 Electrostatic Discharge Immunity IEC 801-3 RF Electromagnetic Field Immunity IEC 801-4 Electrical Fast Transient/Burst Immunity IEC 801-5 Power Line Surge Immunity Low Voltage Directive 73/23/EEC: EN 61010-1 Safety requirements for electrical equipment for measurement, control, and laboratory use
FCC Compliance	Emissions comply with FCC Code of Federal Regulations 47, Part 15, Subpart B, Class A Limits
Certifications	Underwriters Laboratories certified to Standard UL3111-1 for Electrical Measuring and Test Equipment. Canadian Standards Association certified to Standard CAN/CSA-C22.2 No. 1010.1-92, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use.
Temperature (operating)	0° C to +50° C
Altitude (maximum operating)	2000 meters
Safety Class	Test and Measuring
CSA Certified Power Cords	CSA Certification includes the products and power cords appropriate for use in the North America power network. All other power cords supplied are approved for the country of use.
Overvoltage Category	Category: Examples of Products in this Category: CAT III Distribution-level mains, fixed installation CAT II Local-level mains, appliances, portable equipment CAT I Signal levels in special equipment or parts of equipment, telecommunications, electronics
Pollution Degree 2	Do not operate in environments where conductive pollutants may be present.

Typical Characteristics

The tables in this section list the *typical characteristics* that describe the TDS 510A Digitizing Oscilloscope.

Typical characteristics are described in terms of typical or average performance. Typical characteristics are not warranted.

Table 2–13: Typical Characteristics — Signal Acquisition System

Name	Description				
Frequency Limit, Upper, 100 MHz Bandwidth Limited	100 MHz				
Frequency Limit, Upper, 20 MHz Bandwidth Limited	20 MHz				
Calculated Rise Time[1]	**Volts/Div Setting**		**Rise Time**		
	5 mV/div–10 V/div		800 ps		
	2 mV/div–4.98 mV/div		1.2 ns		
	1 mV/div–1.99 mV/div		1.6 ns		
Nonlinearity	<1 DL, differential; ≤ 1 DL, integral, independently based				
Step Response Settling Errors	**Volts/Div Setting**	**Step Amplitude**	**Settling Error (%)[2]**		
			20 ns	**100 ns**	**20 ms**
	1 mV/div–99.5 mV/div	≤ 2 V	≤ 0.5	≤ 0.2	≤ 0.1
	100 mV/div–995 mV/div	≤ 20 V	≤ 1.0	≤ 0.5	≤ 0.2
	1 V/div–10 V/div	≤ 200 V	≤ 1.0	≤ 0.5	≤ 0.2

Table 2–13: Typical Characteristics — Signal Acquisition System (Cont.)

Name	Description	
Accuracy, DC Voltage Measurement, Not Averaged	Any Sample	±(1.0% × |(reading – Net Offset[3])| + Offset Accuracy +0.6 mV × volts/div setting + 0.13 div)
	Delta Volts between any two samples acquired under the same setup and ambient conditions	±(1.0% × | reading | + 1.2 mV + 0.26 div × volts/div setting)

1 **The numbers given are valid 0°C to +30°C and will increase as the temperature increases due to the degradation in bandwidth. Rise time is calculated from the bandwidth. It is defined by the following formula:**

$$Rise\ \ Time\ \ (ns) = \frac{400}{BW\ \ (MHz)}$$

Note that if you measure rise time, you must take into account the rise time of the test equipment (signal source, etc.) that you use to provide the test signal. That is, the measured rise time (RT_m) is determined by the instrument rise time (RT_i) and the rise time of the test signal source (RTgen) according to the following formula:

$$RT_m{}^2 = RT_i{}^2 + RT_{gen}{}^2$$

2 **The values given are the maximum absolute difference between the value at the end of a specified time interval after the mid-level crossing of the step, and the value one second after the mid-level crossing of the step, expressed as a percentage of the step amplitude.**

3 **Net Offset = Offset – (Position × Volts/Div). Net Offset is the nominal voltage level at the center of the A-D converter dynamic range. Offset Accuracy is the accuracy of this Voltage level.**

Table 2–14: Typical Characteristics — Time Base System

Name	Description
Aperture Uncertainty	≤ 5 ps
Accuracy, Delta Time Measurement	For single-shot acquisitions using single-shot sample acquisition modes.[1] Time Measurement Error ≤ .15* Si + (25 ppm × |Reading|) + (Time Per Div ÷ 1000) Add 50 ps (typical) Channel Skew for 2 channel measurements. Sample calculation: To measure the width of a 65.5 ns pulse at 1 GS/sec sampling, Time Measurement Error ≤ (0.15 × 1 ns) + (2.5 × 10^{-5})(65.5 ns) + (50 ns/div ÷ 1000) ≤ 0.15 ns + 0.002 ns + 0.05 ns ≤ 202 ps

1 **The limits are given for signals having pulse height ≥ 5 div, pulse duration ≤ 10 divisions, reference level = 50% mid-point, filter set to Sin (x) /x acquired at ≥ 5 mV/div, 1.4 ≤ $^{Tr}/_{Si}$ ≤ 5, where S_i is the sample interval and t_r is the signal rise time.**

Table 2–15: Typical Characteristics — Triggering System

Name	Description	
	Trigger Source	
	Any Channel	
	Auxiliary	
Input, Auxiliary Trigger	The input resistance is $\geq 1.5\ k\Omega$; the maximum safe input voltage is ±20 V (DC + peak AC).	
Trigger Position Error, Edge Triggering	**Acquire Mode**	**Trigger-Position Error[1,2]**
	Sample, Hi-Res, Average	±(1 WI + 1 ns)
	Peak Detect, Envelope	±(2 WI + 1 ns)
Holdoff, Variable, Main Trigger	Minimum: For any horizontal scale setting, the *minimum* holdoff is 10 times that setting, but is never less than 1 µs or longer than 5 s. Maximum: For any horizontal scale setting, the *maximum* holdoff is at least 2 times the minimum holdoff for that setting, but is never more than 10 times the minimum holdoff for that setting.	
Width, Minimum Pulse and Rearm, for Logic Triggering or Events Delay[3]	5 ns	
Lowest Frequency for Successful Operation of “Set Level to 50%” Function	30 Hz	
Sensitivity, Edge Trigger, Not DC Coupled[4]	**Trigger Coupling**	**Typical Signal Level for Stable Triggering**
	AC	Same as DC-coupled limits[4] for frequencies above 60 Hz. Attenuates signals below 60 Hz.
	Noise Reject	Three and one half times the DC-coupled limits.[5]
	High Frequency Reject	One and one half times the DC-coupled limits[5] from DC to 30 kHz. Attenuates signals above 30 kHz.
	Low Frequency Reject	One and one half times the DC-coupled limits[5] for frequencies above 80 kHz. Attenuates signals below 80 kHz.
Sensitivities, Logic-Type Trigger/Events Delay, DC Coupled[6]	1.0 division, from DC to 100 MHz with a minimum slew rate of 25 divisions/µs at the trigger level or the threshold crossing.	
Sensitivities, Pulse-Type Runt Trigger[6]	1.0 division, from DC to 200 MHz with a minimum slew rate of 25 divisions/µs at the trigger level or the threshold crossing.	
Sensitivities, Pulse-Type Trigger Width and Glitch[6]	1.0 division with a minimum slew rate of 25 div/µs at the trigger level or the threshold crossing. For <5 µs pulse width or rearm time, 2 divisions are required.	
Sync Width (Option 05 Video Trigger)	min. 400 ns for HDTV signals	
Sync Duty Cycle (Option 05 Video Trigger)	min. 50 to 1	

Table 2–15: Typical Characteristics — Triggering System (Cont.)

Name	Description
Hum Rejection[7] (Option 05 Video Trigger)	NTSC and PAL: –20 dB without any trigger spec deterioration. Triggering will continue down to 0 dB with some performance deterioration.

1 **The trigger position errors are typically less than the values given here. These values are for triggering signals having a slew rate at the trigger point of ±0.5 division/ns.**

2 **The waveform interval (WI) is the time between the samples in the waveform record. Also, see the footnote for the characteristics *Sample Rate Range* and *Equivalent Time or Interpolated Waveform Rate* on page 2–4 and *Net Offset* on page 2–10.**

3 **The minimum pulse width and rearm width required for logic-type triggering or events delaying to occur.**

4 **The minimum sensitivity for obtaining a stable trigger. A stable trigger results in a uniform, regular display triggered on the selected slope. The trigger point must not switch between opposite slopes on the waveform, and the display must not "roll" across the screen on successive acquisitions. The TRIG'D LED stays constantly lighted when the SEC/DIV setting is 2 ms or faster but may flash when the SEC/DIV setting is 10 ms or slower.**

5 **See the characteristic *Sensitivity, Edge-Type Trigger, DC Coupled* in Table 2–9, which begins on page 2–11.**

6 **The minimum signal levels required for stable logic or pulse triggering of an acquisition or for stable counting of a DC-coupled events delay signal. Also, see the footnote for *Sensitivity, Edge-Type Trigger, DC Coupled* in this table. (Stable counting of events is counting that misses no events or produces no extra events.)**

7 **The input signal is clamped at the bottom of the sync for the trigger path only. To remove the hum from the display, use a Tektronix Video Display Clamp.**

Table 2–16: Typical Characteristics — Data Handling

Name	Description
Time, Data-Retention, Nonvolatile Memory[1,2]	Battery life is $\geq$ 5 years
Floppy disk	3.5 inch, 720 K or 1.44 Mbyte, DOS 3.3-or-later compatible

1 **The time that reference waveforms, stored setups, and calibration constants are retained when there is no power to the oscilloscope.**

2 **Data is maintained by small lithium-thionyl-chloride batteries internal to the memory ICs. The amount of lithium is so small in these ICs that they can typically be safely disposed of with ordinary garbage in a sanitary landfill.**