Scans
By
Outsource-Options
(NR1DX)

Outsource-Options
Suite 2M
187 Depot Road,
Hollis, NH 03049

nr1dx@arrl.net or Henderson@outsource-options.com

"High resolution scans of obsolete technical manuals"

If you purchased this manual from us (typically through our Ebay name of NR1DX) thank you very much. If you received this from a well-meaning "friend" for free we would appreciate your treating this much like you would "share ware". By that we mean a donation of at least $5-10 per manual is appreciated in recognition of the time, energy and quality of effort that went into preserving this manual. Donations via PayPal go to: nr1dx@arrl.net or can be mailed to us the address above. This is not a hobby for us but a semi-retirement business used to augment our diminished income in the face of the current degraded world economy.

Typically the scans in our manuals are done as follows;

1) Typed text pages are typically scanned in black and white at 300 dpi.
2) Photo pages are typically scanned in gray scale mode at 600 dpi
3) Schematic diagram pages are typically scanned in black and white at 600 dpi unless the original manual had colored high lighting (as is the case for some 70's vintage Tektronix manuals).

Original pages, which exceed the 8.5 x 11 format, are scanned with enough overlap so that they can be printed and pieced. This is done for primarily for two reasons, the time involved in post processing these to their original size is not trivial and most people do not have the ability to print 11 X 17 pages anyway.

If your looking for a quality scanned technical manual in PDF format please drop us a line at nr1dx@arrl.net. and we will be happy to email you a current list of the manuals we have available. If you don't see the manual you need on the list drop us a line anyway we may still be able to point you to other sources. If you have an existing manual you would like scanned please write for details, This can often be done very reasonably in consideration for adding your manual to our library.

Thanks

Dave Henderson, NR1DX

Dave Henderson
Outsource-Options

Front Panel Operation Reference

HP 54111D Digitizing Oscilloscope

Publication Part No. 54111-90913
Microfiche Part No. 54111-80913

Printed in the U.S.A. October 1988

Table of Contents

Chapter 4:

Chapter 5:

Chapter 6: Trigger Menu

Chapter 7:

Chapter 8:

Chapter 9:

Chapter 10:

Chapter 11:

Waveform Math Menu

Introducing the HP 54111D 1

Introduction

The Hewlett-Packard 54111D digitizing oscilloscope provides a selectable up to 2 gigasample/second digitizing rate, full HP-IB programmability, and a feature set for a wide range of applications.

Not only does the HP 54111D allow you to make two-channel simultaneous, high speed single-shot capture, but its extensive feature set and repetitive sampling capabilities make it useful as a high-speed, general-purpose oscilloscope as well.

For extensive waveform evaluation, the HP 54111D provides four 8k deep memories that can be viewed and measured. In addition, such easy-to-use features as zoom and pan, and automated measurements are available at the press of a key.

The HP 54111D's key features include:

- Up to 2 gigasample/second digitizing rate (one channel)
- 500 MHz repetitive bandwidth
- 500 MHz single-shot bandwidth
- 8k of acquisition memory per channel
- 10 nonvolatile waveform memories
- Vertical resolution up to eight bits with bandwidth limits
- Two-channel simultaneous capture at 1 gigasample/second
- Pre and post trigger viewing capability
- Automatic triggering and display scaling
- Automatic waveform measurements
- Waveform math functions (A + B, A - B, invert, A x B, integrate)
- Ten front-panel setup save/recall registers
- General-purpose input coupling
- Extensive triggering capabilities
- Color display
- Hardcopy output to printer or plotter
- Fully programmable over the HP-IB

How To Use This Manual

This manual is the most complete source of information concerning the front panel operation of the HP 54111D. It contains a great deal of information that is not included in other manuals, and it repeats important information presented in the other manuals so that you have one source of front panel information.

If you have not yet read the Getting Started Guide, do so now, and then use this manual when you have questions regarding details of the oscilloscope's operation.

To help you find information quickly, this manual is divided into 16 chapters. Chapters 1 through 14 consist of intructions, explanations, and examples on how to use the HP 54111D oscilloscope. Chapter 15 contains specifications and operating characteristics and chapter 16 contains the the HP 54114A optional 2 gigasample/second information. This manual also contains a table of contents and, of course, an index.

Basic Setup 2

Chapter Contents

This chapter contains an explanation of the power requirements, operating environment, and initial color display setup, as well as a list of accessories provided with the instrument.

WARNING

It is important that you provide the correct power source and operating environment for this instrument. Failure to do so can cause serious damage to the instrument and/or provide a health hazard to the user.

Operating Environment

The instrument must have adequate clearance on all surfaces to provide sufficient air flow for cooling.

CAUTION

Do not block any of the vent holes on the fans' air inlet.

The operating environment must be maintained within the following parameters:

- Temperature: 0° C to 55° C
- Humidity: 95% up to 40° C
- Altitude: 4572 meters (15,000 feet)

The instrument should be protected from temperature extremes that would cause condensation in the instrument.

Power Requirements

The HP 54111D requires a power source of 115 or 230 Vac + 15/ - 25%; 48 - 66 Hz single phase. Power consumption is approximately 350 watts maximum or 700 VA maximum. A screwdriver may be used to change the position of this switch.

CAUTION

Before connecting this instrument to the ac power source ensure that the line select switch on the rear panel is set to the correct voltage. This will avoid damage to the instrument.

Applying Power

The HP 54111D can be turned on after you have selected the correct setting on the line select switch, installed the appropriate power cord, and connected it to the power outlet. The circuit breaker trip current is 7.5 amps. The HP 54111D has two switches that can interrupt the power:

- The (mains) power breaker located in the upper right-hand corner of the rear panel

WARNING

If the mains breaker is in the ON or "1" position electrical current is present inside the HP 54111D. This current can cause electrical shock and personal injury.

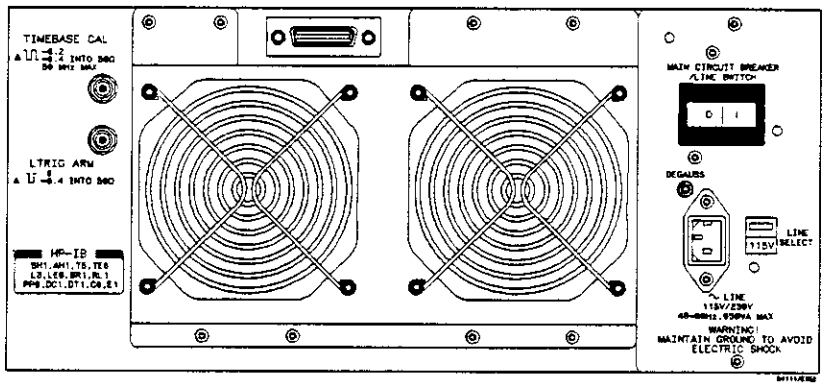


Figure 2-1. HP 54111D Rear Panel

- the STDBY switch located in the lower left-hand corner of the front panel

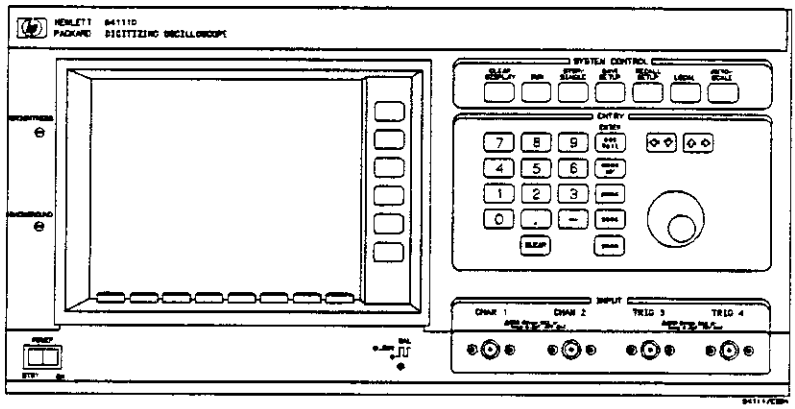


Figure 2-2. HP 54111D Front Panel

Display Setup

The 54111D's electromagnetic color display may require degaussing (i.e., demagnetizing) at installation, or later if necessary. If the display is fuzzy, smeared, or appears to have color distortion, press the degaussing button several times to demagnitize. The degaussing switch is located on the rear-panel on the power panel.

Two screwdriver adjust controls for brightness and background are located on the front panel, to the left of the CRT. The background control sets the luminosity of the background of the CRT. The brightness control sets the gain of the Z axis (i.e., controls the intensity of the information displayed on the CRT). Adjust these controls to a comfortable setting.

List of Accessories

In addition to any optional accessories you may have ordered, the HP 54111D is shipped with the following:

- two HP 10431A 10:1 miniature probes
- one power cable
- *Getting Started Guide*
- *Front Panel Operation Reference*
- *Programming Reference*
- *Feeling Comfortable With Digitizing Oscilloscopes*
- *Service Manual*

Front Panel Overview 3

Chapter Contents

This chapter contains a description of the functional areas that are controlled from the front panel. Use of these sections gives you complete instrument control.

Front Panel Organization

The front panel is separated into four funtional sections for maximum ease-of-use:

- System Control Section
- Entry Devices Section
- Display and Selection Section
- Input Section

You have complete local control of the instrument using these four sections.

System Control

The SYSTEM CONTROL keys are located along the top right half of the front panel. These keys control acquisition, dynamic display, SAVE/RECALL SETUP registers, and automatic display scaling.

Throughout this chapter, references are made to several of the HP 54111D's twelve menus. Each menu is discussed in detail throughout the chapters of this manual.

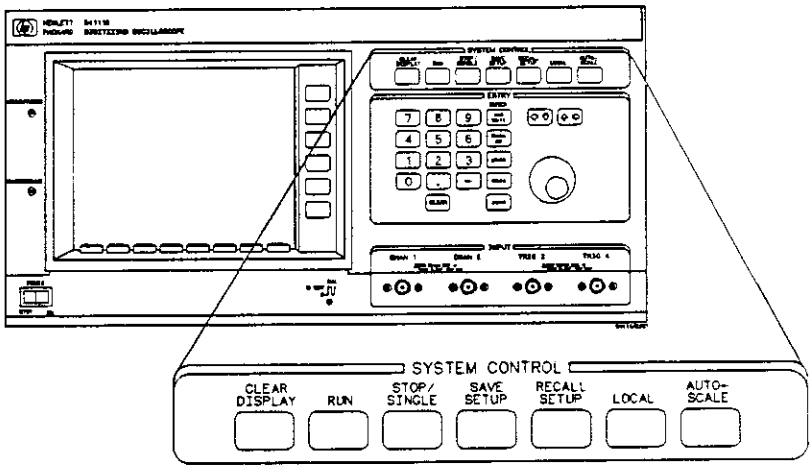


Figure 3-1. System Control

Clear Display Key Pressing the **CLEAR DISPLAY** key causes the HP 54111D to:

- momentarily stop acquiring data
- erase the screen
- resume acquiring data

When the **CLEAR DISPLAY** key is pressed and acquisition has been momentarily stopped, data acquisition is only stopped until the next trigger event. This is barely discernible on the screen.

Note

If the STOP/SINGLE key is pressed before the CLEAR DISPLAY key is pressed the screen remains clear and waveform acquisition does not resume until the RUN key is pressed.

If you have selected a high number of averages (repetitive display mode) and you change the input signal you can quickly set the average registers to the new signal levels by pressing the CLEAR DISPLAY key. This saves the time that the display normally requires to settle to the new signal levels in the average mode.

Run Key Pressing the **RUN** key causes the HP 54111D to resume acquiring data after acquisition has been stopped by the **STOP/SINGLE** key.

Stop/Single Key When the **STOP/SINGLE** key is pressed:

- The instrument stops acquiring data and displays the last acquired data. Each subsequent **STOP/SINGLE** key press arms the instrument to make a single acquisition at the next trigger event.

- To return to the previous operating mode, press the **RUN** key.

If a single acquisition is desired:

- press the **STOP/SINGLE** key to stop acquiring data
- then the **CLEAR DISPLAY** key
- then press the **STOP/SINGLE** key a second time

You can build up the display one acquisition at a time by continuing to press the **STOP/SINGLE** key (see Chapter 7 "Display Menu" for more details of the real time and repetitive display modes).

In the repetitive display mode, pressing the **STOP/SINGLE** key erases the active display if you change the value of TIME/DIV, VOLTS/DIV, or any other front panel control that rescales the displayed waveform (i.e., works as if the **CLEAR DISPLAY** key had been pressed).

In the real-time display mode, pressing the **STOP/SINGLE** key allows you to use the Timebase menu's TIME/DIV and DELAY functions to change the display. TIME/DIV allows you to change the sweep speed (zoom). DELAY allows you to pan the captured signal (pan).

Save/Recall Setup Keys

The HP 54111D allows you to save and recall up to ten different front panel setups in non-volatile memory. To save the current front panel setup in one of the SAVE/RECALL SETUP registers:

- press **SAVE SETUP**
- then press the number (0-9) of the register desired.

Note

This saves all front panel functions, modes, and color selections. This does not save menu selection and entry device assignments.

The front panel setups that are saved:

Channel 1/Channel 2	Display VOLTS/DIV OFFSET Input Coupling Input Impedance
Timebase	TIME/DIV DELAY Delay Reference Auto/Triggered Sweep
Trigger	Mode Edge Mode - All Parameters Pattern Mode - All Parameters State Mode - All Parameters Time Mode - All Parameters Events Mode - All Parameters
Display	Mode Resolution (Real Time Mode) Averaging (Repetitive Mode) Number of Averages (Repetitive Mode) DISPLAY TIME (Repetitive Mode) Screen Graticule

Delta V:	V Markers
	MARKER POSITIONS
	Preset/Variable Levels
Delta T:	T Markers
	START/STOP MARKER positions
	Edge Slopes
	Edge Numbers
Wfm Save:	Display (for each MEMORY)
	Source for Store (WAVEFORM MEMORIES)
Wfm Math:	Functions On/Off
	Function Definitions
Measure:	Source
Hardcopy:	Device
	Print Display (Printer)
	Print Factors (Printer)
	Form Feed (Printer)
	Auto Pen (Plotter)
	Pen Speed (Plotter)
Utility:	Probe Attenuation Factor
	Color Settings

Note

The display does not change when you press SAVE SETUP. It does put the advisory, "Setup Saved," on the screen.

Pressing **SAVE/RECALL SETUP** does not cause execution of action keys.

To recall a previously saved front panel setup:

- Press **RECALL SETUP**, then press the number (0-9) of the desired register. The advisory, *Setup Recalled*, will be displayed.

To return to the condition that existed before the last Autoscale:

- press **RECALL SETUP**, then press **AUTOSCALE**.

To cancel a SAVE/RECALL SETUP:

- press the **CLEAR** key before entering a 0-9 number.

Local Key When the **LOCAL** key is pressed an RTL (return to local) message is sent to the HP-IB interface and the instrument returns to local (front-panel) control, if it was under remote control.

The **LOCAL** key is the only front-panel key that is active when the HP 54111D is under remote operation, however it can be locked out by the HP-IB controller using a local lockout command.

Autoscale Key When the **AUTOSCALE** key is pressed the HP 54111D automatically selects the vertical sensitivity, vertical offset, trigger level, and sweep speed needed to display the input signal. The HP 54111D sets itself to a known state by setting the delay reference to center screen, and delay to 0.

If input signals are present at both vertical inputs:

- the sweep is triggered on channel 1
- the display is set in the dual-screen mode
- the vertical sensitivity and vertical offset for each channel are scaled appropriately

If only one of the vertical inputs has a signal on it the display is in the single-screen mode. When the AUTOSCALE cycle is complete the Timebase menu and TIME/DIV function are selected.

Entry Devices

Located in this portion of the front panel are the three entry devices:

- number pad
- knob
- increment/decrement key (step keys)

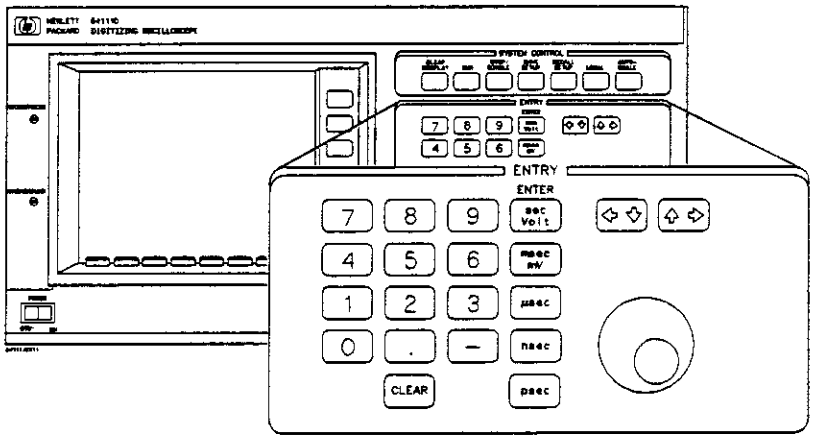


Figure 3-2. Entry Devices

The entry devices are used to change the value of any of the items in the function menus that are displayed in capital letters (e.g. VOLTS/DIV and TIME/DIV).

When an entry is made from the keypad it must be terminated using one of the keys in a vertical column below the ENTER label. This also identifies the units to scale the horizontal or vertical axes.

Display and Selection

The display and selection section contain the CRT, two manual adjustments, menu selection keys, and function selection keys.

The two manual adjustments are located to the left of the display. These are the brightness and background adjustments. Adjust them to a comfortable viewing level.

The HP 54111D provides two sets of selection keys that enable you to control the instrument's front panel. They are the menu and function selection keys.

Menu Selection

The first set (menu selection) is located across the bottom of the CRT and allows you to:

- choose a desired function menu
- change the function select keys
- pressing the more key (the key furthest right) provides an additional set of menu selections

Pressing the more key a second time returns you to the original menu.

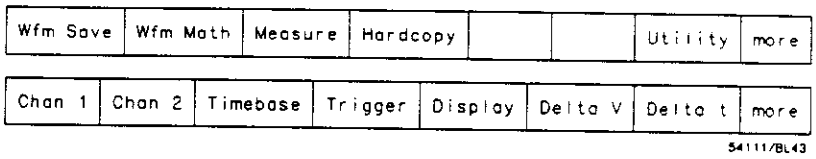


Figure 3-3. Menu Selection

Function Selection The second set (function selection) is located on the right-side of the CRT:

- Some function keys are displayed in inverse video, when pressed, the text in inverse video changes Example: pressing the top key when in the Trigger menu allows you to choose one of five trigger modes.

- Some function keys are displayed in all capital letters, when pressed, you can then use any of the entry devices to change the value of that function, and the value is displayed in the top center of the CRT. Example: pressing the TIME/DIV key when in the Timebase menu allows you to enter the sweep speed at which you want the input signal displayed.

- Some function keys are displayed with the first letter of each word capitalized and the rest in lower-case, when pressed, the function executes immediately. Example: pressing the All key in the Measure menu causes the oscilloscope to execute twelve parametric measurements on the designated waveform.

Note

If the function select key allows you to select a waveform source, the text of the selected source is the same color as the source's waveform. For example, if the default colors are used, text relating to channel 1 is yellow and text relating to channel 2 is green.

Input Section

This instrument has two vertical and two trigger inputs. All inputs have selectable input coupling and impedance. Each input's coupling and impedance can be set to ac at 1 MΩ, dc at 1 MΩ , dc at 50 Ω (not possible when using the HP 10431A probe), or ground. The triggers however, cannot be set to ground.

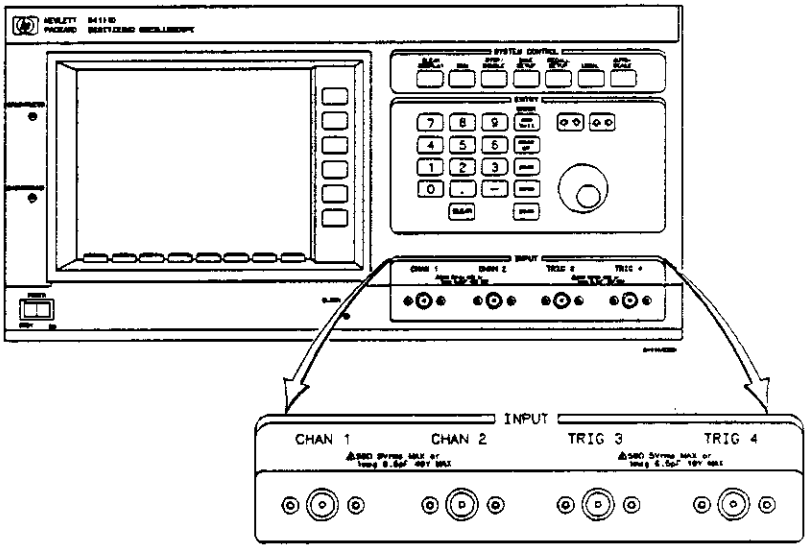
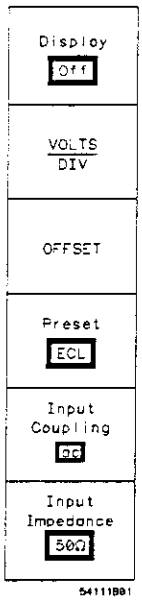


Figure 3-4. Input Section

Channel Menu 4

Chapter Contents



This chapter contains a description of how to control the vertical display, vertical scaling and offset. The channel menus (channel 1 and channel 2) allow you to control the vertical operation of the display as well as some of the HP 54111D's ease-of-use features, such as logic family presets.

The Chan 1 and Chan 2 menus are identical except for direct references to channels 1 and 2.

When you select Chan 1 or Chan 2 (the two left-most selection keys in the menu selection area), either OFFSET or VOLTS/DIV is highlighted indicating that that function can be changed using the entry devices.

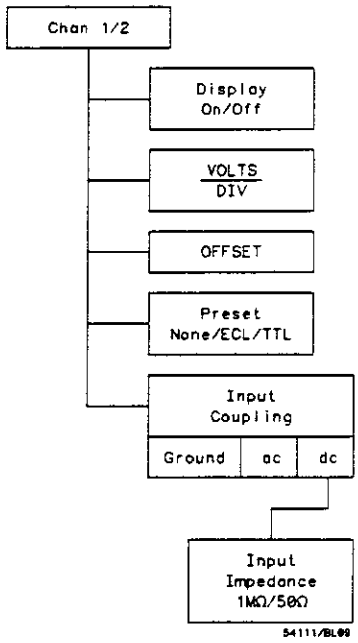


Figure 4-1. Channel Menu

Display On/Off Key

Pressing the **Display On/Off** key causes the selected channel signal to be displayed depending on whether On or Off is selected.

In the real-time mode, although this key turns off the display for a particular channel, it does not stop that channel from acquiring data. Turning off the channel (in both real-time and repetitive modes) increases throughput slightly because there is no post-processing of data. In the real-time display mode, you can view the data acquired while the display was off by turning the channel back on.

Volts/Div Key

When the **VOLTS/DIV** key is selected, the vertical sensitivity of the channel can be changed using any one of the three entry devices:

- Using the number pad and appropriate units key results in sensitivity to three-digit resolution.
- Using the knob, you can increase sensitivity (3 - 2 - 1 sequence) by turning it clockwise, and decrease sensitivity (1 - 2 - 3 sequence) by turning it counterclockwise.
- Using the increment/decrement (step) keys changes sensitivity in a 1 - 2 - 5 sequence.

Offset Key

OFFSET allows you to move the trace up or down via the number pad, the knob, or the step keys to a precise voltage level.

This function works much the same way as an analog oscilloscope's vertical position control. However, because this oscilloscope has a true dc offset on the front-end, it provides a much wider offset range.

The OFFSET voltage (referenced to the center of the waveform display) is shown at the top of the waveform display area.

Preset key

Preset provides three choices:

- ECL - the HP 54111D automatically selects the offset volts/div, trigger level, and input coupling to properly display logic family signals.
- TTL - the HP 54111D automatically selects the offset, volts/div trigger level, and input coupling to properly display logic family signals.
- None - the HP 54111D returns to its previous settings.

The ECL/TTL presets are:

	ECL	TTL
VOLTS/DIV*	200 mV	1 V
OFFSET	-1.3 V	1.6 V
Trigger level	-1.3 V	1.6 V
Input Coupling	dc	dc

* These values are for a single screen display; appropriate values are used for dual and quad screen displays.

To select the desired preset, press the preset key until your selection is highlighted (in inverse video).

Input Coupling key

The Input Coupling for the selected channel may be set to:

- ac - the default input impedance is 1 MΩ .
- dc - the bottom key on the function menu becomes active and allows the choice of either 1 MΩ or 50 Ω input impedance.
- ground - a baseline is displayed showing the location of 0 V, the signal path is not actually grounded.

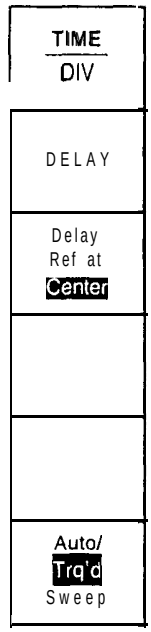
5 TIMEBASE MENU

Section Contents

- Description of how the Timebase menu is used to control the horizontal display.

Overview

The Timebase menu, which is automatically selected after an AUTO-SCALE is performed, allows you to control the horizontal display through the TIME/DIV, DELAY, and Delay Reference functions. This menu also allows you to select a triggered function. It defaults to automatic trigger.



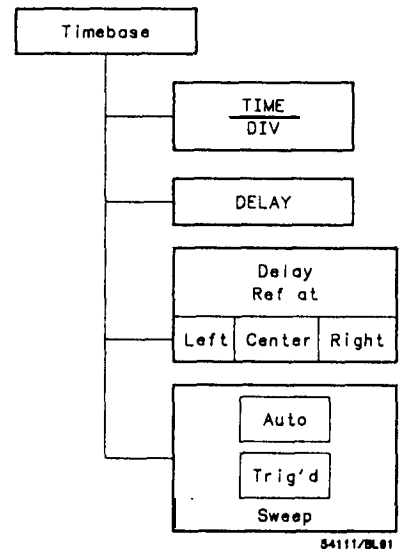


Figure 5-1. Timebase Menu.

Time/Div Key

The TIME/DIV key allows you to vary the time scale on the horizontal axis from 1 s/div to 500 ps/div. This is located at the top of the function menu.

You can use any of the entry devices to vary this scale:

- using the number pad and appropriate ENTER key, the results in sensitivity can be adjusted with up to three digits of resolution.
- using the knob, you can change the sweep speed in a l-2-5 sequence.
- using the increment/decrement keys, you can also change the sweep speed in a l-2-5 sequence.

This key affects the sample rate at which the scope acquires data. The sample rate for the selected sweep speed is displayed to the right of the sweep speed setting.

In the real-time mode and with acquisition stopped, this key also controls the zoom feature (see Chapter 7, “Display Menu”).

Sweep Speed	Sample Rate	Memory Depth (real-time only)
500 ps/div - 99.9 ns/div	2 gigasamples/s *	4.095 µs
500 ps/div - 99.9 ns/div	1 gigasample/s	8.19 µs
100 ns/div - 199 ns/div	500 megasamples/s	16.3 µs
200 ns/div - 499 ns/div	250 megasamples/s	32.7 µs
500 ns/div - 999 ns/div	100 megasamples/s	81.9 µs
1 µs/div - 1.99 µs/div	50 megasamples/s	163 µs
2 µs/div - 4.99 µs/div	25 megasamples/s	327 µs
5 µs/div - 9.99 µs/div	10 megasamples/s	819 µs
10 µs/div - 19.9 µs/div	5 megasamples/s	1.63 ms
20 µs/div - 49.9 µs/div	2.5 megasamples/s	3.27 ms
50 µs/div - 99.9 µs/div	1 megasamples/s	8.19 ms
100 µs/div - 199 µs/div	500 kilosamples/s	16.3 ms
200 µs/div - 499 µs/div	250 kilosamples/s	32.7 ms
500 µs/div - 999 µs/div	100 kilosamples/s	81.9 ms
1 ms/div - 1.99 ms/div	50 kilosamples/s	163 ms
2 ms/div - 4.99 ms/div	25 kilosamples/s	327 ms
5 ms/div - 9.99 ms/div	10 kilosamples/s	819 ms
10 ms/div - 19.9 ms/div	5 kilosamples/s	1.63 ms
20 ms/div - 49.9 ms/div	2.5 kilosamples/s	3.27 s
50 ms/div - 99.9 ms/div	1 kilosample/s	8.19 s
100 ms/div - 199 ms/div	500 samples/s	16.3 s
200 ms/div - 499 ms/div	250 samples/s	32.7 s
500 ms/div - 999 ms/div	100 samples/s	81.9 s
1 s/div	50 samples/s	163 s

Table 5-1. Sample Rate

* with HP 54114A (Option 114) installed

Delay Key

The **Delay** key controls the pre-trigger and post-trigger delay and can be varied via the entry devices. The maximum pre/post trigger delays change with sweep speed and the delay reference setting.

In the real time mode when acquisition is stopped, DELAY controls the pan feature (see Chapter 7, "Display Menu").

When the DELAY function is selected delay time is displayed at the top of the waveform display area:

- negative delay values indicate time before the trigger
- positive delay values indicate time after the trigger
- delay = 0 means the trigger occurs at the delay reference point (right, left, or center of display)

Delay Reference Key

The delay reference key (**Delay Ref**) allows you to reference the delay to the right or left graticule edge or center screen. In the real time mode, the display is referenced to the left/center/right of the entire 8k record.

- the time at the delay reference is equivalent to the delay time.
- Delay = 0 is the trigger point

Memory Bar

Only in the real time mode:

- a memory bar is displayed at the top of the waveform area.
- you can view 501 points on screen.

The memory bar baseline represents the entire waveform record. As the **Delay Ref** key is cycled, the memory bar moves from the left/right/center of the memory bar, echoing the **Delay Ref** key. This highlighted line segment shows you which portion of the waveform record is being displayed.

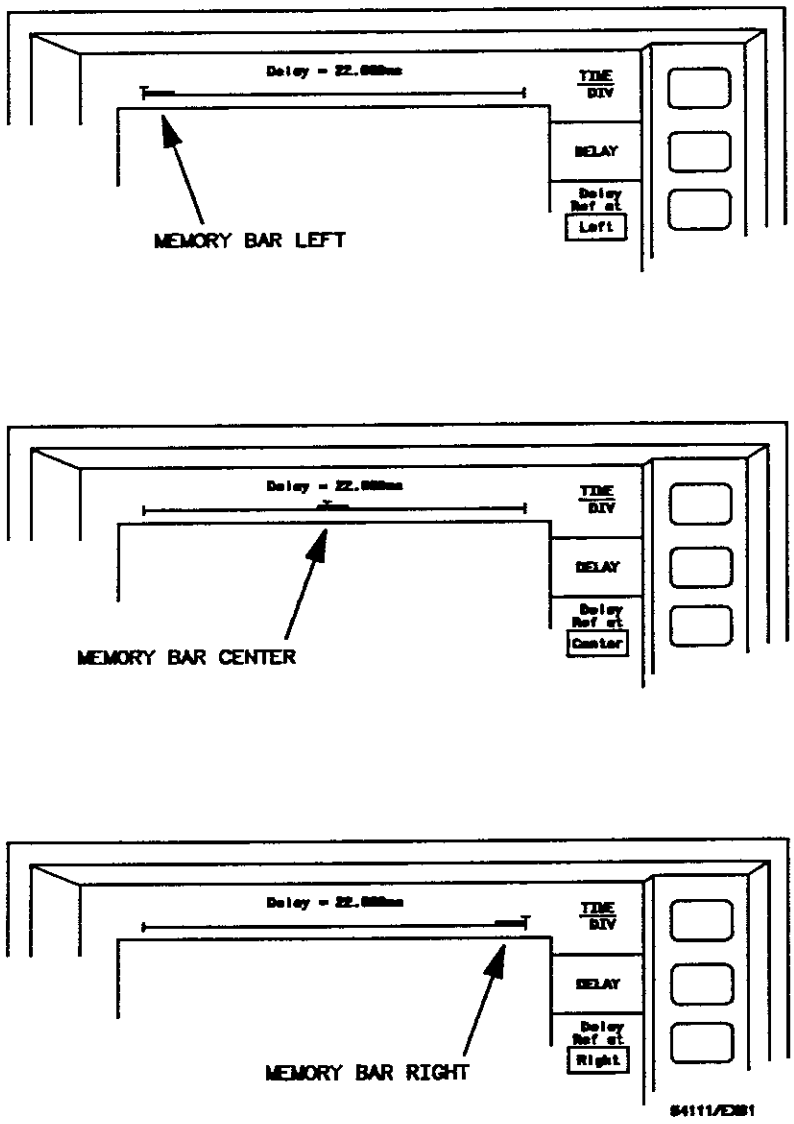


Figure 5-2. Memory Bar at Delay Left/Center/Right

A "T" is also displayed along with the memory bar. The "T" shows where the trigger point is relative to the portion of the waveform being displayed.

Increasing the delay time moves the "T" to the left and decreasing delay time moves it to the right (see Chapter 7, "Display Menu" for more details).

Auto/Trg'd Sweep Key

The HP 54111D allows you to choose the trigger type. The instrument will trigger on the waveform in your application, or if you do not know if or when a trigger event will occur you can set the HP 54111D to generate a trigger.

Auto-Sweep

If you choose auto sweep and there is not a signal input the HP 54111D provides a baseline on the display. If you choose auto sweep and there is a signal but it is not triggered the display is unsynchronized, but a baseline is not provided.

Triggered Sweep

Always use triggered sweep if the trigger repetition rate is slower than 50 Hz (as would be the case for long DELAY or large TIME/DIV settings).

If you choose triggered sweep and no trigger is present the HP 54111D does not sweep, and the data acquired on the previous trigger remains on-screen.

Triggered sweep prevents the HP 54111D from generating a sweep before the trigger event. The displayed signal initiated by auto-sweep is asynchronous with the signal on the sweep initiated by the trigger event. The oscilloscope triggers normally if the trigger repetition rate is faster than 50 Hz.

Status Line

The status line that is displayed in the upper left-hand corner of the screen indicates the current trigger status. It is updated approximately twice each second.

In the triggered-sweep mode, the status line indicates whether the instrument is *Running* or *Awaiting Trigger.* In the auto-sweep mode, the status line indicates whether the instrument is *Running* or *Auto Triggering.* Other status indications are *Stopped, Measuring, Printing, Plotting,* and *Testing.*

A/D Reference Calibration

The HP 54111D automatically performs an A/D reference calibration on its A/D converters for both channels when the HP 54111D's operating system determines the need. This feature provides consistent measurements without requiring you to make adjustments, and has been designed to not interfere with user measurements. When the HP 54111D is awaiting a trigger, the A/D reference calibration is disabled. However, it is important to note that the HP 54111D's A/D references may drift while it is awaiting a trigger.

If the ambient temperature is steady, drift is insignificant. Drift becomes significant when the ambient temperature changes more than 5° F (2.5 ° C) during the time when calibration is disabled.

There are two ways to avoid problems from this phenomenon:

- Generally, it is sufficient to keep the HP 54111D in a *Stopped* status until 30 seconds before the trigger. While Stopped, the HP 54111D will calibrate itself if RUN is pressed before an acquisition.

- Perform an A/D reference calibration (see Chapter 14 "Utility Menu") just before setting the HP 54111D to trigger on the event. This procedure can be initiated over the bus under program control, by simulating key presses (see Chapter 2 of the HP 54111D *Programming Reference Manual,* KEY command).

In computer-aided-test applications, the A/D reference calibration can be performed periodically during the test cycle to prevent interruption of tests by unplanned calibrations.

If important data is taken, you can determine the offset and reference calibrations by inserting dc signals at three divisions above and below center screen immediately after the acquisition. This data can be processed under computer control to remove the effects of any reference skew.

Trigger Menu 6

Chapter Contents

This chapter contains a description of the oscilloscope's five trigger modes. The HP 54111D has two external trigger inputs and the two full channel inputs that can be used as trigger inputs.

There are examples demonstrating all triggering techniques to help you better understand the sophisticated triggering capabilities.

The Trigger menu allows you to select the trigger modes. In each of the trigger modes you can select source, slope, and holdoff. In addition, this menu is your access to the HP 54111D's logic-pattern triggering capability.

The trigger menu provides five trigger modes:

- edge
- pattern
- state
- time-delay
- event-delay

These are accessed by pressing the Trigger Mode key (the top function key) until the mode you want is displayed in inverse video.

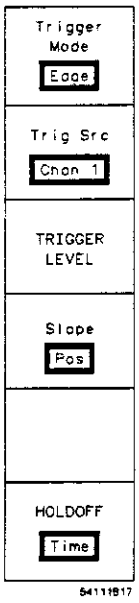
How the Trigger Modes Overlap

Specify TRIGGER LEVEL (i.e., threshold) while in the Edge Trigger mode. This trigger level applies to all five trigger modes. It is the only parameter that is passed unchanged from mode to mode once specified (Chan 1 & 2, Trig 3 & 4).

If the trigger repetition rate is below 50 Hz, always use the triggered-sweep function (see "Timebase Menu", Chapter 5). This prevents the oscilloscope from prematurely producing a trigger when there is a large event-delay count or delay time.

Edge Trigger

The edge mode allows you to:



- Select one of four trigger sources (Trig Src key)
- Adjust the trigger level (TRIGGER LEVEL key)
- Select the slope of the input signal that defines the trigger (Pos/Neg key)
- Select the coupling, input impedance, and attenuation for the trigger sources 3 and 4
- Define the HOLDOFF in time or events.

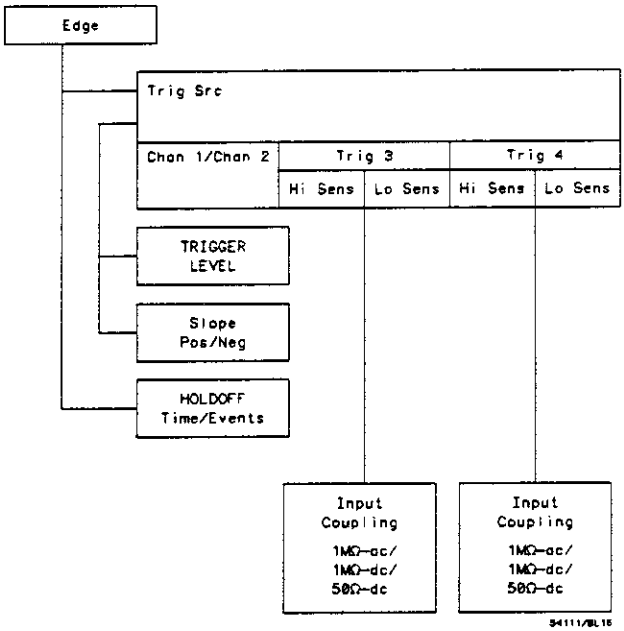


Figure 6-1. Edge Trigger Menu

Trg Src Key The **Trig Src** key permits you to select one of four trigger sources:

- Chan 1
- Chan 2
- Trig 3
- Trig 4

TRIGGER LEVEL Key If you select channel 1 or 2 as the trigger source and then press **TRIGGER LEVEL** a horizontal dotted line is displayed showing the trigger level with respect to the displayed signal.

Slope Key Press **Slope** to define the triggering edge as either the rising or falling edge of the selected input signal.

Note

Both the trigger slope and level can be set independently for each source and are retained even when another trigger source or mode is selected.

Coupling Key If you select **TRIG 3** or **TRIG 4** you can choose from different maximum trigger sensitivities (see Chapter 15, "Specifications").

Channels 1 and 2 can be set for coupling of either 50 Ω dc, 1 MΩ ac or dc input impedance

HOLFOFF Key Holdoff allows you to disable the oscilloscope's trigger circuit for a definable period of time or number of events after a trigger event occurs. Pressing the **HOLDOFF** key allows you to define holdoff.

Note

An event is a change in the input that satisfies the trigger conditions.

To change holdoff settings use any of the entry devices. If selected, the holdoff is displayed at the top of the waveform display area.

If you select HOLDOFF Time:

- you can define a holdoff from 70 ns to 670 ms.

Note

For holdoff-by-time values > 50 ms and holdoff-by-events values that cause a holdoff time > 50 ms use the triggered sweep function (see "Timebase Menu, chapter 5).

If you select HOLDOFF Events:

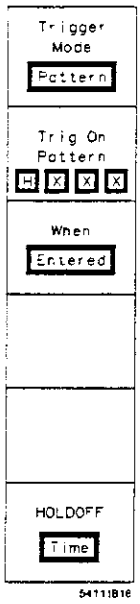
- you can define a holdoff from two events to 67,000,000 events.
- maximum counting rate for events is 80 MHz.
- you can trigger stably on a complex waveform by counting the number of trigger events that are to be skipped before accepting the next for a trigger. Setting the holdoff to one less than the number of events occurring over the fundamental period yields a stable display.

Holdoff-by-events is equivalent to placing a divide-by-N counter in the trigger path where N is the holdoff value.

Unlike older analog oscilloscopes, the HP 54111D's trigger system is completely independent of the timebase. This means that adjusting the DELAY or TIME/DIV function does not disturb the display synchronization established with holdoff.

Pattern Trigger

The pattern mode allows you to set up the HP 54111D to trigger on a four-bit pattern and trigger:



- when entering
- when exiting
- when pattern is present < or > a specified amount of time.

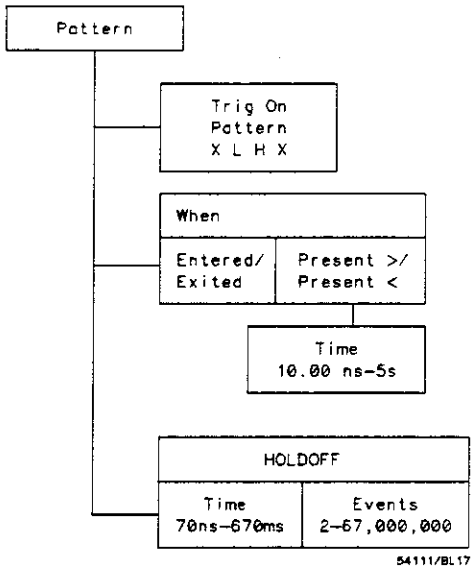


Figure 6-2. Pattern Menu

Trig On PATTERN Key

Pressing the **Trig On PATTERN** key highlights one of four characters that are displayed in inverse video. The four characters are referred to as channel 1, channel 2, trigger input 3, and trigger input 4, respectively.

Use one of the entry devices to change this character to one of three letters:

- X is a "don't care" condition (i.e., a bit with an X means that the associated input is not used as a trigger qualifier).
- L requires an input less than the trigger level of that input.
- H requires an input greater the trigger level of that input.

For example, if the pattern is "LHXX," then the voltage on the channel 1 signal must be below the trigger level set up for channel 1 and the voltage on the channel 2 signal must be above the trigger level set up for channel 2 to satisfy the pattern condition. The signals on trigger inputs 3 and 4 are ignored as they are set to the "don't care" condition.

The condition for the input associated with the highlighted bit is displayed at the top of the waveform display area.

Set the TRIGGER LEVEL for each trigger source while you are in the edge mode. These trigger levels must be set before going to the pattern mode or proper pattern triggering may not occur.

When Entered /Exited/Present < /Present > Key

When you press the **When** key the inverse video text field next to the key changes from:

- Entered
- Exited
- Present <
- Present >

If *Entered* is selected the HP 54111D triggers on the last transition that makes the PATTERN true.

If *Exited* is selected the HP 54111D triggers on the first transition on any of the inputs that cause the PATTERN to be false, after it has been true and then becomes false.

If *Present* > is selected a **TIME** key is added to the Pattern menu that allows you to define a minimum time period (from 10 ns to 5 seconds) before a trigger event occurs when the PATTERN becomes false after being true for the minimum time period.

Note

If the pattern becomes true and then goes false before the specified time, a trigger does not occur.

When *Present* < is selected a trigger occurs only if the trigger pattern is true and then becomes false before the specified time period has elapsed. The pattern must be true for at least 1 ns to be recognized and only occurs at the first transition that makes the pattern false.

HOLDOFF Key Pressing HOLDOFF allows you to specify holdoff in either events or time.

Pattern Trigger Exercise

This exercise demonstrates how the input signals can be used to generate a trigger.

Pattern triggering can be useful when you are testing digital circuitry and must qualify an acquisition with signals from more than one source.

The equipment required to complete this exercise includes:

- HP 54111D oscilloscope
- HP 8116A function generator
- BNC tee
- two one-meter coaxial cables

You may use another function generator as long as it is capable of providing:

- variable width
- 10 MHz
- 2 V output
- 5 ns rise/fall time
- minimum pulse width of 10 ns

Initial Setup Set up the instruments by:

- connecting the BNC tee to channel 1 of the HP 54111D
- connecting one cable from the output of the function generator to the BNC tee on channel 1
- connecting the other cable from channel 2 to the other side of the BNC tee

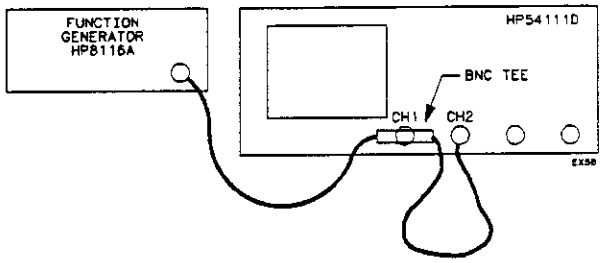


Figure 6-3. Instrument Hook-up

The unequal cable lengths between the function generator and channels 1 and 2 provide a time differential between the signals displayed on the oscilloscope. The amount of propagation delay that is generated by a one meter cable is approximately 6 to 7 ns. The delay between channels is used to demonstrate the triggering capability of the HP 54111D.

Instrument Setup Set the function generator controls as follows:

- Function = Pulse
- Frequency = 10 MHz
- Width = 50 ns
- Amplitude = 2 V
- Offset = 0 V

If you are using an HP 8116A function generator, ensure that the "DISABLE" light is off.

After pressing AUTOSCALE, set the controls as follows:

Timebase menu	TIME/DIV = 5 ns/div
	Sweep mode = Trg'd
Display menu	Display = Single Screen
	Graticule = Axes
Chan 1 & 2 menus	offset = 0
	Chan 1 & 2 coupling = dc
	Chan 1 & 2 input impedance = 50 Ω
	Chan 1 & 2 VOLTS/DIV = 200 mV/div
Trigger menu	TRIGGER LEVEL for Chan 1 & 2 = 0
	Trig Src = Chan 1

After the setup is complete the oscilloscope should be triggering on the positive edge of channel 1.

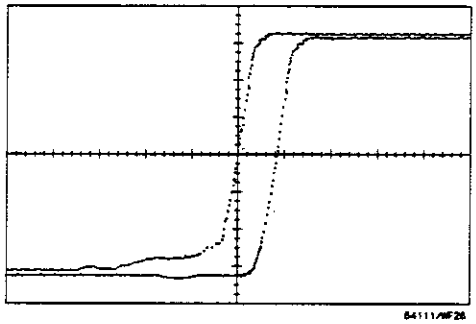


Figure 6-4. Pattern Trigger Waveform

Pattern When Entered

- select the Trigger menu
- select the Pattern Trigger Mode
- select *When Entered*

This causes the HP 54111D to generate a trigger on the edge that makes the trigger pattern true. In the pattern trigger mode, the HP 54111D can trigger when entering or exiting a pattern.

The **Trig On Pattern** key allows you to define a pattern that is used to trigger the oscilloscope. For this exercise use HHXX. **H** indicates high, and **X** indicates a "don't care" condition.

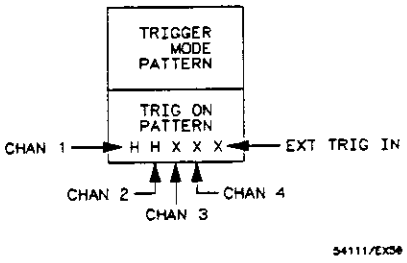


Figure 6-5. Setting the Pattern

This pattern requires that the signals on channel 1 and 2 must be positive with respect to the trigger level in order to generate a trigger.

When you set up the oscilloscope for this exercise, the trigger level for channels 1 and 2 were set to 0 V. This means that the last input either on channel 1 or 2 that goes above 0 V generates a trigger.

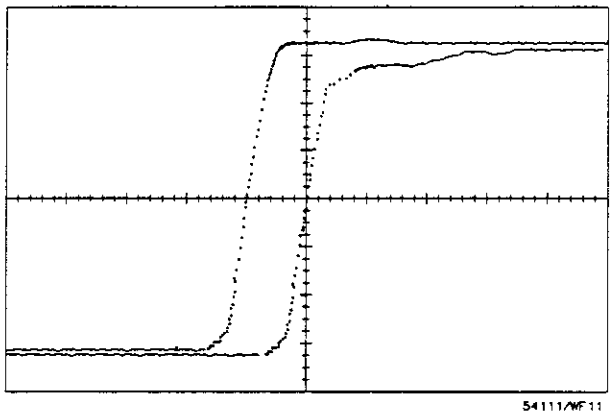


Figure 6-6. Pattern HHXX Waveform When Entered

In this exercise, you referenced the trigger event to center screen. Notice that the signal from channel 2 crosses center screen at the 0 V level. This crossing completes the requirement for the trigger event.

Pattern When Exited

You can also set up the HP 54111D to trigger on the first edge that makes the trigger pattern false by pressing the **When** key and selecting *Exited* as the variable. In this example, the first edge to make the pattern false is the negative edge from channel 1.

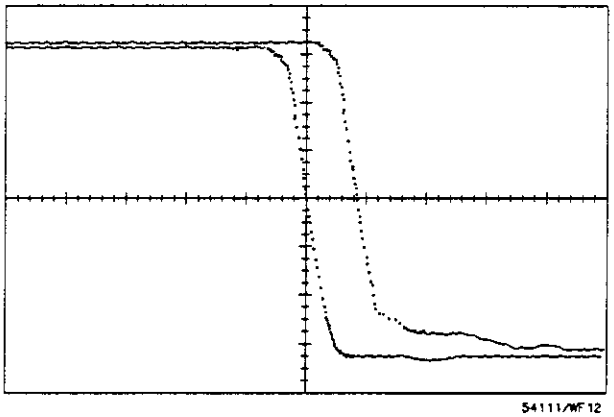


Figure 6-7. Pattern HHXX Waveform When Exited

Time-qualified Pattern

Along with the ability to trigger on the exit or entry of a pattern the HP 54111D can qualify a pattern trigger with time. You may set the oscilloscope to trigger on a pattern that has been present for a minimum or maximum period of time by selecting the When Present > or < function.

Applications for this trigger mode include:

- glitch detection
- triggering on timing violations
- capturing bus hangup conditions

For the HP 54111D to generate a trigger when it is in the When Present mode:

- the pattern must be present for a minimum period of time between 10 ns and 5 seconds
- one of the pattern sources must change, causing the pattern to be invalid.

The minimum time period available is 10 ns, and the maximum is 5 seconds.

Select the When Present > function and set time = 10 ns (if it isn't already). With the HP 54111D in this configuration:

- it will trigger on the first edge that causes pattern HHXX to be false after it has been present for a minimum of 10 ns.
- from the time that channel 2 satisfies the trigger until channel 1 goes false is 50 - 55 ns.
- this allows the HP 54111D to trigger on the negative edge of channel 1 the same way it did when you used the When Exited mode.

Select the When Present < function and notice that the signals are no longer displayed and the prompt in the upper left corner of the display indicates the instrument is *Awaiting Trigger.*

For the HP 54111D to trigger in the When Present < mode, the pattern must be valid for a shorter period of time than specified by the time variable, in this case 10 ns.

In this example, to generate a trigger, channels 1 and 2 must transition to a high state. Then one of them must invalidate the pattern by moving to a low state within 10 ns of the edge that originally made the pattern true.

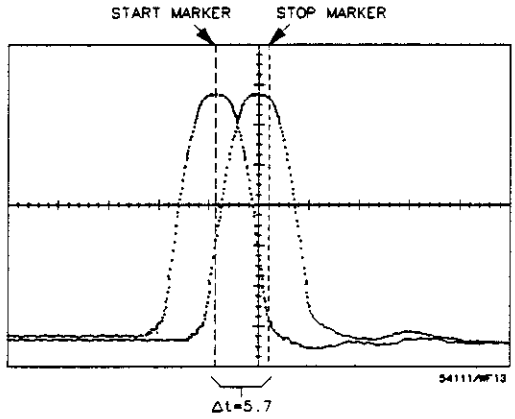


Figure 6-8. Waveform with 5.2 ns Overlap

Using the vernier keys on the function generator:

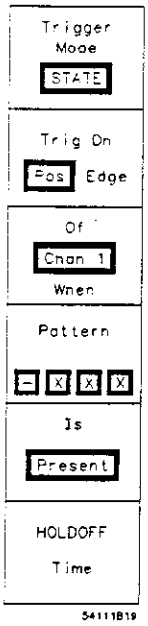
- set the pulse width to 10 ns - with the pulse set this narrow, the period of time that channels 1 and 2 satisfy the pattern requirements is about 3 ns (i.e., less than the 10 ns time qualifier).

- the oscilloscope starts triggering and the trace returns to the display.

- increase the pulse width in 1 ns increments until the instrument stops triggering:

- the oscilloscope should stop triggering when the pattern is validated for more than 10 ns, at about 15 ns pulse width. at this point, channels 1 and 2 validate the pattern for more than 10 ns and the trigger conditions are not met.

State Trigger



The State mode allows you to select one of the inputs as a simple edge source (clock), and use the other three to define a pattern (X, L, or H as in the pattern mode). This extends the logic triggering capability of the HP 54111D by letting you select one of the inputs as a clock and use the other inputs as a qualifier.

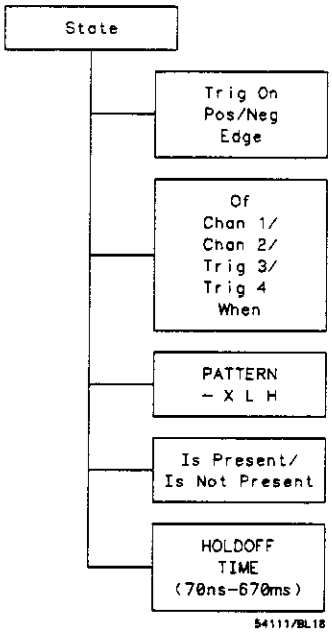


Figure 6-9. State Trigger Menu

The only limitations of the State Trigger Mode are:

- maximum clock speed of 80 MHz
- only holdoff by time is available

Trig On Pos/Neg Edge Key Pressing the **Trig On Pos/Neg Edge** key selects the polarity of the edge of the clock source as the trigger.

Of Key Pressing the **Of** key selects the clock source (Chan 1, Chan 2, Trig 3, or Trig 4). Notice that as you press the **Of** key the PATTERN key variables change. The " - " in the pattern shows which source is being used as the edge source or clock.

Pattern Key Pressing the **PATTERN** key allows the three remaining inputs to be set: - to **H** (high), **L** (low), or **X** (don't care) to define the logic pattern that is used to qualify the clock edge.

Is/Is Not Key Pressing the **Is/Is Not Present** key determines if the pattern must be present or must not be present to qualify the clock edge as a trigger.

The thresholds for each input of the pattern are those you set with TRIGGER LEVEL in the edge mode.

State Trigger Exercise

This exercise demonstrates how an input pattern can be used to qualify a clock edge that is to be used as a trigger.

This mode is useful when it is necessary to synchronize the display to a system clock and detect a system state. For example, consider a synchronous memory bus. The state trigger mode could be used if you want to see only events that occur when reading from a specific block of memory.

The equipment required for this exercise includes:

- HP 54111D oscilloscope
- HP 8116A function generator
- BNC tee
- two one-meter coaxial cables

Initial Setup Set up the instruments by:

- connecting the BNC tee to channel 1 of the HP 54111D
- connecting one cable from the output of the function generator to the BNC tee on channel 1
- connecting the other cable from channel 2 to the other side of the BNC tee.

The unequal cable lengths between the function generator and channel 1 and 2 provide a time differential between the signals displayed on the oscilloscope. The amount of propagation delay that is generated by a one meter cable is approximately 6 to 7 ns. The delay between channels is used to demonstrate the triggering capability of the HP 54111D.

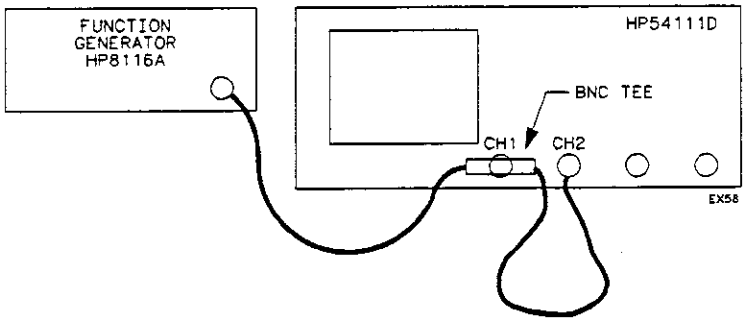


Figure 6-10. Equipment Hook-up

Instrument Setup Set the function generator controls as follows:

- Function = Pulse
- Frequency = 10 MHz
- Width = 50 ns
- Amplitude = 2 V
- Offset = 0 V

If you are using an HP 8116A function generator, ensure that the "DISABLE" light is off.

After pressing the AUTOSCALE key on the HP 54111D, set the controls as follows:

Timebase menu	TIME/DIV = 5 ns/div
	Sweep mode = Trg'd
Display menu	Display = Single Screen
	Graticule = Axes
Chan 1 & 2 menus	offset = 0
	coupling = dc
	input impedance = 50 Ω
	VOLTS/DIV = 200 mV/div
Trigger menu	TRIGGER LEVEL for chan 1 and 2 = 0
	Trig Src = Chan 1

After the setup is completed the oscilloscope should be triggering on the positive edge of channel 1.

Setting State Trigger

This exercise uses channel 2 as the edge source (clock) and channel 1 as the qualifier.

- Select the Trigger menu:
- press **Trigger mode** key until *State* is selected
- set **Trig On Pos/Neg Edge** key to *Pos*
- set the **Of** key variable to *Chan 2* to select channel 2 as the clock source
- set PATTERN = *H - XX*

This indicates that channel 1 must be high (above the trigger level) before a signal edge on channel 2 can be used to generate a trigger. Trig 3 and Trig 4 inputs are ignored because they are set to the "don't care."

In this configuration the HP 54111D triggers on the first positive edge on channel 2 that occurs during a high on channel 1.

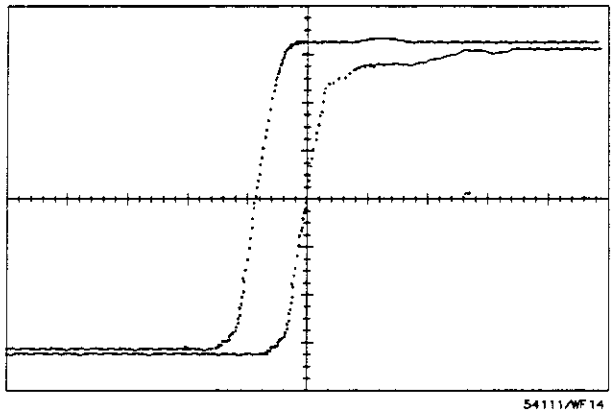


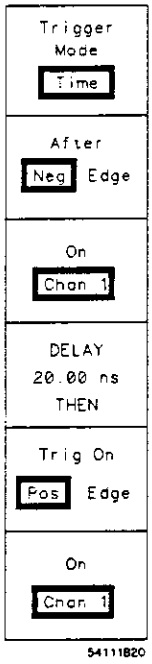
Figure 6-11. Pattern H-XX Waveform

Note

Notice that if you press the Is Present/Is Not Present key and change it to Is Not Present, the oscilloscope stops triggering (i.e., the signal on channel 1 is true when the positive-going edge on channel 2 occurs, therefore a trigger does not occur).

Time Trigger

The Time menu allows you to arm on a signal edge of any source, wait for a period of time and then trigger on an edge from any of the four inputs.



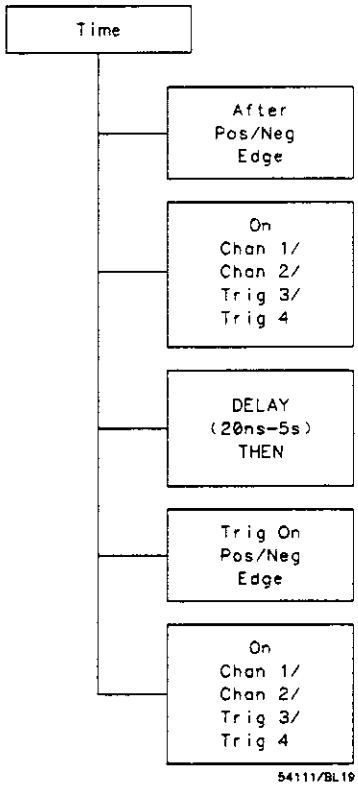


Figure 6-12. Time Trigger Menu

Pos/Neg Edge Key Pressing the **Pos/Neg Edge** key selects the polarity of the arming edge.

On Key Pressing the first **On** key selects the source of the arming edge.

DELAY...THEN Key Pressing the **DELAY .... THEN** key defines the period of time between the arming edge and the time the HP 54111D will accept a trigger. The range is from 20 ns to 5 seconds (use entry devices).

Trig On Pos/Neg Edge Key Pressing the **Trig On Pos/Neg Edge** key selects the polarity of the trigger edge.

On Key Pressing the second **On** key selects the source for the trigger edge.

Time Delay Trigger Exercise

This exercise demonstrates how to use time to qualify a trigger event. Frequently in digital circuits there is a period of time when an output is invalid after a state change. This exercise shows how to set the oscilloscope so that it will ignore potential trigger events until after a defined period of time.

The equipment required for this exercise includes:

- HP 54111D oscilloscope
- HP 8116A function generator
- two one-meter coaxial cables

Initial Setup Set up the instruments by:

- connecting the BNC to channel 1 of the HP 54111D
- connecting one cable from the output of the function generator to the BNC tee on channel 1
- connecting the other cable from channel 2 to the other side of the BNC tee.

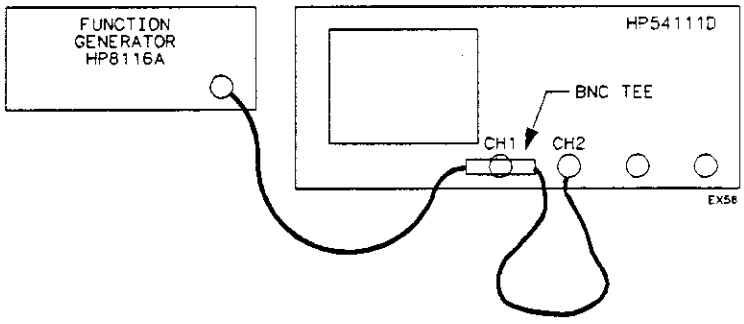


Figure 6-13. Equipment Hook-up

The unequal cable lengths between the function generator and channel 1 and 2 provide a time differential between the signals displayed on the oscilloscope. The amount of propagation delay that is generated by one meter cable is approximately 6 to 7 ns. The delay between channels is used to demonstrate the triggering capability of the HP 54111D. Instrument Setup

Set the function generator controls as follows:

- Function = Pulse
- Frequency = 10 MHz
- Width = 50 ns
- Amplitude = 2 V
- Offset = 0 V

If you are using an HP 8116A function generator, ensure that the "DISABLE" light is off.

After pressing AUTOSCALE, set the controls as follows:

Timebase menu	TIME/DIV = 5 ns/div
	Sweep mode = Trg'd
Display menu	Display = Single Screen
	Graticule = Axes
Chan 1 & 2 menus	offset = 0
	coupling = dc
	input impedance = 50 Ω
	VOLTS/DIV = 200 mV/div
Trigger menu	TRIGGER LEVEL for chan 1 and 2 = 0
	Trig Src = Chan 1

After the setup is complete the oscilloscope should be triggering on the positive edge of channel 1.

Setting Time Trigger

- Select the Trigger menu:
- press **Trigger menu** key until *Time* is selected
- Set **After Pos/Neg** key to *Pos*
- Set the first **On** key to *Chan 1*
- Set the **DELAY ... THEN** key to *DELAY 1.000 s THEN*
- Set the **Trig On Neg/Pos Edge** to *Neg*
- Set the second **On** key to *Chan 2*

In this configuration, the HP 54111D generates a trigger on the last of three sequential events:

- On channel 1, a positive-going signal must cross the trigger threshold
- One second must elapse
- On channel 2, a negative-going signal must cross the trigger threshold

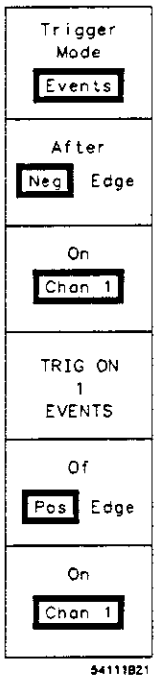
Press the CLEAR DISPLAY key and notice that the HP 54111D is triggering at one second intervals.

Change the delay time and notice the time between trigger intervals changes proportionally with the delay time.

Changing the polarity of the **Trig On Edge** key from *Neg* to *Pos* causes the HP 54111D to trigger on the positive edge of channel 2.

Event Trigger

The Event Trigger mode allows you to define an edge as a trigger qualifier. Once this edge is detected the HP 54111D will accept a trigger after a definable number of edges on any input.



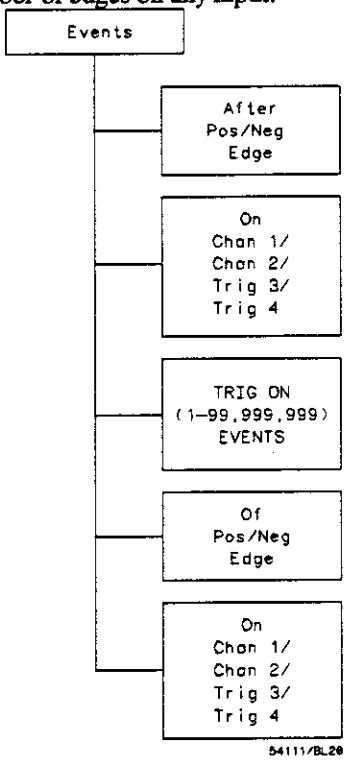


Figure 6-14. Events Trigger Menu

After Pos/Neg Edge Key Pressing the **After Pos/Neg Edge** key selects the polarity of the arming edge.

On Key Pressing the first **On** key selects the source of the arming edge.

TRIG ON N EVENTS Key Pressing the **TRIG ON N EVENTS** key defines the number of trigger events that must occur before the HP 54111D will trigger (after the qualifier). The range for this key is from 1 to 99,999,999 (use entry devices).

Of Pos/Neg Edge Key Pressing the **Of Pos/Neg Edge** key selects the polarity of the trigger edge.

On Key Pressing the second **On** key selects the source of the trigger edge.

The polarity of the arming edge and the trigger edge are complementary if only a single channel is selected.

Event Delay Trigger Exercise

This exercise demonstrates the ability of the HP 54111D to use events to delay the trigger.

One specific application for this trigger mode is to isolate a specific line of video information by delaying the trigger a specific number of horizontal sync pulses after you have initially qualified the event delay with the vertical sync.

The delay-by-events mode is particularly useful in systems where the data rate fluctuates or jitters, as in a disc drive. You could use the delay by events mode to arm on the index pulse in a disc drive, then trigger on a data pulse anywhere around the track. This stabilizes the display on a particular pulse.

The event trigger mode works much the same way as the time trigger mode, except that it allows you to delay the trigger using events rather than time.

The equipment required for this exercise includes:

- HP 54111D oscilloscope
- HP 8116A function generator
- two one-meter coaxial cables
- BNC tee

Initial Setup Set up the instruments by:

- connecting the BNC tee to channel 1 of the HP 54111D
- connecting one cable from the output of the function generator to the BNC tee on channel 1
- connecting the other cable from channel 2 to the other side of the BNC tee.

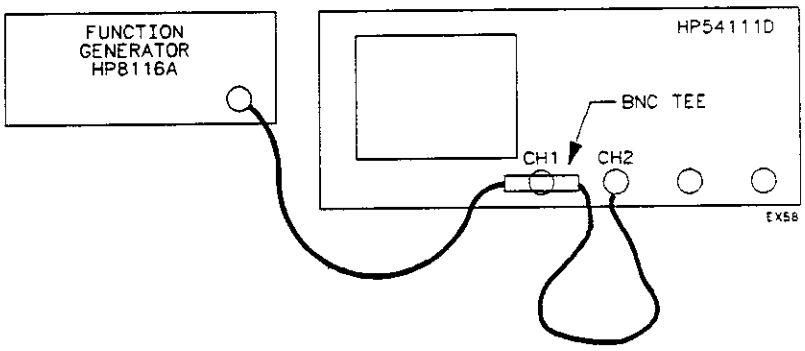


Figure 6-15. Equipment Hook-up

The unequal cable lengths between the function generator and channel 1 and 2 provide a time differential between the signals displayed on the oscilloscope. The amount of propagation delay that is generated by a one meter cable is approximately 6 to 7 ns. The delay between channels is used to demonstrate the triggering capability of the HP 54111D.

Setting Event Trigger

This exercise uses a positive edge on channel 2 to cause the oscilloscope to start counting a given number of edges from a second source (channel 1 in this exercise). The oscilloscope generates a trigger after the specified number of edges on the second source have been connected. Select the Trigger menu:

- Press **Trigger mode** key until *Event* is selected
- Set the **After Neg/Pos Edge** key to *Neg*
- Set the first **On** key to *Chan 2* to select Chan 2 as qualifier source.
- Set the **TRIG ON ... EVENTS** key to *TRIG ON 10,000,000 EVENTS* to define the number of events that are used to delay the trigger
- Set the **Of Pos/Neg Edge** key to *Pos* to select the positive edge for the trigger source
- Set the second **On** key to *On Chan 1* to select Chan 1 as the source for the delay events and the trigger

Press the **CLEAR DISPLAY** key and notice that the oscilloscope is triggering once a second. This is expected because the frequency of the function generator is set to 10 MHz.

Change the trigger-on-events number and notice the effect on the display. The trigger interval changes proportionally with the number of events.

Display Menu 7

Chapter Contents

This chapter contains a description of the real-time (single-shot) and repetitive digitizing modes, plus an example illustrating the use of pre/post-trigger displays and the memory bar.

Also included is a description of the 6/7/8-bit data filters in the real-time mode and the averaging capabilities in the repetitive mode as well as a discussion of the tradeoff between filtering and bandwidth.

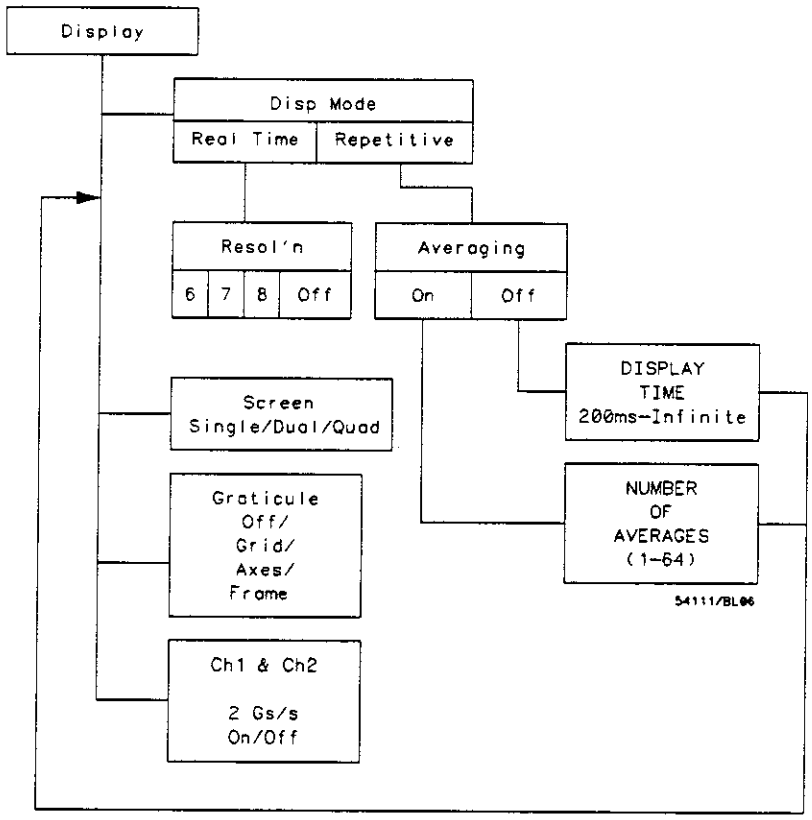


Figure 7-1. Display Menu

Display Mode Key

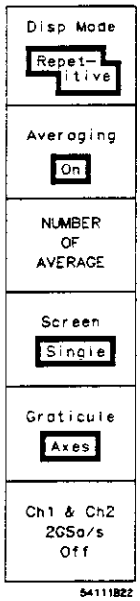
After you have pressed the Display menu key Mode the **Disp Mode** key is highlighted, allowing you to select the desired display mode:

- Real Time
- Repetitive

Depending on the display mode you select, the HP 54111D is configured for either single-shot or repetitive acquisition. Because of these different display modes, you have virtually two oscilloscopes in one instrument; one with up to 250 MHz bandwidth single-shot (1 gigasample/second digitizing rate), and the other with a 500 MHz repetitive bandwidth.

Repetitive Mode

When in the repetitive mode, the HP 54111D uses a random repetitive sampling technique (see *Feeling Comfortable With Digitizing Oscilloscopes).*



If you select the Repetitive display mode:

- the HP 54111D displays data collected from multiple acquisitions from either or both of the input channels.
- data from multiple acquisitions can be averaged to generate a display (the **Averaging** key appears when Repetitive is selected).
- data from each acquisition can be displayed for a definable period of time; persistence = 200 ms to 10.9 seconds or indefinitely; persistence = infinite at values of 11 seconds and greater.
- establishes waveform records at 501 data points.
- makes waveform memories 5-8 available (see Chapter 10).

Averaging Key

The **Averaging** key allows you to turn the Averaging mode On or Off.

If Averaging is On:

- **NUMBER OF AVERAGES** key is activated and controlled by the entry devices
- data from multiple acquisitions (1-64) is averaged to generate the displayed waveform(s).

In the averaging mode, the last acquired data points are averaged with previously acquired data before they are displayed. When you select the **NUMBER OF AVERAGES** key you can specify the number of averages you want from 1 to 64 by using the entry devices.

Displayed noise can be significantly reduced using the averaging mode. As the number of averages is increased from 1 to 64, the display becomes less responsive to changes to the input signal(s), however, using more averages reduces noise and improves resolution.

Persistence

If Averaging is Off:

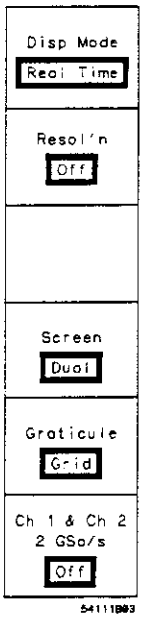
- **DISPLAY TIME** key is activated and controlled by the entry devices.
- data is maintained on the display for a defined period of time (minimum of 200 ms) or indefinitely.
- any display time equal to or greater than 11 seconds = infinite
- persistence time is listed at the top of the display.

In the infinite persistence mode data points remain on the display until the **CLEAR DISPLAY** key is pressed, or any other major setup parameter is changed.

If variable persistence (persistence other than infinite) is selected the display changes as the input signal changes. The signal is stored indefinitely on the display if the trigger is lost and the oscilloscope is in *Trg'd Sweep*.

A minimum persistence setting is useful when the input signal is changing and you need immediate feedback, such as rapidly probing from point to point, or setting the amplitude or frequency of a signal source. More persistence is useful when observing long-term changes in the signal or low signal repetition rates. Infinite persistence is useful for worst-case characterizations of signal noise, jitter, drift timing, etc.

Real Time Mode



If you select the real time display mode, the HP 54111D displays data collected during successive single-shot acquisitions from either or both input channels. Because the HP 54111D can make a single-shot capture simultaneously on channels 1 and 2, you can capture two simultaneous non-recurring or very low repetition rate events. Some or all of the 8k waveform buffer memories (each channel has its own 8k buffer) can be displayed. The displayed signal is completely updated as each new acquisition is made.

At the top of the waveform display area the following are displayed:

- memory bar representing the displayed portion of the waveform record
- the memory bar display line represents the entire 8k waveform record
- a T indicates the trigger point's location with respect to the displayed signals

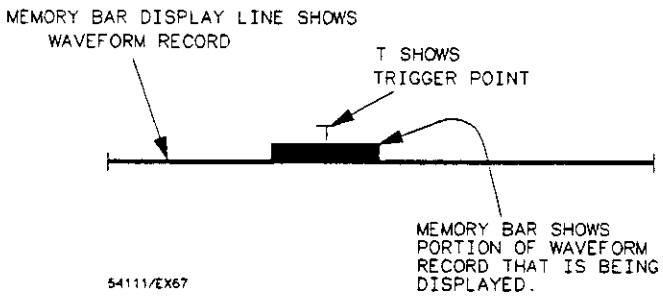


Figure 7-2. Memory Bar

Resolution Key

Pressing the **Resol'n** (resolution) key allows you to select 6, 7, or 8-bit digital filters to increase the resolution of the displayed signal and achieve a more faithful reproduction of the input signal. One of the selections allows you to turn the filter off, allowing you to view raw data.

Increasing the resolution by selecting the 7 or 8 bit filter reduces the bandwidth. The bandwidth limitations are:

Off	Full (500 MHz)
6 bits	up to 250 MHz
7 bits	up to 100 MHz
8 bits	up to 25 MHz

If you reduce the sweep speed to below 50 ns/div the bandwidth limit of each of these filters is reduced linearly with the sample rate (see Chapter 5).

For example, the maximum bandwidth using the 8-bit filter at 50 ns/div is 25 MHz. If you change the sweep speed to 500 ns/div, the bandwidth using the 8-bit filter is limited to 2.5 MHz. If you need a high bandwidth at a low sweep speed consider using the Repetitive display mode with Averaging on.

These digital filters work very much like analog bandwidth-limit filters. In the real-time display mode these filters, as well as the sweep speed, affect bandwidth.

Screen Key

The **Screen** key allows you to define the waveform display area as:

- Single screen (1 area) with all input signals, displayed memories, and displayed functions superimposed in the waveform display area.
- Dual screen (2 separate areas) with channel 1/function 1 displayed in the top half of the display and channel 2/function 2 displayed in the bottom half. Any of the waveform memories may be independently displayed in either half of the display.
- Quad screen (4 separate areas) with signals from channel 1, channel 2, function 1, and function 2 displayed from top to bottom, respectively. Any of the waveform memories may be independently displayed in any one of the four display areas.

Vertical scaling is changed automatically to provide an appropriate display as the screen function is changed.

Graticule Key

Pressing the Graticule key allows you to change or erase the display graticule.

The three graticules available are:

- Grid
- Axes
- Frame

Or you may turn the background graticule off.

Ch1 & Ch2 2GSa/s On/Off Key

The **Ch1 & Ch2 2GSa/s** key is always available and active from the Display menu. By turning this key on you will activate 2 gigasample/second aquisition when sampling at 1 ns intervals.

Note

Do not turn this key on unless you are using the HP 54114A 2 GSa/s Test Set (optional). Any measurements made while this is on and the test set is not mounted will be unpredictable.

When the HP 54111D is sampling at less than 1 GSa/s (sweep speed 100 ns or greater, the message in this field changes to *Ch1 & Ch2 Combine.*

If this key is turned on and the oscilloscope is operating in the Real Time mode the result is a current average of 2.

Memory Bar Exercise

This exercise demonstrates the memory bar, as well as the HP 54111D's ability to display signals that occur before and after the trigger event. The memory bar is very helpful when it is important to know what portion of the waveform record is being displayed. For this exercise:

- use a 5 MHz square wave connected to channel 1
- set the sweep speed to 50 ns/div
- set the Display mode to Real Time (memory bar is displayed)

After the signal is displayed select the Delay function of the Timebase menu and use the entry devices to vary the delay. While the oscilloscope is running (**STOP/SINGLE** key not pressed), varying DELAY will vary the acquisition record with respect to the trigger point.

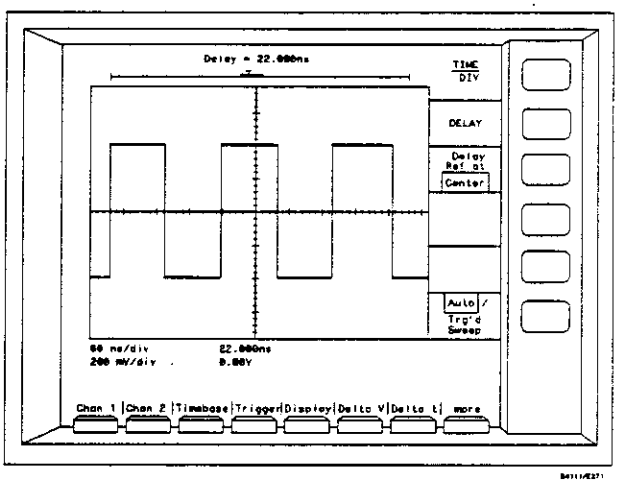


Figure 7-3. Memory Bar Using Delay

You can view three different portions of the waveform record based on a trigger reference point while running (i.e., acquiring data). These are:

- left
- right
- center

These are selected with the **Delay Ref** key (Timebase menu). While acquisition is stopped, you can position the display window anywhere on the waveform record by changing the DELAY value.

Note

With the memory bar and the "T" to the right, all data acquired occurs before the trigger. In this situation, you cannot input any negative value.

Move the memory bar and "T" to the left or center screen. Delay time moves the 8k acquisiton window relative to the trigger point. Notice that as you change the delay, the "T" moves to the right or left of the memory bar depending on whether you use a negative or positive delay.

Negative delay allows you to view pre-trigger events and positive delay allows you to view post-trigger events.

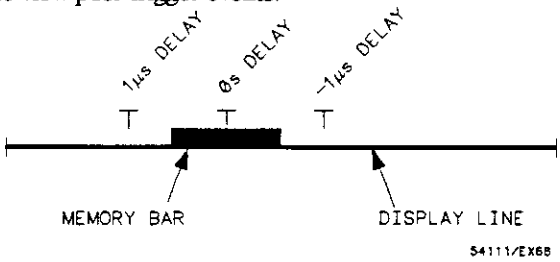


Figure 7-4. Memory Bar with 1 microsecond Delay

Now, set DELAY to 1 µs:

- the "T" moves to the left of (before) the memory bar indicating that you are viewing the portion of the input signal that occurred 1 ms after the trigger event.

If you set the delay to - 1 µs:

- the trigger moves to the right of (after) the memory bar indicating that you are viewing the signal 1 µs before the trigger event.

Single Shot Exercise

This exercise demonstrates how to take advantage of the HP 54111D's single-shot capture capability using the Repetitive display mode. It explains how to build a waveform using the STOP/SINGLE key. The exercise will explain how the Real Time display mode captures and displays captured data.

With the HP 54111D's 1 gigasample/second digitizing rate, you can capture very fast non-recurring events, such as a microprocessor start-up sequence. This allows the capture of error-causing glitches that disrupt system performance.

The equipment required for this exercise includes:

- HP 54111D oscilloscope
- HP 8116A function generator
- one meter coaxial cable

You may use another function generator if it is capable of providing:

- 500 kHz
- 2 V
- 10 ns pulse

Initial/Instrument Setup

Connect the output of the HP 8116A to the channel 1 input of the HP 54111D.

Set up the HP 8116A as follows:

- Normal mode
- Frequency = 500 kHz
- pulse width = 10 ns
- Amplitude = 2 V
- Offset = 0
- Function = pulse
- Make sure the disable light is turned off.

After pressing AUTOSCALE, set up the HP 54111D as follows:

Chan 1 menu:	VOLTS/DIV = 500 mV/div
	Input Coupling = dc
	Input Impedance = 50 Ω
Timebase menu:	TIME/DIV = 2 ns
Display menu:	Display mode = Repetitive

Using the System Control keys:

- press the **STOP/SINGLE** key to stop acquisition
- press **CLEAR DISPLAY** key
- press the **STOP/SINGLE** and **CLEAR DISPLAY** keys alternately; this displays, and then erases single-shot data.
- press the **STOP/SINGLE** key repeatedly and notice that the waveform fills in.

If Averaging is Off:

- data points on the display are not changed by new data when the **STOP/SINGLE** key is pressed.
- data stays on screen until the instrument setup is modified or the **CLEAR DISPLAY** key is pressed.

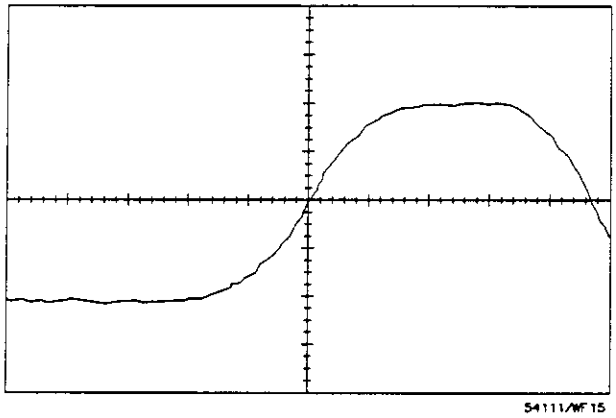


Figure 7-5. Single Acquisition Initial Waveform

If Averaging is On:

- data on screen is averaged with new data when the STOP/SINGLE key is pressed (assuming enough data points have been acquired to satisfy the NUMBER OF AVERAGES).

To see the 1 gigasample/second digitizing rate, press:

- **CLEAR DISPLAY** key
- **STOP/SINGLE** key

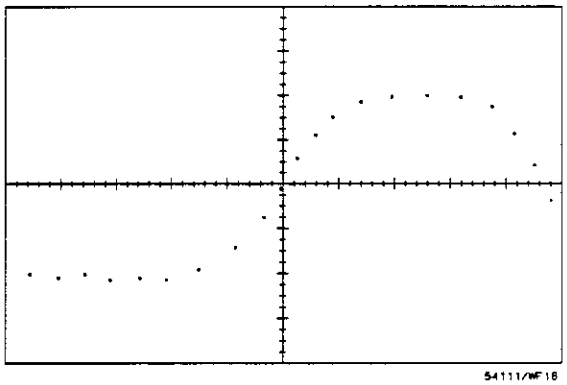


Figure 7-6. 1 gigasample/second Acquisition

The display shows a series of data points 1 ns apart. This 1 ns separation reflects the 1 gigasample/second digitizing rate.

To see the limitations of single-shot capture in the repetitive display mode:

- select the Timebase menu
- set TIME/DIV = 500 ps
- press **CLEAR DISPLAY** key
- press **STOP/SINGLE** key

Five data points from the input signal are displayed.

To acquire a more useful display using the single-shot mode at faster TIME/DIV settings:

- select the Real Time display mode (Display menu)
- set Resol'n = 6 bits
- press **CLEAR DISPLAY** key
- press **STOP/SINGLE** key

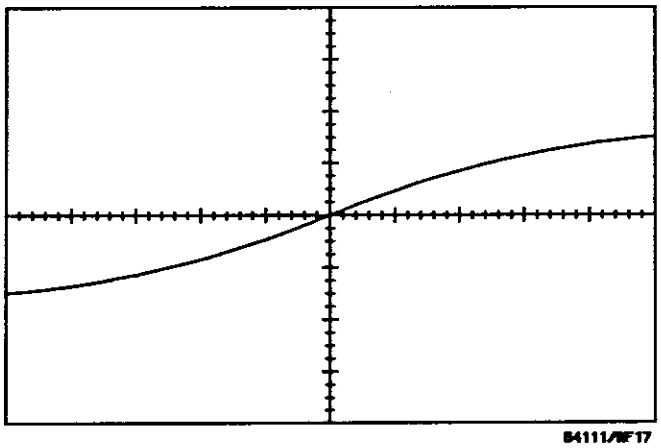


Figure 7-7. Single Acquisition Real Time

In the real time display mode, the HP 54111D uses a digital reconstruction filter to provide a more continuous waveform display. It automatically operates when there are less than 501 points on screen (i.e. TIME/DIV settings faster than 50 ns/div).

Zoom and Pan Exercise

This exercise demonstrates how the TIME/DIV function can be used to zoom (i.e. horizontally expand, magnify, or compress a single-shot waveform) or pan (horizontally move along a portion of the captured waveform) on the time axis while in the real-time display mode.

Zooming either expands or compresses the waveform on the horizontal axis and is changed by adjusting TIME/DIV. Decreasing TIME/DIV expands the waveform, and increasing TIME/DIV compresses the waveform.

Panning moves the waveform on the horizontal axis and is changed by adjusting DELAY time. Increasing DELAY moves the waveform to the left, and decreasing DELAY moves the waveform to the right.

Applications that require precise evaluation of low repetition rate signals such as radar and transponder pulse trains, are simplified by zooming and panning on single-shot data.

Initial/Instrument Setup

Connect the output of the HP 8116A to the channel 1 input of the HP 54111D.

Set up the HP 8116A as follows:

- Normal mode
- Frequency = 500 kHz
- Pulse width = 10 ns
- Amplitude = 2 V
- Offset = 0
- Function = pulse

Make sure the disable light is turned off.

After pressing AUTOSCALE, set up the HP 54111D as follows:

Chan 1 menu:	VOLTS/DIV = 400 mV
	Input Coupling = dc
	Input Impedance = 50 Ω
Timebase menu:	TIME/DIV = 5 ns
Display menu:	Display mode = Real Time
	Resol'n = 6 bits

Using The Zoom Feature

To acquire a single-shot waveform record:

- press the **STOP/SINGLE** key
- press the **CLEAR DISPLAY** key
- press the **STOP/SINGLE** key again to make a single acquisition

After the 8k single shot waveform record is acquired:

- select the Timebase menu
- select TIME/DIV

Varying TIME/DIV allows you to view either a larger or smaller portion of the 8k waveform record. This allows you to display the whole waveform record by increasing TIME/DIV or to zoom in on a segment of the record by decreasing TIME/DIV. The memory bar expands or contracts as the portion of the record being displayed is increased or decreased.

Zooming Out

To demonstrate zooming out:

- set TIME/DIV = 1 μs/div

Changing the TIME/DIV to 1 μs/div compresses the waveform to approximately eight horizontal divisions and allows five of the 500 kHz pulses to be displayed. The memory bar indicates that the entire waveform record is being displayed.

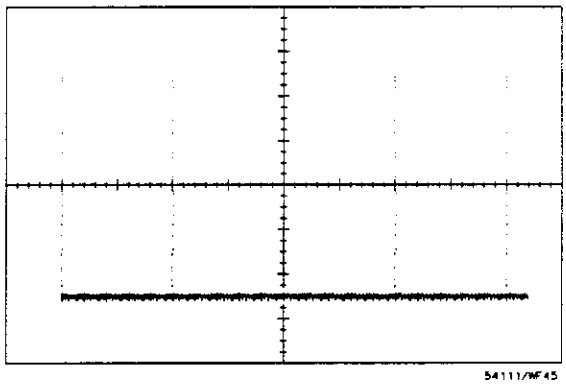


Figure 7-8. Zooming Out

In this example, we acquired 8192 data points at a 1 gigasample/second digitizing rate. Using the 2 ns/div TIME/DIV setting (2 samples/div) provides 409.6 screen diameters of data. On the HP 54111D ten divisions = one screen diameter. As TIME/DIV is increased, the number of screen diameters is reduced linearly (i.e. more and more 1 ns samples are needed to define the longer periods of time that are represented on the display). At the TIME/DIV setting of 1 us/div, the 8192 1 ns samples represent 8.192 divisions (i.e., 8.192 μs).

The displayed portion of the 8k waveform record is mapped into the 501 horizontal data points of the HP 54111D's display. If the 8k waveform record represents less than 10 x TIME/DIV (i.e., less than full screen), the waveform record will be mapped into proportionally fewer display data points. In this example, 0.8192 X 501 (410) display data points are used when TIME/DIV is set to 1 us/div.

Increasing TIME/DIV on a single-shot waveform record or a waveform memory is referred to as "zooming out." Conversely decreasing TIME/DIV on these waveforms is referred to as "zooming in."

Zooming In To demonstrate zooming in set TIME/DIV = 500 ps/div

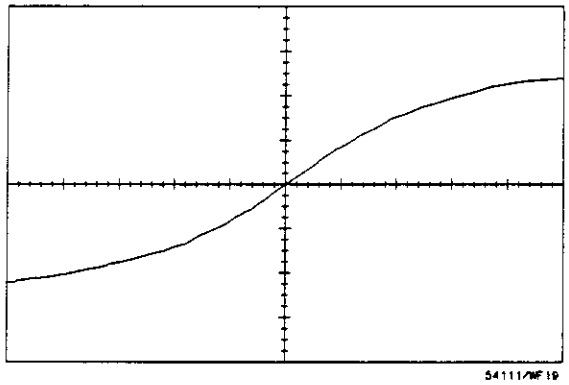


Figure 7-9. Zooming In

As TIME/DIV is decreased the amount of time represented on the display is reduced. This expands the signal.

With TIME/DIV set at 500 ps/div, the samples are two horizontal divisions apart (i.e., 1 gigasample/second digitizing rate). The HP 54111D uses a digital reconstruction filter to fill in the waveform to provide a more usable display.

Panning Varying DELAY time allows you to view various segments of the waveform record. To demonstrate panning:

- set TIME/DIV = 5 ns/div
- set DELAY = 25 ns

The screen now provides a detailed look at the waveform after the pulse. The delay time indicates that you are viewing the waveform 25 ns after the trigger point.

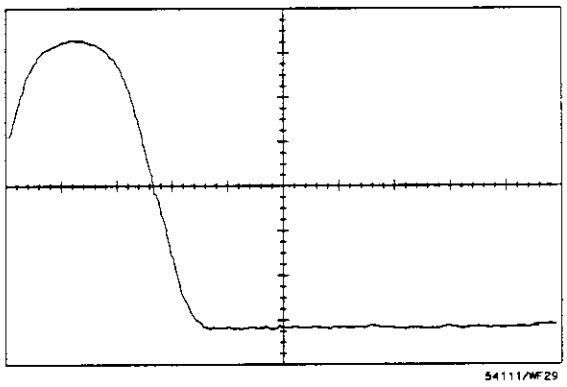


Figure 7-10. Panning Right

As DELAY is increased, the waveform moves to the left because you are looking farther and farther past the trigger point.

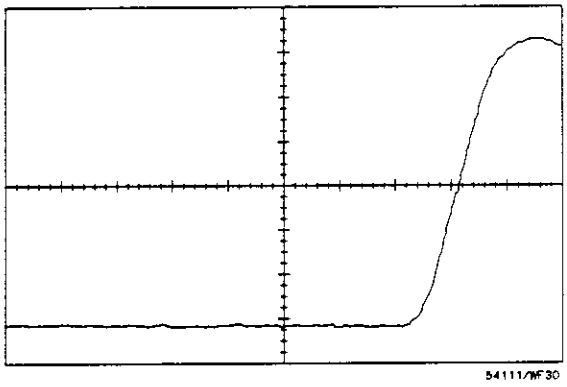


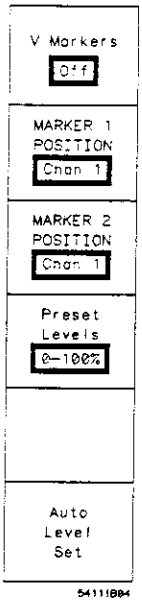
Figure 7-11. Panning Left

If DELAY is increased in the negative time direction (i.e., decreased) the waveform moves to the right because you are viewing the signal before the trigger point.

This feature allows you to look at a large time window in detail. This is similar to using a magnifying glass to view a page of small print.

Delta V Menu 8

Chapter Contents



This chapter contains a description of the voltage markers and automatic preset levels. An exercise illustrates how to make a source-to-source voltage measurement.

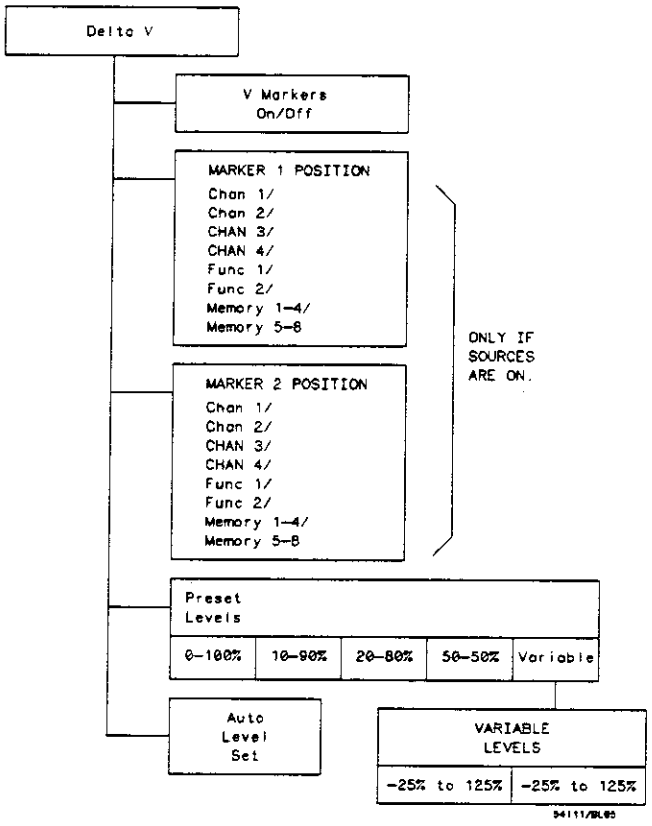
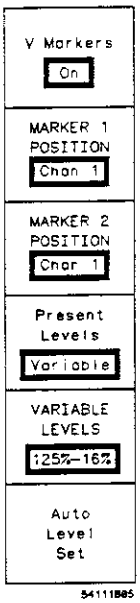


Figure 8-1. Delta V Menu

The Delta V menu allows you to control two calibrated horizontal markers that can be used to make manual voltage measurements.

V Markers



After you have selected the Delta V menu and turned on the V markers you can define the source for either of the V Markers. The V Markers can be referenced to any source if the display for that source is turned on (excluding pixel memories). When the source has been defined you can position the marker anywhere on the source waveform.

The voltage shown at the top of the waveform display area indicates the voltage level of the selected V marker.

The V Marker sources can be:

- channels 1 or 2
- functions 1 and 2 (set up in the Waveform Math menu)
- waveform memories 1 through 4 are available as marker sources only in the real-time mode
- waveform memories 5 through 8 are available as marker sources only in the repetitive mode

For a source to be available, its display must be turned on.

After assigning the markers to the desired source, the MARKER 1 POSITION and MARKER 2 POSITION function keys allow you to position the markers vertically using the entry devices.

Marker 1 has long dashes, and marker 2 has short dashes.

If you are using the default colors, the V marker you have selected and its label are orange. If MARKER 1 POSITION or MARKER 2 POSITION is the selected function, the value for ΔV and the voltage level of the selected marker are also in orange. The **MARKER POSITION** key that is not selected and its associated marker are displayed in gray.

Values for ΔV (the difference between the two markers) and the voltage level for each marker are displayed at the bottom of the screen.

Preset Levels Key

When you press the **Preset Levels** key you can select specific placement locations that the HP 54111D will place the markers on the displayed waveform. The available locations on the waveform are:

- 0%-100%
- 10-90%
- 20-80%
- 50-50%
- Variable

The HP 54111D automatically positions the V markers on the display calculating the current position being 0%-100%.

Variable Levels

Selecting Variable adds the **VARIABLE LEVELS** key to the menu and provides two variables that are used to define the levels of the V markers in the same manner fixed preset levels did. The variable preset levels can be changed by using any of the entry devices from -25% to 125%.

Auto Level Set Key

Auto Level Set key performs a histogram on the displayed data to find the 0% and 100% levels, then automatically sets the V markers to the selected preset levels of the displayed signal(s).

Source-to-Source Voltage Measurement

This exercise demonstrates how to use the Preset key to position the V Markers.

The equipment required for this exercise includes:

- HP 54111D oscilloscope
- two HP 10431A probes

Initial/Instrument Setup

Set up your HP 54111D as follows:

- install the HP 10431A probes on Channel 1 and Channel 2
- attach the probe tips to the front-panel cal signal on the HP 54111D
- press **AUTOSCALE**
- Select the Delta V menu and turn on the V Markers
- set Preset Levels = 0 - 100%
- press **Auto Level Set** key

To see how the Preset Levels key works, press the key several times and notice how the markers move to the defined levels.

Making the Measurement

Assigning the V markers to different sources allows you to make voltage measurements between those sources.

Set the HP 54111D as follows:

- set MARKER 2 POSITION = Chan 2
- position marker 1 at the top of the channel 1 waveform and marker 2 at the bottom of the channel 2 waveform

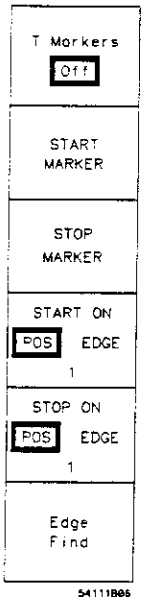
Marker 1 is at the top of channel 1 (top display) and marker 2 is at the bottom of channel 2 (bottom display).

The difference between the two voltage markers is listed at the bottom of the display labeled ΔV.

This technique can be used with any of the sources to make source-to-source voltage measurements.

Delta t Menu 9

Chapter Contents



This chapter contains a description of the stop and start markers and how they relate to the voltage markers. An exercise demonstrates how to make a time interval measurement.

The Delta t function menu controls two calibrated time markers that can be used to make measurements on the horizontal axis. These markers can be positioned using signal edges or time reference.

These markers make it possible to make time interval measurements based on the voltage levels set in the Delta V menu (e.g., 20% to 80% risetime measurements)

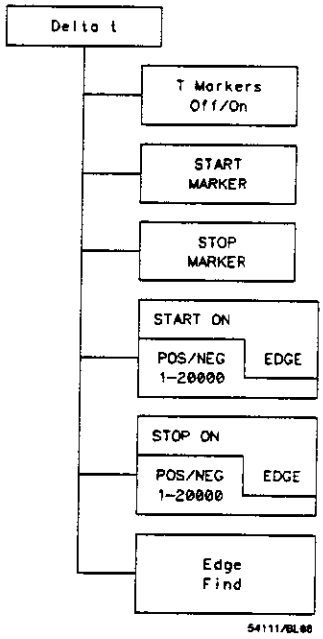


Figure 9-1. Delta t Menu

The values of the two markers with respect to the trigger point and to each other (i.e., delta time) are displayed at the bottom of the waveform display area.

Start/Stop Markers

After you have selected the Delta t menu and turned on the t markers you can move each t marker manually by selecting START MARKER or STOP MARKER and using the entry devices.

If default colors are used, the selected t marker is displayed in orange.

Start/Stop On Edge

The **Start/Stop On Edge** keys allow you to move the t markers to any displayed signal edge based on the voltage marker values set in the Delta V menu.

After you have selected one of the edge keys you may select the number of the edge (from 1 to 2000) of interest using any one of the entry devices. If an edge key has been selected and is pressed a second time the polarity of the edge changes.

The V Marker levels define the intersections of the displayed signal edges as follows:

- start-on-edge marker is associated with V Marker 1
- stop-on-edge marker is associated with V Marker 2
- associated V Marker must intersect the signal for the start/stop-on-edge markers to find the defined edge(s).

If the advisory message, *Edges required for measurement not found* appears, return to the Delta V menu and adjust the V Markers to intersect the signal of interest.

Edge Find Key

The **Edge Find** key moves the t markers to the waveform edges defined by the start/stop-on-edge keys.

Hint: use this key if you have moved the t markers (using the START/STOP MARKER keys) and you want to return to the edges defined by the edge keys.

Time-interval Measurement Exercise

This exercise demonstrates many of the functions available through the Delta t menu.

The equipment required for this exercise includes:

- HP 54111D oscilloscope
- HP 10431A probe

Initial/Instrument Setup

Set up your HP 54111D system as follows:

- Connect the front-panel cal signal to channel 1 using an HP 10431A probe
- Press **AUTOSCALE**
- Select the Timebase menu and set the TIME/DIV to 500 ms/div
- Select the Delta t menu and turn the t markers On.
- Move the START MARKER to the first negative edge of the cal signal
- Move the STOP MARKER to the second negative edge and measure the period of the pulse.

Below the waveform display area, the value of the start marker indicates that it is approximately 500 μs before the stop marker, and approximately 2.3 ms before (- 2.3 ms) the trigger event (delay = 0) which was established at center screen when you pressed AUTOSCALE. The time interval between the t markers (Δt) is approximately 500 μs. This is the pulse width.

- Select the Delta V menu and turn the V Markers on.
- Press the **Preset Levels** key until 50-50% is selected.
- Press the **Auto Level Set** key to set the V Markers to the Preset Levels.
- Return to the Delta t menu and press the **STOP ON POS/NEG EDGE** key several times

Notice that the POS/NEG indicator alternates, and the stop marker alternates from the positive edge to the negative edge of the pulse. Try using each of the entry devices to move the start edge to another pulse. The stop edge can be changed using the same technique.

Note

If you attempt to move one of the t markers to an edge that is not displayed, the error message "Edges required for measurement not found" is displayed for 5 seconds.

- Set the start marker to the first (1) positive edge and set the stop marker to the fifth (5) positive edge. The time interval between the two t markers is listed at the bottom of the display (Δt).

This technique can be used to measure burst duration or to measure the time over a number of signal repetitions.

Waveform Save Menu 10

Chapter Contents

This chapter contains a description of how to store and view waveforms using the real-time, repetitive, and pixel memories.

The Wfm Save menu allows you to access the 10 memories that are available from the HP 54111D's front panel. Of the ten memories that are available, eight are waveform memories, designated as waveform memories 1 through 8. All memories are nonvolatile provided the backup power source remains intact and the circuit between the memory board and power supply are intact.

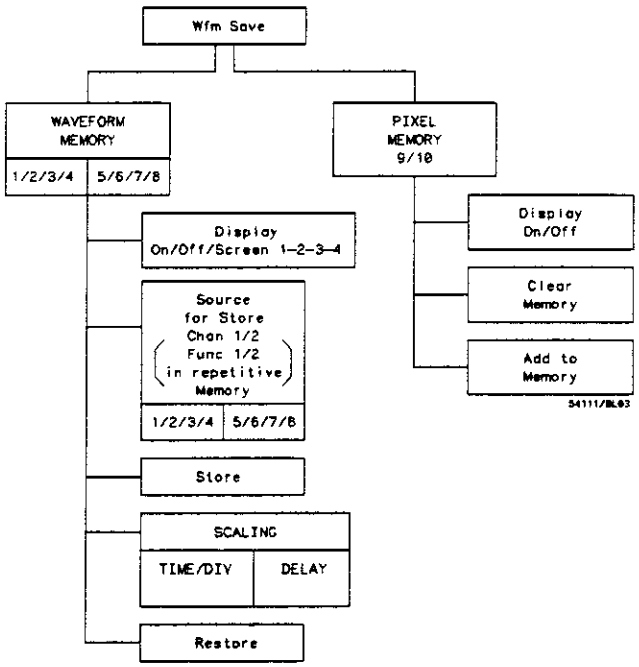


Figure 10-1. Waveform Save Menu

Waveform memories 1-4 are 8k data points long and can be accessed in the real-time mode. Waveform memories 5-8 are 501 data points long and are available in repetitive. Two are pixel memories and are designated as pixel memories 9 and 10.

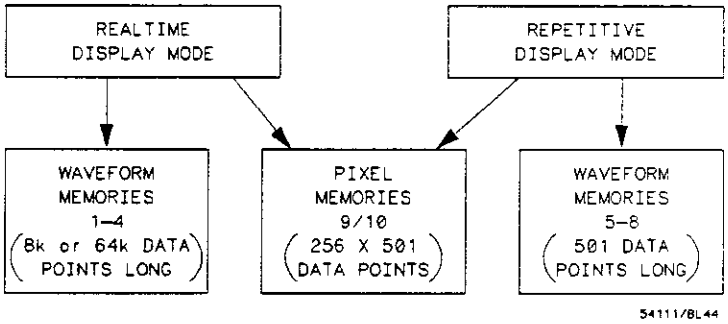


Figure 10-2. Memory Type vs. Display Mode

Pixel Memories

Pixel memories are a literal pixel dump from screen to memory. They are additive and are primarily used in situations where it is necessary to compare multiple signal acquisitions.

As you toggle through the WAVEFORM/PIXEL MEMORY key you will notice that when memories 9 and 10 are selected, the field label lists PIXEL MEMORY.

Pixel memories 9-10 are:

- available in both display modes
- 256 x 501 bit memories
- constructed so that multiple waveforms can be stored in each

If more than one waveform is stored in a pixel memory the waveforms are superimposed

Display Key When you select Pixel Memory 9 or 10 the second key is the **Display** key. This allows you to turn the pixel memory on or off.

Clear Memory Key The third key in the submenu changes to the **Clear Memory** key that allows you to erase the contents of the selected pixel memory.

Add to Memory Key The fourth key is the **Add to Memory** key, and when pressed all displayed channels and functions are stored to the selected pixel memory joining whatever data is already stored there.

You cannot make automatic measurements (from Measure menu) on waveforms stored in a pixel memory because waveform factors are not maintained. Factors are not maintained because multiple waveforms can be displayed that can have differing scaling factors.

Repetitive Waveform Memories

When waveforms are stored in one of the four waveform memories available in the repetitive mode, the following waveform factors are stored as part of the record:

- vertical sensitivity
- vertical offset
- sweep speed
- time delay

This allows you to make automatic measurements on waveforms stored in these memories.

Note

Waveform memories can store only one waveform at a time. If you store a waveform to a memory that already contains a waveform record, the first record is written over and lost.

Display Key The **Display** key allows you to turn the selected waveform memory display on or off.

If the Display is turned on you have the choice of displaying the waveform memory in any of the dual or quad screen locations. When the function selection key is pressed after the Display is turned on, you can continue to press the key and select which screen the memory is to be displayed.

Source For Store key The **Source For Store** key allows you to select which source is to be stored in the specified WAVEFORM MEMORY.

If the source is:

- a channel or a function, you must turn on that source
- a memory that memory must have something stored in it

Store Key Press the **Store** key to invoke the store function. When the key is pressed the HP 54111D immediately stores the waveform according to all previous settings.

Real Time Waveform Memories

When waveforms are stored in one of the four waveform memories available (1-4) in the real time mode, the following waveform factors are stored as part of the record:

- vertical sensitivity
- vertical offset
- sweep speed
- time delay

This allows you to make automatic measurements on waveforms stored in these memories.

Note

Waveform memories can store only one waveform at a time. If you store a waveform to a memory that already contains a waveform record, the first record is written over and lost.

Display Key The **Display** key allows you to turn the selected waveform memory display on or off.

If the display is turned on you have the choice of displaying the waveform memory in any of the dual or quad locations. If the HP 54111D is in a multiple screen mode and the function selection key is pressed after the display is turned on, you can continue to press the key and select which screen the memory is to be displayed.

Source For Store Key The **Source For Store** key allows you to select which source is to be stored in the specified WAVEFORM MEMORY.

If the source is:

- a channel or a function, you must turn that source on
- a memory that memory must have something stored in it

Store Key Press the **Store** key to invoke the store function. When the key is pressed the HP 54111D immediately stores the waveform according to all previous settings.

Scaling Key The **Scaling** key is available only in the real time mode. The scaling function applies to real time waveforms exactly the same as the memory bar. Using this function on stored real time waveforms you can expand or compress the waveform and view any part of the stored waveform (DELAY or panning) or as much or as little of the waveform (TIME/DIV or zooming) as you desire.

When you have a waveform stored in one of memories 1-4:

- Press the SCALING key
- Turn the memory Display on
- Select TIME/DIV or DELAY
- Using any of the entry devices, pan or zoom to view various sections and portions of the waveform

Note

It is easier to view the memory contents if you turn the source off. Then you display only the memory.

Restore Key Pressing the **Restore** key allows you to restore the selected memory to its original TIME/DIV and DELAY values. If you have been using the scaling functions, press Restore to return the waveform in the selected memory to its original memory values.

Memory Selection

To select a memory:

- Enter the Waveform Save Menu
- Press **WAVEFORM MEMORY** key to select the desired memory location

Note

As you continue pressing the key, notice that only those memory locations that are compatible with your Display mode are available.

- Turn the Display for the memory source on (optional).
- Select **Source For Store.** This selects the channel, memory, or function. Ensure your selected source has been turned on.
- Press **Store** to store the selected source to the memory

Waveform Math Menu 11

Chapter Contents

This chapter contains a brief description of the waveform math operations and a Waveform Math menu map. A waveform math exercise is also included at the end of the chapter.

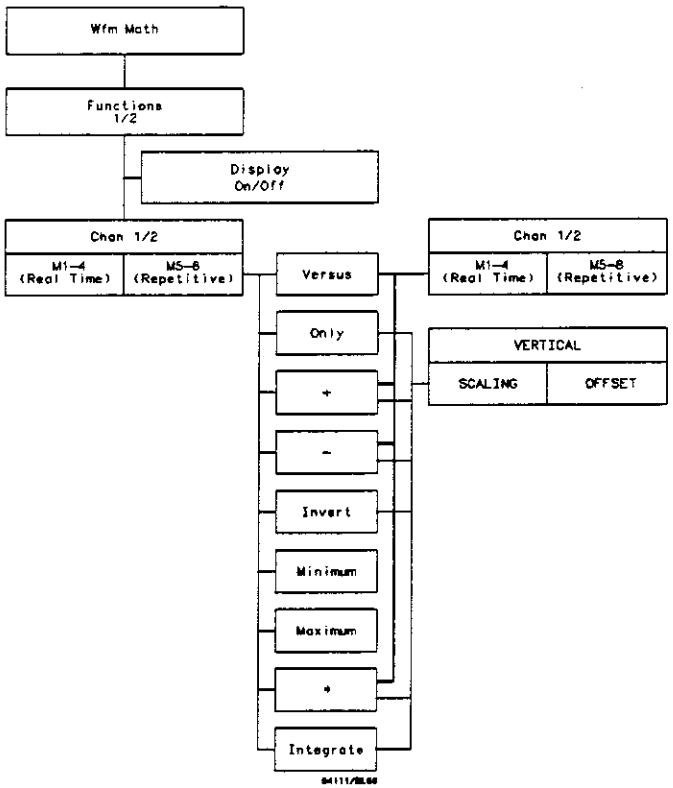


Figure 11-1. Waveform Math Menu

The Menu

The Waveform Math Menu includes the following mathematical operations:

- Versus
- Only
- Plus (+)
- Subtract (-)
- Invert
- Minimum
- Maximum
- Multiply (*)
- Integrate

Provisions for amplitude and offset scaling for all but Versus, Minimum, and Maximum math functions are also included in this menu.

Operation

To perform a waveform math operation:

- enter the Waveform Math Menu
- select one of the Functions

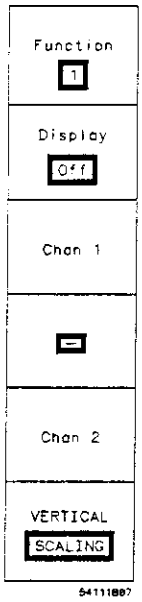
Note

A Function is defined by first choosing the mathematical function and then the two operands (see Waveform Math Map, Figure 11-1).

An operand may be channel one or two, or memory one through eight. Remember that memories one through four may only be accessed in the Real Time mode and memories five through eight can be accessed only in the Repetitive mode. Pixel memories (memories 9 and 10) may not be used as operands.

Function Menu

After you have entered the Wfm Math menu, Function 1 or 2 will be displayed. A waveform math function must now be defined.



Function Key This key allows you to select either Function 1 or Function 2.

Display Key The Display Key allows you to turn the selected Function on or off. When the display for a function is turned on, the vertical deflection factor is displayed below the waveform display area and the offset in Volts is displayed with the Function.

First Operand Key This key selects the first operand of the mathematical operation. The operand may be one of the two channels, or you may choose a waveform stored in one of the memories. When the oscilloscope is in the Real Time mode, only memories one through four may be selected. In the Repetitive mode only memories five through eight are accessible. Memories can only be used in a function if a waveform has been stored into it.

The operand choices are remembered with the mathematical function. In the example display at the left, the subtract (-) function is stored with the operands Chan 1 and Chan 2. Therefore the math function should be selected before the operand choices are made.

Operator Key This key allows you to select one of the mathematical operations.

Second Operand Key This key allows you to select the second operand of the mathematical operation. The same selections are available as the for the first operand key.

Vertical Key When the Vertical Key key is displayed, the function displayed may be scaled. The key toggles between SCALING and OFFSET.

Scaling factors are displayed at the top and bottom of the waveform display area.

Function Scaling

Vertical scaling is provided for all mathematical functions except Versus, Minimum and Maximum. Scaling is a method of readjusting vertical sensitivity; therefore you can select vertical sensitivity and reposition the function waveform on screen. The **Scaling** key toggles between VERTICAL SCALING or VERTICAL OFFSET. To change vertical sensitivity or offset, use any of the front panel entry devices.

The scaling factors are stored with the mathematical function used. This feature allows you to define another function and retain scaling data with the previous function.

Default Scaling

Default scaling forces the results of a function to be rescaled and displayed on screen if the scale factors have been misadjusted. Default scaling is executed every time a new operand is selected. If the function amplitude is adjusted out of range, the waveform may be restored to the screen by toggling through the operands.

Time Scaling

In cases where the operands are not of the same time scale, the first operand will determine the timebase scale for the function. The timebase scale for the function is displayed below the waveform display area. Time scaling cannot be changed as long as the function menu is displayed.

Vertical Scaling Units

The fundamental measuring units of an oscilloscope are Volts/Div in the vertical axis and Time/Div in the horizontal axis. This philosophy is used regardless of the mathematical function chosen. No provisions have been made to manage units for all combinations of operands and mathematical functions available for the HP 54111D.

The Multiply Example Apply a + 2V signal to Channel 1 and a - 3V signal to Channel 2. Choose a Function and select math function MULTIPLY (*).

Notice that the result displayed is in fundamental units of - 6V even though the actual units are volts squared.

The Integrate Example The integral of an operand is calculated as the summation of Volt/Time.

- Apply a + 2V dc signal to Channel 1.
- Set the Timebase to 100 ms/Div.
- Choose a Function and select the INTEGRATE math function.
- Set vertical scaling to 1V/Div.

The actual units of the integrate function are Volt seconds/Div, however, the display shows the fundamental units of Volt/Div.

Math Function Definitions

A mathematical function is selected by pushing the **Operation** Key until the desired function is displayed on screen, next to the key. The definitions are:

Versus The Versus function draws a Volts versus Volts display of the two selected operands. Vertical Scaling is not available for this function. This mathematical function can not be stored in memory.

Only The Only function allows you to display the first operand and scale it.

Plus (+) The two selected operands are added together in this function. Addition proceeds on a point by point basis.

Subtract (-) The Minus operation allows you to subtract any two operands. As in the Plus function, subtraction proceeds on a point by point basis.

Invert The Invert function inverts the data of the first operand. Default scaling is determined by the operand. User scaling is also provided.

Minimum The first operand value is compared to the current function value. An equal to or the lesser value is stored into the function. The comparisons are made on a point by point basis. Default scaling is determined by the original operand.

Maximum This function operates in the same manner as Minimum. Here, the operand value is compared to the function value and an equal to or greater value is stored into the function.

Multiply The Multiply function calculates the voltage product of the two specified operands. Multiply is also executed on a point by point basis.

Integrate The Integrate function calculates the integral of the vertical value of the designated operand. Integration proceeds on a point by point basis. If no data point is encountered in the operand, then integration uses the next valid data point. Any non-existing data points encountered are not summed, only the available data is integrated. Default scaling is determined by the original operand.

Function Display

The Functions are displayed in different screens depending on the SCREEN mode chosen. If Single screen is chosen, then both functions are displayed in the same screen. This is the only screen mode that allows you to overlap both functions. In the dual screen mode Function 1 will be displayed in the top screen and Function 2 will be displayed in the bottom screen. In the quad screen mode, Function 1 and 2 are displayed in the third and fourth screens from the top.

Waveform Math Exercise

In this exercise you will use the Wfm Math menu to subtract and add two operands.

Instrument Setup

Set up the HP 8116A as follows:

- Normal mode
- Frequency = 1 MHz
- Amplitude = 2 V
- Offset = 0 V
- Function = Sine wave

Set up the HP 54111D as follows:

- Install the BNC tee to output of function generator
- Connect one end of a coaxial cable to one end of the tee and the other end to the BNC on channel 1.
- Connect the other coaxial cable from the other end of the tee to channel 2.
- Set input impedance of Channel 2 to 50 Ω (See Figure 11-2 for the equipment setup.

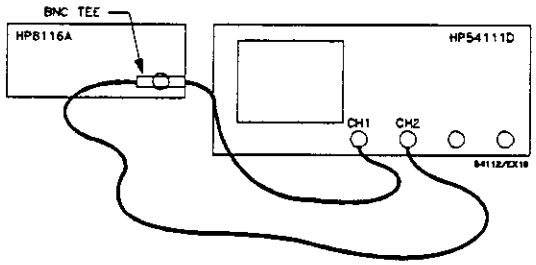


Figure 11-2. Equipment Setup

- Press AUTOSCALE
- Enter the Display menu and select Repetitive mode and Dual Screen.

Subtract Math Function

The first example demonstrating the math functions is subtracting one waveform from another.

- Enter Wfm Math Menu and select Function 1
- Select the Subtract (-) math function
- select Chan 1 as the first operand and Chan 2 as the second operand.
- Turn Function Display on.

Notice that the function display shows 0V (see Figure 11-3).

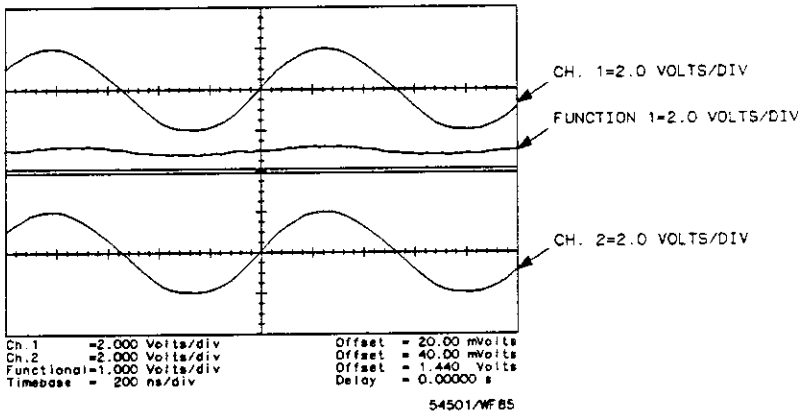


Figure 11-3. Subtracting Two Operands

If you would like to keep this data for future reference, you can store Function 1 in one of the waveform memories. To characterize this function, select the Measure menu and use any of the automated measurements.

Plus (+) Math Function

In this procedure you will add two operands.

Using the same equipment set-up, select the Plus (+) math function, Chan 1 as the first operand and Chan 2 as the second operand.

Turn the Function Display on. Notice that the function display shows 4V (see Figure 11-4).

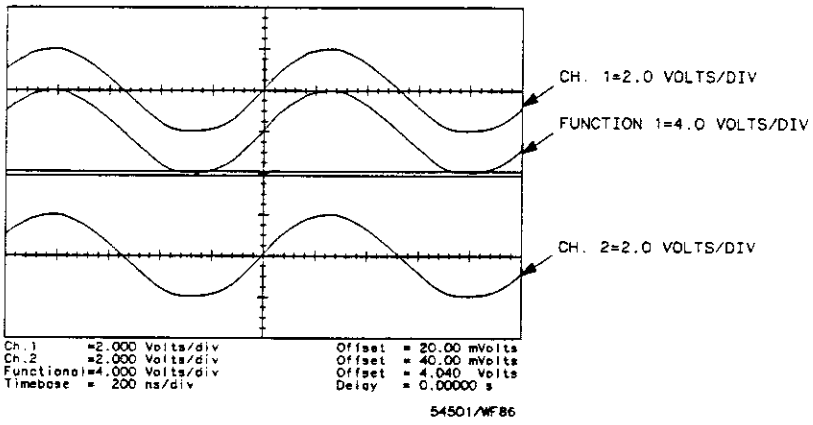
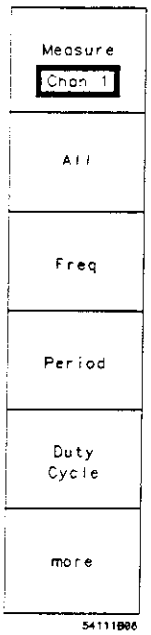


Figure 11-4. Adding Two Operands

Measure Menu 12

Chapter Contents

This chapter contains a description of the automatic waveform measurements.



The Measure menu is your access to the HP 54111D's twelve automatic measurements. You can measure twelve waveform parameters simply by pressing the All key, or you can select each measurement individually. These automatic measurements conform to the IEEE standard 194-1977, "IEEE Standard Pulse Terms and Definitions" (see Appendix C for information on how the oscilloscope makes automatic measurements).

You can also document the results of the measurements with either an HP-IB printer or plotter (see Chapter 13 Hardcopy Menu).

After you have selected the Measure menu, you can use three measure-function menus that you can cycle through by pressing the more key (bottom key in the function menu).

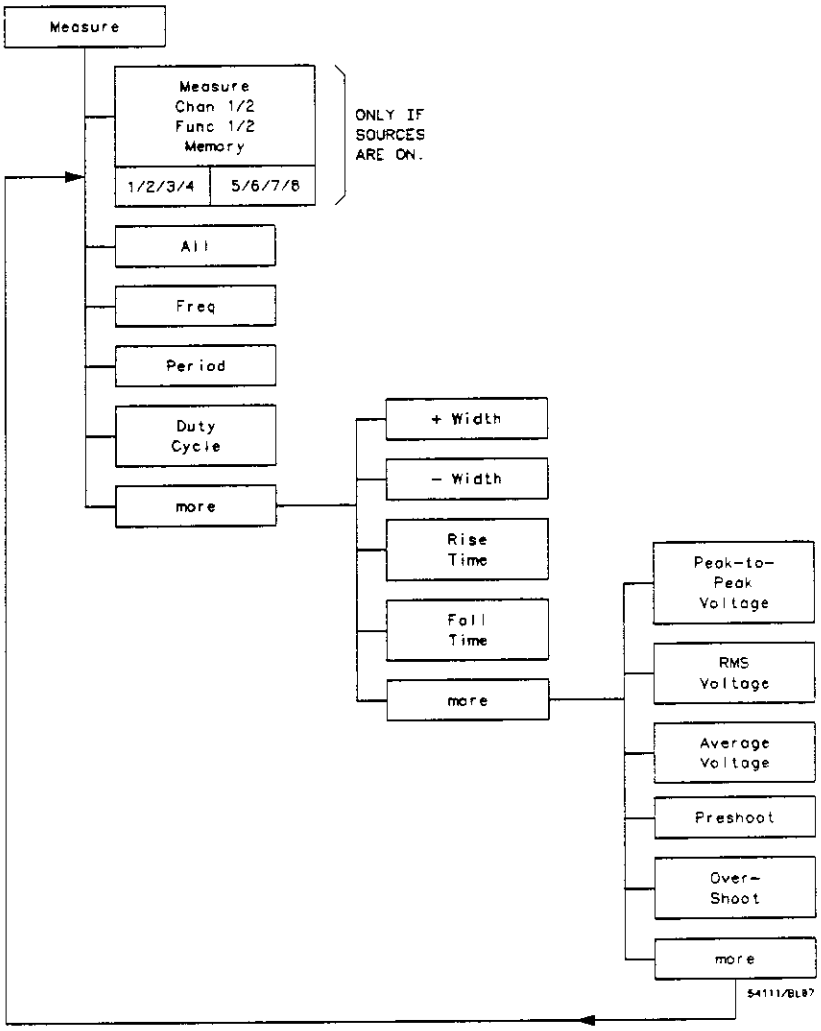


Figure 12-1. Measure Menu

Measure Key

The **Measure** key (top of the function menu) allows you to:

- select the waveform source to be measured
- measure a source

Note

To measure a source, it must be turned on (i.e., it must be displayed).

You may use any of the following as a source:

- channels 1 and 2
- functions 1 and 2
- memories 1-4 when the HP 54111D is in the real-time mode
  memories 5-8 when the HP 54111D is in the repetitive mode

All Key

Pressing the **All** key causes the 54111D to automatically make the measurements listed below and displays the results at the bottom of the CRT.

Frequency	+ Width	Peak-to-Peak Voltage
Period	- Width	RMS Voltage
Duty Cycle	Rise Time (10-90%)	Average Voltage
Fall Time (90-10%)	Preshoot	Overshoot

Any of these measurements can be made independently by pressing the appropriate key.

When a measurement is made, the voltage and time markers are automatically placed on the signal based on the screen window. Thus, if you change the window by panning or zooming, the measurements will change accordingly. The points where the markers intersect the signal indicate the data points used to make the measurement.

Hardcopy Menu 13

Chapter Contents

The Hardcopy Menu allows you to get a hardcopy of all screen data with either an HP-IB graphics printer or a plotter without an external controller. The hardcopy will include the displayed waveform, measurement factors, graticule and time references. This chapter contains information on how to configure the system and a description of all the hardcopy keys.

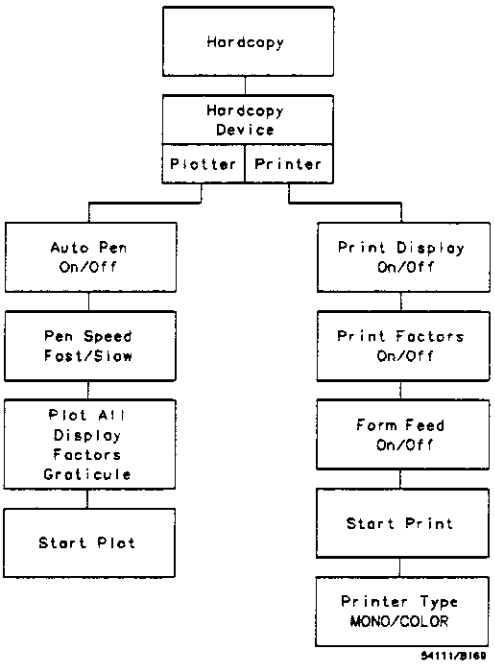


Figure 13-1. Hardcopy Menu

Configuring the System

The following settings are necessary when making a hardcopy using the HP 54111D:

- After displaying the waveform to be copied, push Utility key and select the HP-IB Menu.

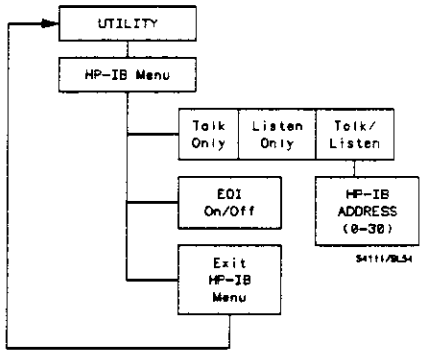


Figure 13-2. Utility/HP-IB Menu

- Set the HP54111D to talk only mode (see figure 13-2).
- Set the printer or plotter to "Listen Only" or "Listen Always." If there is no Listen Only switch, set the address of the printer or plotter to 31 (all 1's on the address switch). This is an invalid address and will automatically set the peripheral to the "Listen Only" mode.
- Initialize the printer or plotter by cycling power.

Hardcopy Menu

The Hardcopy menu is divided into two submenus:

- Printer Menu
- Plotter Menu

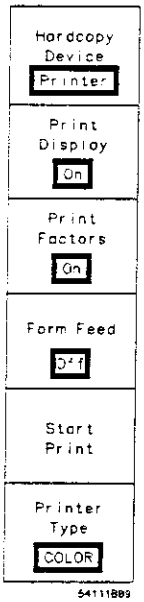
The Printer Menu allows you to select the printer type and automatic Form Feed On/Off.

The Plotter Menu allows Auto Pen On/Off and Pen Speed choices.

Both menus allow you to plot or print just the display, the measurment factors, graticule, or everything displayed on screen.

Printer Menu

To Print waveform data, push the Hardcopy key and select Printer as the hardcopy device.



Hardcopy Device Key This key allows you to select the peripheral device for hardcopy. You can select either Printer or Plotter.

Print Display Key When the **Print Display** key is on, both the waveform and the graticule will be printed.

Print Factors Key When On, the measurement factors displayed under the waveform area will be printed.

Form Feed Key If Form Feed is on, the paper in the printer will automatically form feed when the print is complete.

Start Print Key After all options have been selected, press **Start Print** to begin printing.

Printer Type Key This key selects an HP Graphics printer or the HP PaintJet Printer.

After the print sequence has begun, the printer menu is substituted by another menu containing the following two options.

Pause/Continue Key This option allows you to stop the print sequence until you restart the sequence with the Continue key.

Abort Hardcopy Key This key stops the printing sequence entirely.

Color Printer

The oscilloscope is compatible with the HP PaintJet printer. With four exceptions, the PaintJet color assignments correspond to those on the display and the color menu of the instrument. These exceptions are necessary for better veiwabillity of the printed data.

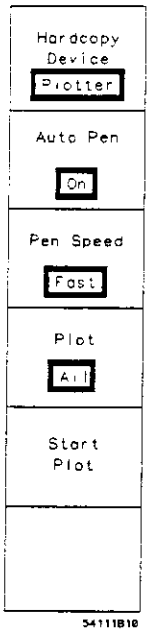
This means that changing color settings in the color menu, will in some cases, change different elements of the output display on the PaintJet printer. The assignments are listed below:

Display	Display Color No.	PaintJet Output
Stored Traces	7 (White)	2 (Halfbright)
Background	0 (Black)	7 (White)
Overlap	8, 11-15 (Magenta)	0 (Black)
Channel 1	4 (yellow)	8 (Magenta)

Example: If the background (color 0) menu is changed to blue, the PaintJet background will remain white, while the overlap will become blue.

Plotter Menu

To plot waveform data, push the Hardcopy key and select Plotter as the hardcopy device.



Any plotters that are compatible with HP-GL (Hewlett-Packard Graphics Language) may be used as the hardcopy device.

Hardcopy Device Key

This key allows you to select the peripheral device for hardcopy. You can select either Printer or Plotter.

Auto Pen Key

The HP 54111D supports multi-pen plotters. If the Auto Pen option is on, the plotter selects a new pen when a different portion of the screen data is to be plotted.

The pen selection is as follows:

Pen No.	Usage
1	Graticule, timebase factors, function 1 and associated factors.
2	Channel 1 and associated factors.
3	Waveform memories and associated factors and both pixel memories.
4	Channel 2 and associated factors.
5	Function 2 and associated factors

If Auto Pen is off, the plotter does not change pens when a new screen item is to be plotted.

Pen Speed Key The **Pen Speed** key allows you to select fast or slow speeds if the plotter has that capability.

If the Display is in the persistence mode (repetitive display mode with averaging off), or if you are plotting pixel memories, the output from the HP 54111D causes the plotter to plot each data point of the display.

In the realtime mode, all data points displayed on screen are plotted.

In all other cases, waveforms are plotted in a continous line.

Plot Key When pushed, the **Plot** key toggles through Plot All, Plot Display, Plot Factors, and *Plot Graticule*. In the Plot All mode everything displayed on screen is plotted. In the other modes only the selected portion of the screen is plotted.

Start Plot Key When this key is pushed the plotter sequence starts.

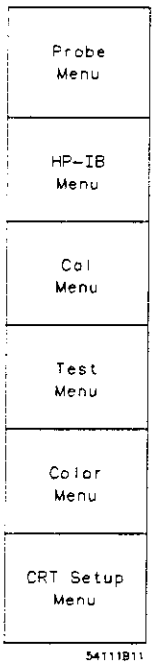
While the plotter sequence is in progress, the original menu is substituted with another containing the following options.

Pause/Continue Key This key allows you to momentarily interrupt the plotting sequence. When the Continue key is pushed, plotting will continue from the point of interruption.

Abort Key This key allows you to discontinue plotting entirely and return to the menu.

Utility Menu 14

Chapter Contents



This chapter contains a description of the utility functions, including probe attenuation, HP-IB interface, self-calibration, color control, and CRT setup. Exercises are included to illustrate how to set the attenuation factors and change the colors on the display.

The Utility menu key allows you to access six submenus:

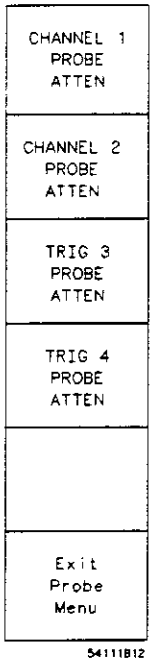
- Probe Menu
- HP-IB Menu
- Cal Menu
- Test Menu
- Color Menu
- CRT Setup Menu

The function keys for each menu are accessed by pressing the appropriate key.

If the HP 54111D fails to calibrate contact your Hewlett-Packard Service Center.

The Test Menu and CRT Setup Menu are discussed in the *HP 54111D Service Manual* and are not covered here.

Probe Menu



After you have selected the Probe Menu you may set a probe attenuation ratio from 100.0 m to 1.000 k on any of the four inputs. If an HP 10431A probe is attached to the input, the range is 1 to 10,000.

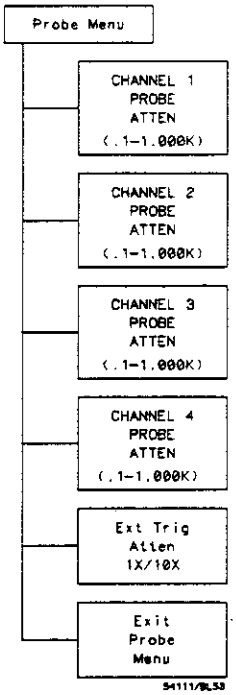


Figure 14-1. Probe Menu

You can use any of the entry devices to enter the attenuation ratio.

When you define a probe attenuation factor the actual sensitivity at the BNC input of the instrument does not change, only voltage displays and markers are adjusted accordingly. When an HP 10431A, or other probe with a sense ring contact is attached, the attenuation factor is multiplied by 10; when detached, the attenuation factor is divided by 10.

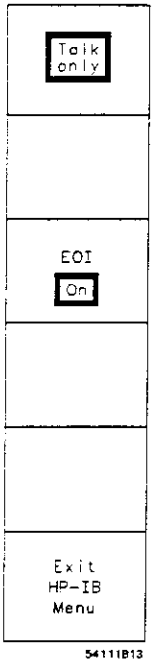
For example, if the attenuation factor is 1.510 and then the probe is attached, the attenuation factor becomes 15.10.

At power up, the attenuation factor will either be set to 1:1 if no probe is attached, or set to 10:1 if a probe with a sense ring is attached (i.e., probe attenuation factors are not saved at power down).

The attenuation factors are stored along with the rest of the front panel setup in the Save/Recall registers.

HP-IB Menu

Select the HP-IB menu when you need to connect the HP 54111D to other HP-IB devices.



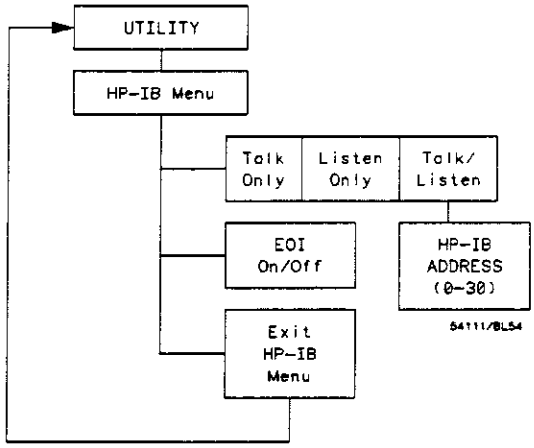


Figure 14-2. HP-IB Menu

After you have selected the HP-IB menu, you may set the HP-IB mode to:

- Talk Only
- Listen Only
- Talk/Listen

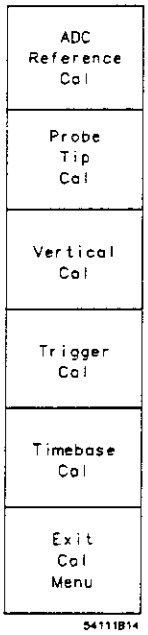
Set the HP 54111D to Talk Only when connected directly to a printer or plotter. When Talk/Listen is selected, the HP-IB ADDRESS key is activated (the default address is 7).

EOI Key The EOI (end or identify) key allows you to invoke this HP-IB function. When EOI is on the HP 54111D will identify the last byte of a multibyte sequence. The default condition for EOI is "On", (see HP 54111D Programming Reference manual).

Cal Menu

The Cal Menu allows you to:

- calibrate the HP 54111D's analog-to-digital converters
- calibrate to the probe tip
- calibrate vertical sensitivity
- calibrate trigger level and hysteresis
- calibrate the timebase reference frequency and channel-to-channel skew (with and without HP 54114A)



The HP 54111D must be calibrated if the advisory *Front Panel Calibration Needed* is displayed during power up. This occurs when:

- battery pack failure occurs
- microprocessor or I/O assemblies have been removed
- two-key down power up has been performed

A one-key down power up sets the oscilloscope to the default conditions (see Table 1-1 in the *HP 54111D Programming Reference Manual* for a list of the reset conditions). A two-key down power up sets the oscilloscope to the default conditions, however, it also erases all software calibration factors and replaces cal factors with defaults. If a two-key down power up is performed, a complete software recalibration is required. The procedure to perform this is listed below. The recalibration can be done by the user because the software calibration routines have been designed to ensure that calibration traceability is maintained.

To ensure traceability, follow these three rules:

- Perform the software calibration routines in the order specified in the procedure below.

- Ensure that the instrument is not outside its calibration interval because the calibrator signal is only specified during this interval.

- the value that the user enters into the Timebase Freq Cal should be the same value that was recorded on the test record that was returned by the calibration lab from which the traceability originated.

When you select the Cal menu, the following submenu appears:

- ADC Reference Cal
- Probe Tip Cal
- Vertical Cal
- Trigger Cal
- Timebase Cal

If you wish to perform the software calibration routines on the instrument, perform them in the order listed below:

- Vertical Cal
- ADC Reference Cal is automatically performed as part of the Vertical Cal cycle, but can be done separately or in addition to the other calibration routines if desired.
- Probe Tip Cal
- Trigger Cal
- Timebase Cal
- Channel-to-Channel Skew

Note

When the HP 54111D is turned on, a self test is automatically performed and a message appears indicating whether the instrument passed or failed the self test. If the instrument fails, let it run for fifteen minutes (warm-up cycle), then perform the software calibration routines. Cycle the power, and if the instrument still fails the self test, contact your nearest Hewlett-Packard Service Center.

ADC Reference Cal

The ADC Reference Cal allows you to set reference voltages to eliminate any gain/offset differences between the four converters in each channel. For a description of the acquisition system see the theory of operation section of the *HP 54111D Service Manual.*

Note

Inputs larger than 2 volts may affect the calibration routine. The effect of smaller signals is negligible.

ADC Reference Cal offers two modes, which can be selected using the increment/decrement keys or the knob:

- auto mode
- manual mode

If **Auto** is selected the HP 54111D automatically performs an ADC reference calibration on its A/D converters for both channels when its operating system determines that this is necessary. This calibration is performed (if needed) at the start of an acquisition cycle before the *Awaiting Trigger* advisory is displayed. This is designed so that the calibration routine will not interfere with a single-shot capture after *Awaiting Trigger* is displayed. If *Awaiting Trigger* is displayed for a long time, an ADC reference calibration should be initiated manually, if this will not interfere with the trigger event.

When the HP 54111D is awaiting a trigger, the ADC reference calibration is disabled. However, it is important to note that the instrument's ADC references may drift while awaiting a trigger. If the ambient temperature is steady, drift is insignificant; drift becomes significant when the ambient temperature changes by more than 5° F (2.5° C) during the time when calibration is disabled.

There are two ways to avoid problems from this phenomenon:

- Generally, it is sufficient to keep the HP 54111D in a *Stopped* status until 30 seconds before the trigger. While *Stopped*, the HP 54111D will calibrate itself.

- Perform an ADC reference calibration just before setting the HP 54111D to trigger on the event. This procedure can be initiated over the bus under program control by simulating key presses (as described in the *HP 54111D Programming Reference Manual*, Chapter 2, Key command).

If **Manual** is selected the instrument will not automatically calibrate when needed. If the instrument determines that a calibration is needed, the ADC Reference Cal key turns red and flashes.

ADC Reference Cal Procedure: To start calibration press the ADC **Reference Cal** key.

The advisory *Calibrating A to D references* will be displayed on the screen. Calibration is complete when the advisory is removed.

ADC Cal failure is indicated by the appearance of more than one trace on a single channel or the trace being greatly displaced

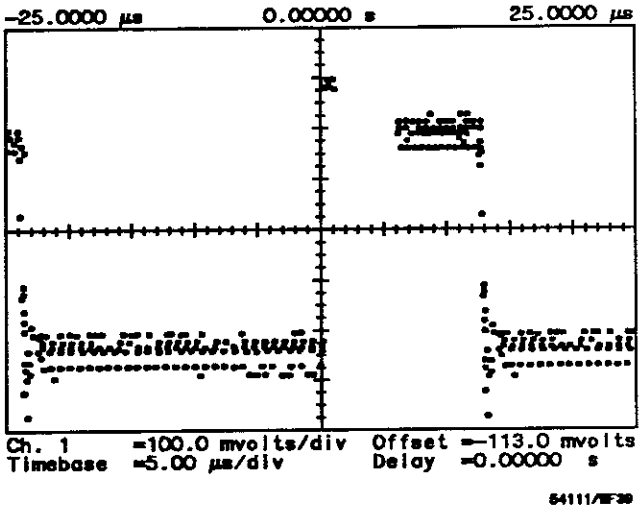
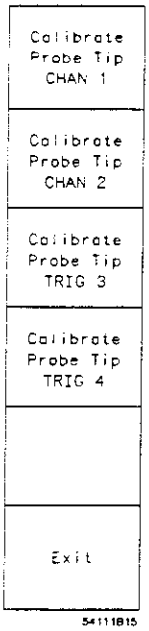


Figure 14-3. ADC Reference Calibration Necessary

Note

You may see a display like Figure 14-3 if the HP 54111D has been set to manual mode and the ADC reference cal has subsequently drifted. Check this before calling the HP Service Center.

Probe Tip Cal The Probe Tip Cal enables calibration from the probe tip through the A/D converters.



Instrument Setup: Connect the front-panel CAL signal through a 10:1 probe to the channel 1 input. If you change probes, you must perform a probe tip cal.

Probe Tip Cal Procedure: The following procedure refers to channel 1, but it can be used to calibrate any of the four inputs as needed.

- Enter the Cal menu by selecting the Utility menu and then the Cal menu.
- Select the **Probe Tip Cal** key
- Select **Calibrate Probe Tip CHAN 1** key

The screen will clear and then display a set of instructions relating to Probe Tip Cal with or without the HP 54114A. Follow the instructions by:

- connecting the front panel CAL signal through an HP 10431A probe to channel 1
- pressing the **Continue** key when ready to start calibration.

Note

If a 10:1 probe other than the HP 10431A is used, set input impedance to 1 MΩ and coupling to dc

When the calibration has started the advisory *Performing CHAN 1 calibration to probe tip* will be displayed and a counter (moving arrow) will travel across the CRT during calibration. When the calibration is complete the HP 54111D will automatically return to the Probe Tip Cal menu.

If the **Exit** key is pressed before the calibration procedure is complete the advisory *Channel 1 Input Gain Calibration Aborted* is displayed on screen. The instrument will return to the Probe Tip Cal menu.

Probe Tip Cal failure is indicated by incorrect vertical scaling.

Vertical Cal Vertical Cal allows you to software calibrate vertical sensitivity and offset.

Instrument Setup: All inputs to CHAN 1 and CHAN 2 must be disconnected.

Vertical Cal Procedure: Enter the Cal menu by selecting Utility and then the Cal menu.

- Press the **Vertical Cal** key. The advisory *Remove probes from CHAN 1 and CHAN 2 inputs. Press Continue when ready* will be displayed on the screen.

- To start calibration remove all probes from inputs and press **Continue**.

When the calibration has started the advisory *Setting up hardware for Cal* will be displayed for about two seconds. The instrument will then calibrate vertical gain at 49.9 mV 20.0 mV, 19.9 mV, 10.0 mV, 9.99 mV, 5.00 mV, 4.99 mV, 2.00 mV 1.99 mV, and 1.00 mV per division. A counter (moving arrow) will travel across the CRT during calibration to indicate that the instrument is working. When calibration is complete the HP 54111D will automatically return to the Utility menu.

If the **Exit** key is pressed before the calibration procedure is complete the advisory *Vertical Calibration Aborted* appears. The instrument will return to the Cal menu and the cal factors will not be changed.

Vertical cal failure is indicated by incorrect vertical gain and/or offset.

Trigger Cal Trigger Cal allows you to calibrate trigger levels and trigger sensitivity (hysteresis).

Instrument Setup: All inputs to CHAN 1, CHAN 2, TRIG 3, and TRIG 4 must be disconnected.

Trigger Cal Procedure: Enter the Cal menu by selecting the Utility menu and then the Cal menu.

- Press the Trigger Cal key the advisory *Remove probes from CHAN 1 and CHAN 2 inputs. Press Continue when ready* will be displayed on the screen.

- To start trigger calibration on channel 1 or 2 remove all probes from inputs and press **Continue.**

When calibration has started, if the advisory *TRIG X hardware failure, calibration not possible* appears that channel has failed the self-test and no calibration will be attempted on that channel. If the fail advisory does not appear the advisory *Performing internal vertical trigger calibration of channels Setting sensitivity on CHAN 1* will be displayed on the screen. The instrument will then calibrate the channel's trigger at 20 mV, 10 mV, and 5 mV range. A counter (moving arrow) will travel across the CRT during calibration. After channel 1 has been calibrated the HP 54111D will automatically repeat the same procedure for channel 2.

When channel 1/2 trigger calibration is complete the advisory *Remove probes from TRIG 3 and TRIG 4 inputs Press Continue when ready* will be displayed the screen.

To start trigger calibration on TRIG 3 and TRIG 4 remove all probes from inputs and press **Continue.** When calibration has started on TRIG 3 and TRIG 4 the advisory *Performing internal vertical trigger calibration of channels. Setting sensitivity on TRIG 3* will be displayed on the screen. A counter (moving arrow) will travel across the CRT during calibration. After TRIG 3 has been calibrated the HP 54111D will automatically repeat the same procedure for TRIG 4.

The HP 54111D will automatically return to the Cal menu when the calibration is complete.

If the Exit key is pressed before calibration procedure is complete the advisory *Trigger Calibration aborted WARNING: Cal factors may be invalid* appears. Part of the Cal factors are invalid.

If the CHAN 1/2 Cal test was interrupted the HP 54111D will automatically exit to the TRIG 3 and TRIG 4 calibration screen. If the TRIG 3/4 Cal test was interrupted the HP 54111D will automatically return to the Cal menu.

Trigger Cal failure is indicated by incorrect trigger levels and trigger sensitivity.

Timebase Cal Timebase Cal is used to software calibrate channel skew and timebase frequency.

Channel Skew aligns the signal that is input to CHAN 1 CHAN 2, TRIG 3, and TRIG 4. Alignment occurs at the intersection of the input signal's edge and the HP 54111D's center horizontal graticule. For each input, this point becomes time-aligned with the zero-delay point. Alignment includes time delays both internal and external to the HP 54111D, including probe or cable length.

It is important to supply a squarewave with a 2 ns rise time, repetition rate $\geq$ 500 kHz, amplitude of $>$ 2 major divisions and $<$ 8 major divisions in the single screen mode. The signal must cross the center horizontal graticule with one positive edge (set in the Timebase menu).

- set channel 1/2 trigger levels to center horizontal graticule.
- set trigger 3/4 impedance coupling and trigger levels identical to channel 1

If these conditions are not met you must exit the menu and establish the signal conditions specified above.

- If the conditions are met, press **Continue.**

Both channels will be time-aligned to the center graticule.

Note

Check the Timebase Cal signal from the rear panel. In most cases this signal meets all input signal criteria for skew cal.

The recommended signal generators are the HP 8161A and HP 8082A pulse generators attached to the BNC tee and equal-length cables (see Figure 14-4).

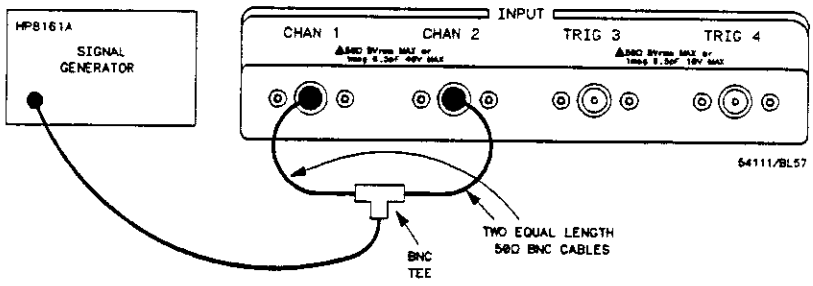
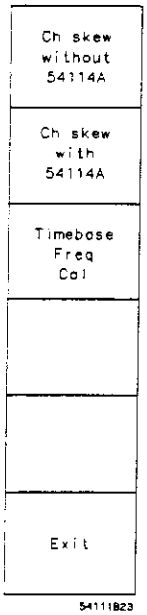


Figure 14-4. Channel-to-Channel Skew Instrument Setup



Channel Skew Procedure: Enter the Cal menu by selecting Utility and then the Cal menu.

- Enter the Channel Skew menu by selecting the Timebase Cal menu and then the **Ch skew without 54114A** key, then the Channel Skew menu.
- Read the advisory and verify that specified conditions are met.
- When ready to start calibration press the **Continue** key.

When calibration has started, the following advisory is displayed *Aligning Channel to Channel Skew and CHAN 1 trigger Aligning Trigger for XX ns Sample Period* where XX indicates 1 ns, 2 ns, 4 ns, 10 ns, 20 ns, 40 ns, 100 ns, 200 ns sample period. After CHAN 1 has completed aligning itself, the following advisory *Aligning CHAN 2 trigger Aligning Trigger for XX ns sample period* where XX indicates 1 ns, 2 ns, 4 ns, 10 ns, 20 ns, 40 ns, 100 ns, 200 ns sample period.

- After CHAN 2 has been aligned to CHAN 1, the advisory *Connect Common Signal Source to CHAN 1 and TRIG 3. Press Continue when ready.* Follow the instruction by removing the BNC cable from CHAN2 and connecting it to TRIG 3.

- When ready to start calibration press the **Continue** key.

When calibration has started, the advisory *Aligning TRIG 3 Aligning Trigger for XX ns Sample Period* where XX indicates 1 ns, 2 ns, 4 ns, 10 ns, 20 ns, 40 ns, 100 ns, 200 ns sample period.

- After TRIG 3 has been aligned to CHAN 1, the advisory *Connect Common Signal Source to CHAN 1 and TRIG 4 Press Continue when ready.* Follow the instruction by removing the BNC cable from TRIG3 and connecting it to TRIG 4.

- When ready to start calibration press the **Continue** key.

When the calibration has started, the advisory *Aligning TRIG 4 Aligning Trigger for XX ns Sample Period* where XX indicates 1 ns, 2 ns, 4 ns, 10 ns, 20 ns, 40 ns, 100 ns, 200 ns sample period.

After TRIG 4 has been aligned to CHAN 1 the instrument will automatically return to the Cal menu.

If the **Exit** key is pressed before the calibration procedure is completed the advisory *Channel Skew Calibration aborted WARNING: Cal factors may be invalid* appears, then part of Cal factors are invalid. The instrument will return to the Cal menu.

If the setup is incorrect the advisory *Signal not found, Calibration aborted* will be displayed on the screen. The instrument will automatically return to the Cal menu.

Timebase Freq Cal: Allows you to calibrate the accuracy of time interval measurements made with the HP 54111D.

Instrument Setup: Connect the Timebase Cal output from the rear panel of the instrument to a frequency counter with a 50 Ω BNC cable. The counter should be able to count at least 51 MHz at an input level of - 200 mV to - 400 mV square wave (HP 5315A or HP 5384).

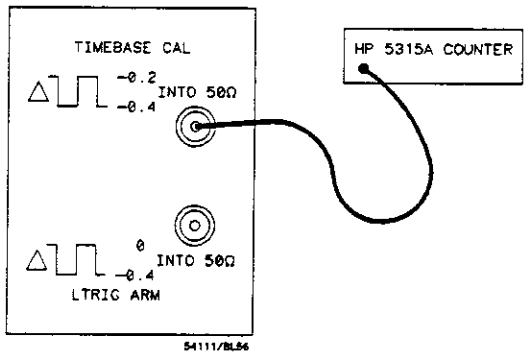


Figure 14-5. Timebase Frequency Cal Instrument Setup

Note

To maintain a traceable calibration (e.g., U.S. National Bureau of Standards), you must use a traceable frequency counter. The Timebase Frequency Calibration is not a calibration that should normally be done by the user. If not performed correctly, then Timebase Calibration can be lost. Please see the HP 54111D Service Manual for more information.

Timebase Freq Cal Procedure: Enter the Cal Menu by selecting the Utility menu and then the Cal menu.

- Enter the Timebase Freq Cal menu by selecting the Timebase Cal menu and then the Timebase Freq Cal menu.

In the Timebase Freq Cal menu the advisory *Connect rear panel TIMEBASE CAL output to frequency counter. Enter results using keypad and press Continue.*

Acceptable range is 50000000 to 50100000
Current value is _____
Frequency _____Hz

After the instrument is set up and the Timebase Freq Cal is selected:

- Read the frequency from the counter. The frequency output will change when Timebase Freq Cal menu is entered.

- Enter the frequency reading (enter eight digits) from the frequency counter into the HP 54111D with the use of the Enter keypad.

- To start calibration press **Continue**.

If the **Exit** key is pressed before calibration is complete, the previous calibration factors will be saved and the instrument will return to the Cal menu.

When calibration is complete the HP 54111D will automatically return to the Cal menu.

One-Key Down Power Up

A one-key down power up is an instrument preset. It causes the instrument to power up in a known state (see Table 1-1).

To perform a one-key down power up:

- Turn the front-panel power switch to STBY
- Press and hold down the bottom function key (along the right side of the CRT) and toggle the power switch to ON
- Continue to hold bottom function key until all test patterns have been completed and the Power-up Self Test Passed message is displayed.

Two-Key Down Power Up

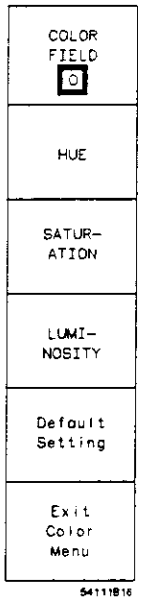
A two-key down power up is a hard reset of the instrument. It completely clears the memory (i.e, clears everything stored in RAM) including all cal factors (channel-to-channel skew, vertical gain/offset, probe tip, timebase frequency cal) and setup information stored in the save/recall registers.

To perform a two-key down power up:

- Turn the front-panel power switch to STBY
- Press and hold down the top and bottom function keys (along the right side of the CRT), turn on the instrument
- Continue to hold the top and bottom function key until all test patterns have been completed (within approximately 30 seconds).

The instrument is not operable until 30 minutes after the two-key down power up is performed. A signal source and frequency counter are required to reestablish the cal factors after the two-key down power up.

Color Menu



The color menu allows you to define the 16 (0-15) color fields available on the HP 54111D. All 16 fields can be individually modified to suit a specific need.

Color selections are maintained in non-volatile memory and are part of the Save/Recall memories.

After you have selected the Utility menu and the Color menu:

- use the Color Field key (top key) or one of the entry devices to select the color number you wish to change.
- Then use the HUE, SATURATION, and LUMINOSITY functions to modify it.

Hue Key The HUE key allows you to change the color. The range is from 0 to 100, with red located at 0/100, green at 33, and blue at 67. You can use any of the entry devices.

Saturation Key The SATURATION key allows you to define the percent of pure color that is to be mixed with white. The range is from 0 to 100, with 0 being white (regardless of the hue setting) and 100 being the pure color (determined by hue). You can use any of the entry devices.

Luminosity Key The LUMINOSITY key allows you to define the relative brightness of the color. The range is from 0 to 100, with 0 being black and 100 being maximum brightness. You can use any of the entry devices.

Default Setting Key The Default Setting key allows you to set all colors to their default states (see table 14-1).

Table 14-1. Default Color Settings

Color #	Color	Display Use	PaintJet Use	Hue	Sat	Lum
0	Black	Background	Overlap	0	0	0
1	Beige	Highlighting	Highlighting	12	51	100
2	Gray	Text (Halfbright)	Stored Traces	0	0	55
3	Red	Advisory	Advisory	0	100	100
4	Yellow	Channel 1	Not used	17	100	100
5	Green	Channel 2	Green	33	100	100
6	Orange	Markers	Markers	11	100	100
7	White	Stored traces (when selected)	Background	0	0	100
8	Magenta	2 trace overlap	Channel 1	90	100	100
9	Tangerine	Function 1	Function 1	8	100	100
10	Blue	Function 2	Function 2	53	85	90
11	Magenta	Memory bar	Not used	90	100	100
12	Magenta	3 trace overlap	Not used	90	100	100
13	Magenta	2 trace + memory overlap	Not used	90	100	100
14	Magenta	3 trace + memory overlap	Not used	90	100	100
15	Magenta	4 trace + memory overlap	Not used	90	100	100

Specifications 15

Introduction

This chapter contains a list of specifications for refrence and performance verification. This chapter also includes supplemental characteristics which are typical parameters as additional information.

All specifications cited in this chapter and manual applies for temperature ranges ±5°C from point of last software calibration.

Vertical (Voltage)

Channels	2	
Bandwidth (-3dB)*	**Real Time**	**Repetitive**
dc-coupled	dc to 250 MHz	dc to 500 MHz
ac-coupled	10 Hz to 250 MHz	10 Hz to 500 MHz
Transition Time (10 to 90%)	See Operating Characteristics	700 ps
Deflection Factor (full scale = 8 div)	1 mV/div to 5 V/div continuous	
Resolution (% of full scale)	8 bits to 25 MHz (0.4%) 7 bits to 100 MHz (0.8%) 6 bits to 250 MHz (1.6%)	6 bits (1.6%) 8 bits with averaging to 500 MHz (0.4%)
DC Gain Accuracy	±2% of full-scale**	
DC Offset Accuracy	±1.5% of setting ±0.2%***	

* Bandwidth for settings 1 mV/div to 4 mV/div is reduced to 150 MHz.

** When calibrated to probe tip using the front panel calibration source. Applies to major ranges (5 mV, 10 mV/div, 20 mV/div, 50 mV/div, 100 mV/div, 200 mV/div, 500 mV/div, 1 V/div, and 2 V/div). All continuous settings between these ranges are ±3% of full scale. All settings between 1 mV and 4 mV are ±4% of full scale.

*** Increases to ±0.4 divisions at 5 mV/div to 9 mV/div, and ≥1 division below 5 mV/div.

DC Measurement

Accuracy

Single data point	± Gain Acc. ± Offset Acc. ± Resolution
Between data points on the same waveform	± Gain Acc. ± 2 x Resolution
DC Offset RAnge	± 200 mV (1 mV/div to 4 mV/div) ± 1 V(5 mV/div to 49 mV/div ± 10 V (50 mV/div to 499 mV/div) ± 40 V (500 mV/div to 5 V/div
Input coupling	ac/dc/dc-50Ω/gnd
Maximum Safe Input Voltage	± 40 Volts @ 1 MW (dc + peak ac), 5 Vrms @ 50Ω

Note

All voltages correspond to a 1:1 attenuation setting. If a 10:1 probe is attached, multiply all voltages by ten. The HP 10431A has a maximum voltage of ± 400 V.

Horizontal (Time)

	Real-time	**Repetitive**
Digitizing Rate	1 gigasample/second to 50 samples/second	
Deflection Factor	500 ps/div to 1 s/div	

Memory Depth Per Channel	8k	501
Pre-trigger Delay Range	-8 μs at timebase settings 50 ns/div and faster, increasing to -160 sec at 1 s/div	
Post-trigger Delay Range	0.16 s at timebase settings 500 ns/div and faster, increasing to 10,000 seconds at 1 s/div	
Time Interval Measurement Accuracy		
Single channel	±300 ps* ±0.03% of reading	±100 ps* ±0.03% of reading
Dual channel	±600 ps** ±0.03% of reading	±200 ps** ±0.03% of reading

Triggering

Sources	**Internal Channels 1,2**	**External Triggers 3,4**
Sensitivity	0.1 of full-scale, dc to 200 MHz*	15 mV (high sensitivity)** dc to 200 MHz
	0.2 of full-scale, 200 MHz to 500 MHz*	45 mV (high sensitivity)** 200 MHz to 500 MHz

Decreased to (±0.2% of time range ±0.03% of reading) for time ranges 200 ns and slower. Time range is (time/div x 10).

** Decreased to (±0.4% of time range ±0.03% of reading) for time ranges 200 ns and slower. Time range is (time/div x 10).

Trigger Level Range	±3 x full-scale	±1 V (high sensitivity)**
Maximum Safe Voltage	NA	±10 volts @ 1 MΩ (dc + peak ac), 5 Vrms @ 50Ω
Input Operating Range	NA	±1 V (high sensitivity) dc + peak ac

* Applies to settings 5 mV/div to 5 V/div.

** For low sensitivity, multiply voltage values by 10.

Operating Characteristics

Vertical

Real-time Mode Transition Time (10% to 90%): 1.4 ns. Calculated by measuring a 1.4 ns risetime source. In the 6-bit filter mode, a 1.4 ns input risetime is measured as 2.0 ns = $[(1.4)2 + (1.4)2]^{1/2}$

Input Impedance: 1 MΩ at <6.5 pF or 50Ω(dc).

Input Protection: 50Ω input resistance is protected. When maximum safe input voltage is exceeded.

Dynamic Performance (typical):

	Effective bits of resolution			
Input Frequency	1 MHz	20 MHz	90 MHz	250 MHz
6 Bit Mode	5.5 bits	5.5 bits	5.5 bits	5.0 bits*
7 Bit Mode	6.2 bits	6.2 bits	6.0 bits	N/A
8 Bit Mode	7.2 bits	7.0 bits	N/A	N/A

* unfiltered data transferred over HP-IB

Channel-to-Channel Isolation: 60 dB at 500 MHz

Horizontal

Delay Between Channels: difference in delay between channels can be front-panel calibrated to compensate for differences in input cables or probe length.

Reference Location: the reference point can be located at the left edge, center, or right edge of the display. The reference point is the trigger plus the delay time.

Trigger Holdoff

Holdoff-by-events: range of events counter is from 2 to 67 million events. Maximum counting rate is 80 MHz. An event is defined as anything that satisfies the triggering conditions selected.

Holdoff-by-time: adjustable from 70 ns to 670 ms.

Trigger Modes

Edge trigger: on any source.

Pattern trigger: a pattern can be specified for all sources. Each source can be specified as high, low, or don't care. Trigger can occur on the last edge to enter the specified pattern or the first edge to exit the specified pattern.

Time qualified pattern trigger: trigger occurs on the first edge to exit the specified pattern, only if the pattern was present for less than (greater than) the specified time. Time is adjustable fro 10 ns to 5 seconds. Recovery time is ≤ 8 ns. In the "Pattern present (time)" mode, the pattern must be present ≥ 1 ns for the trigger to respond.

State trigger: a pattern can be specified for any of the sources. Trigger can be set to occur on an edge of either polarity on the source specified as teh clock (not one of the pattern sources) when the pattern is present or not present. Setup time for the pattern to be present prior to the clock edge is < 4 ns; hold time is zero. Maximum clock repetition rate is 80 MHz.

Delay Trigger

Events-delayed mode: the trigger can be armed by an edge on any source, then triggered by the nth edge on any other soiurce. The number of events, n, can be set from 1 to 10^8 - 1. Maximum event counting rate is 150 MHz.

Time-delayed mode: the trigger can be armed by an edge on any source, then triggered by the first edge on any other source after a specified time has elapsed.

Display

Data Display Resolution: 501 points horizontally by 256 points vertically.

Data Display Formats

Split screen: channel displays are two or four division high, corresponding to quad or dual display mode.

Full screen: channels are overlaid and are eight divisions high.

Display modes

Variable persistence: the time that each data point is retained on the display can be varied from 200 ms to 10 seconds, or it can be displayed in the infinite persistence mode.

Averaging: the number of averages can be varied from 1 to 64. On each acquisition, 1/n times the new data is added to (n-1)/n of the previous value at each time coordinate. Averaging operates continuously; the average does not converge to a final value after n acquisitions, except over HP-IB.

Graticules: Full grid, axes with tic marks, frame with tic marks, or graticule off.

Data reconstruction: On sweep speeds when less than 500 points are acquired across the screen, a built-in digital filter will automatically reconstruct the data in the real-time acquisition modes (single-shot acquisition). The filter "off" position in the display mode will display raw data.

Display colors: A default color selection is set up. Different colors are used for display background, channels, functions, background test, highlighted text, advisories, markers, overlapping waveforms, and memories. If desired, colors may be changed either from the front panel or over the HP-IB.

HP-IB Data transfer rate: 80 kbytes/s

Measurement Aids

Markers: dual voltage markers and dual time markers are available. Voltage markers can be assigned to channels, memories, or functions.

Automatic Edge Finders: the time markers can be assigned automatically to any displayed edge of either polarity on any channel. The voltage markers establish the threshold reference for the time markers in this mode.

Automatic Pulse Parameter Measurements: the following pulse parameter measurements are performed automatically (as defined by IEEE standard 194-1977,"IEEE Standard Pulse Terms and Definitions").

Frequency	Overshoot
Period	Peak-topeak voltage
Duty cycle	Average voltage
Positive pulse width	RMS voltage
Negative pulse width	Top voltage*
Risetime	Base voltage*
Falltime	Maximum voltage
Preshoot	Minimum voltage

Waveform Math: six independent functions are provided for waveform math. The operations are +,-,invert, Minimum, Maximum, *, integrate. The vertical channels or any of the waveform memories can be used as operands for waveform math.

* only available over the HP-IB

Setup Aids

Presets: vertical deflection factor, offset, and trigger level can be preset independently on each channel for ECL and TTL levels.

Autoscale: pressing the Autoscale key causes the vertical and horizontal deflection factors and the trigger source to be set for a display appropriate to the signals applied to the inputs. Requires a duty cycle great than 0.1% and frequency greater tha 50 Hz. Operative only for relatively stable input signals.

Save/REcall: ten front panel setups may be saved in non-volatile memory. If Autoscale is inadvertently pressed, pressing Recall followed by Autoscale, restores the instrument to the state prior to the last Autoscale.

Environmental Conditions

Operating temperature: +15°C to +55°C (+59°F to + 131°F)

Nonoperating temperature: -40°C to + 75°C (-40°F to + 167°F)

Operating humidity: up to 95% relative humidity (non-condensing) at +40°C (+104°F)

Non-operating humidity: up to 90% relative humidity at -65°C (+149°F)

Operating altitude: up to 4600 meters (15,000 feet)

Non-operating altitude: up to 15,300 meters (50,000 feet)

Vibration: vibrated in three orthogonal axes for 15 minutes each axis; 0.38 mm (0.015 inches) peak-to-peak excursions; 5 to 55 Hz; 1 minute/octave sweep

Power Requirements

Voltage: 115/230 Vac, -25% to +15%, 48-66 Hz

Power: 350 watts maximum, 700 VA maximum

Weight

Net: approximately 27 kg (59 lb)

Shipping: approximately 32 kg (70 lb)

Dimensions

425.7 x 617.2 x 234.2 millimetres (16.76 x 24.3 x 9.22 inches)

HP 54114A 2 GSa/S Test Set 16

Introduction

The HP 54111D can be configured to double the single shot acquisition rate to 2 gigasamples/second. Since the sample rate is doubled the vertical bandwidth is also doubled to approximately 500 MHz and the channel count is reduced to one. This is accomplished by adding the optional HP 54114A Test Set (option 114 to the HP 54111D).

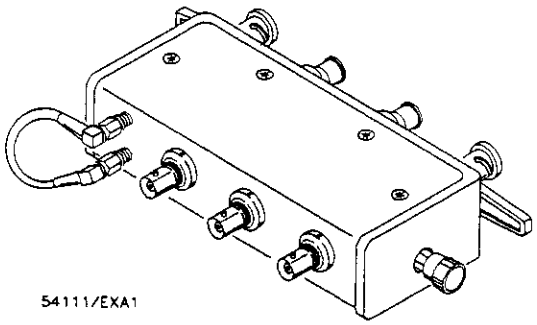


Figure 16-1. HP 54114A Test Set

Description

The HP 54111D oscilloscope acquires data on two channels simultaneously at 1 GSa/s. This rate of acquisition yields one data sample every nanosecond with a resolution of 10 psec.

Interleaving

The HP 54114A takes advantage of the 10 psec resolution and 500 MHz bandwidth of each channel. It combines the simultaneous acquisition by interleaving and routing the data into one channel, gaining an effective sampling rate of 2 GSa/s.

Combining the data from two channels into one requires a precise time delay of 500 psec (one-half of one 1 GSa/s sample) between the two channels. The HP 54114A Test Set is used to route two channels into one and delay channel 2 by exactly 500 psec.

Installation

The HP 54114A is mounted on the HP 54111D front panel on the four input BNC connectors. To mount the Test Set:

- Enter the Display menu and press the **Ch1 & Ch2 2GSa/s** (it may be labelled **Ch1 & Ch2 Combine** if the sampling rate is slower than 1 GSa/s) key to turn on the 2GSa/s sampling feature. The advisory *Attach 54114A* is displayed on the screen.

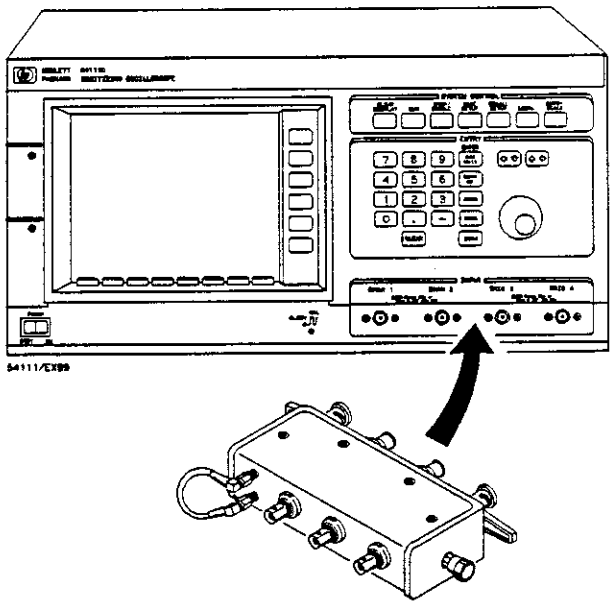


Figure 16-2. Installing the HP 54114A

- Line up the four male BNC connectors on the rear of the Test Set with the four input BNCs on the front of the HP 54111D.

Note

The HP 54114A can be installed upside-down. When installing make sure the fine adjustment knob is on the right side and the coarse calibration cable is on the left.

- Slide the HP 54114A Test Set into place and secure the position by turning the locking levers clockwise until they click.

Calibration

There are three calibration routines necessary to optimize the accuracy and performance of the 2 GSa/s measurements.

- Coarse Delay Calibration
- Fine Delay Calibration
- Probe Tip Calibration w/HP 54114A

The coarse delay calibration is a process used to select a cable that allows the test set to compensate for delay variations between HP 54111D oscilloscopes. If your HP 54114A was ordered as HP 54111D option 114 this calibration was done at the factory.

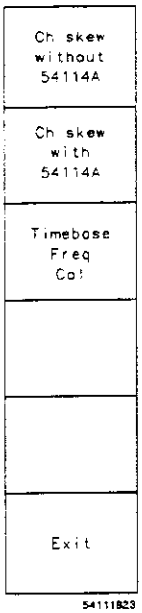
The fine delay calibration is a front panel calibration used to set the delay settings to precisely 500 ps between channel 1 and channel 2.

Note

System delay is dependent upon the system attenuator range and recalibration may be necessary if the oscilloscope vertical range is changed.

The probe tip calibration may be performed when the HP 54114A Test Set is installed to bring the vertical ranges from 5% to $\leq 2\%$ accuracy levels.

Calibration Setup To set up the instruments for calibration:



- Perform the HP 54111D Skew calibration without the HP 54114A Test Set (in the Utility menu) to ensure that channel 1 and channel 2 are operating within the specifications.

- Install the HP 54114A Test Set and set the HP 54111D oscilloscope on a signal that has a risetime of < 5 ns.

Note

A 6 dB attenuator installed on the HP 54111D when performing the skew cal improves the accuracy for both the fine and coarse delay calibration, however, it is not essential. This ensures the signal amplitude is the same for 54114A on or off.

- Set the Timebase to 500 ps/div.

- Enter the Display menu and press the **Ch1 & Ch2 2GSa/s** key to turn the feature *On*. This sets channels 1 and 2 together with the same channel sensitivities, input impedance and other display setups. When channel 1 is changed, channel 2 changes exactly the same as channel 1.

- Set the Display Mode to *Repetitive,* **Averaging** on and **NUMBER OF AVERAGES** to 8.

Coarse Delay Calibration Coarse delay calibration is used to select the Chan 1 coarse delay on the HP 54114A Test Set to compensate for channel to channel delay variations and adjust the test set to a specific HP 54111D oscilloscope. This procedure must be done initially with each oscilloscope and must be repeated only if the test set is moved to another oscilloscope.

If you purchased your HP 54111D with Option 114, the cable will have already been selected to match the test set with the oscilloscope. If you purchased the HP 54114A separately and are upgrading your HP 54111D, then you must perform the coarse calibration.

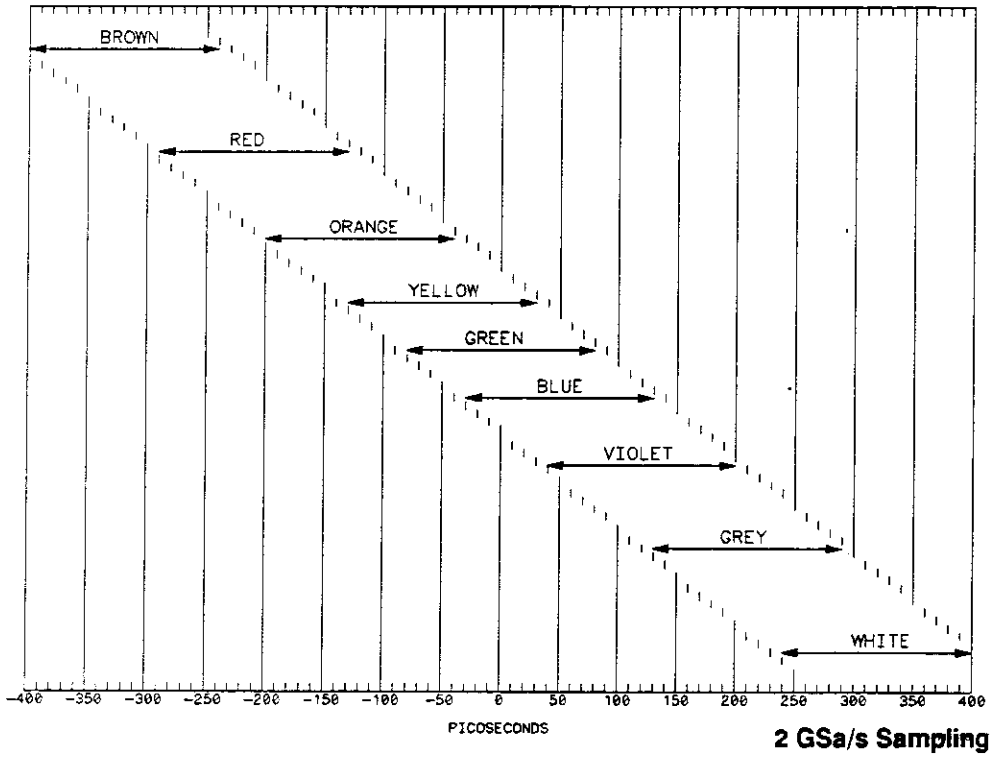
To perform the coarse calibration:

- Install the HP 54114A Test Set on the oscilloscope.
- Select the Cal menu and press the **Timebase Cal** key. Perform the Skew Calibration with HP 54114A (in the Utility menu).

When the skew calibration selection is made (in the Utility menu) the advisory *Attach 54114A with correct Chan1 Coarse Delay cable. For coarse cable selection, Ch1 to Ch2 skew = nn ps* will be displayed.

- Refer to Table 16-1 to select the proper coarse calibration cable that best brackets the channel 1 to channel 2 delay, and install it on the test set.

Table 16-1. HP 54114A Coarse Calibration Reference Chart



When the correct cable has been installed on the HP 54114A continue with the instructions on the screen. The advisory is *Connect common signal source to CHAN1 and TRIG3.*

- When all signal conditions have been satisfied, *press Continue and both channels will be time aligned to the center graticule.*

Fine Delay Calibration

The Fine Delay Calibration is necessary to set channel 2 delay to exactly 500 ps skew from channel 1. This is essential to optimize the 2 GSa/s sampling rate and maximize the bandwidth using the test set.

To set the fine delay:

- Ensure the HP 54114A is installed and a fast risetime signal generator (< 5 ns) is connected to the Test Set.
- Enter the Display menu and turn the Ch1 & Ch2 2GSa/s feature on.
- Press **AUTOSCALE.**
- Set the oscilloscope timebase to 500 ps/div.
- Set the HP 54111D to:

  Repetitive mode
  Averaging on
  NUMBER OF AVERAGES to *8*
  Ch1 & Ch2 2GSa/s to *Off*
  (ignore the advisory to remove the test set)
  Delay to 0.0000.
  Channel 1 On
  Channel 2 Off

Allow the channel 1 waveform to accumulate and average until a fine, definitive waveform within one pixel (approximately 10 ps) is displayed. The waveform must cross the horizontal axis within 4 mm of center screen (2 minor divisions). If the waveform crosses beyond this point the skew calibration or trigger level was incorrect and should be repeated.

- Enter the Wfm Save menu and save this waveform in memory. Turn the selected memory on and display the saved waveform. The saved waveform is displayed in white.

Channel 1 is acquiring data and displaying in yellow (default) and the memory is being displayed in white while any signal overlap is being displayed in magenta. Allow the HP 54111D to acquire data. You can see the relationship between channel 1 and the saved waveform.

Enter the Display menu and press the **Ch1 & Ch2 2 GSa/s** key. This will turn the feature on and set the two channels at exactly the same setup.

- Turn Chan 1 off and Chan 2 on.

- Alternately press **CLEAR DISPLAY** and turn the Chan 2 Fine Delay knob until the stored waveform and channel 2 waveform are exactly superimposed.

This technique will adjust the channel 2 signal to be precisely 500 ps, or delayed one half of one sample interval, relative to channel 1.

When the sweep speed is slower than 50 ns/div (sampling rate is less than 1 GSa/s) the HP 54111D displays the combined data. The oscilloscope aligns the data points and averages the acquired data. The displayed data is the realtime average of 2. To display combined data turn Chan 2 off, Chan 1 on and set the display mode to Real Time.

Probe Tip Cal with 54114A

It is necessary to calibrate the HP 54111D with the HP 54114A Test Set installed to minimize probe tip error. The calibration and resultant calibration factors are more critical with the HP 54114A mounted. The following instrument hook-up reflects the need for a more precise calibration.

Probe Tip Calibration Procedure:

- Hook up the equipment per Figure 16-3.

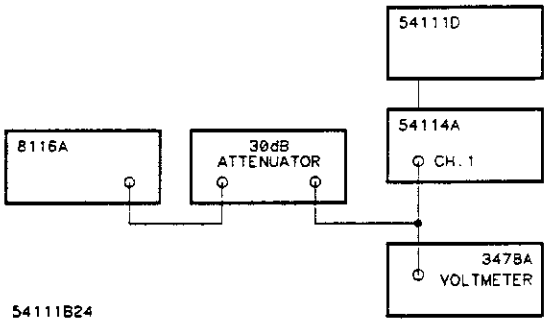


Figure 16-3. Probe Tip Cal Equipment Setup

- Set the HP 8116A to output a 2 kHz squarewave, 50.0% duty cycle, through a 30 dB attenuator, from 0 volt low level to 5.1 volt high level. Input this signal into the HP 54114A mounted on an HP 54111D.

- Turn the 2 GSa/s feature on the HP 54111D on.

- Adjust the HI level voltage level until 80 mV rms is displayed on the HP 3478A..

- Enter the Utility menu and calibrate the signal path through the HP 54114A for channels 1 and 2.

- Calibrate Triggers 3 and 4 with a 6 dB attenuator in the signal path terminated in 50 Ω. Select High trigger sensitivity and a 40 mV trigger level.

Implementation

Several factors must be considered when using the HP 54114A Test Set at 2 GSa/s acquisition. To increase the real time bandwidth and sampling rate the HP 54111D was reduced to one channel and the sensitivity was reduced one-half, however, the sensitivity change has been compensated for by changing probe attenuation when entering the 2 GSa/s mode.

When in the 2 GSa/s mode with twice as many samples the real time bandwidth is increased to 500 MHz with all filters off. As the bandwidth is increased the oscilloscope performance is also increased. Resolution is improved by virtue of the increased bandwidth.

Resolution	**One Channel Operation @ 2 GSa/s (typical bandwidth)**	**Two Channel Operation @ 1 GSa/s (typical bandwidth)**
Off	500 MHz	250 MHz
6	410 MHz	250 MHz
7	200 MHz	100 MHz
8	50 MHz	25 MHz

When in the 2 GSa/s mode, all filters, measures, markers, and functions will be active and can work on the 2 GSa/s data.

Two records of skew data are maintained so that you can go in and out of the 2 GSa/s mode without requiring another front panel calibration. Only one vertical cal record is maintained, so for optimum vertical accuracy it is necessary to calibrate the system for the mode selected.

Upgrade Kit

Hewlett-Packard has made available an upgrade kit for all HP 54111Ds. It is possible to make all 1 GSa/s 54111D oscilloscopes sample at 2 GSa/s and add nonvolatile memory.

Two parts are necessary to upgrade the HP 54111D:

- HP 54114A Test Set
- HP 54111D Upgrade Kit, part number 54111-68702

The modifications incorporated in the upgrade kit are extensive and some are transparent to the user. As a result the following parts are included in the kit:

- Microprocessor board, part number 54111-66519 *
- Installation instructions, part number 5959-6077
- *Service Manual,* part number 54111-90912
- *Front Panel Operation Reference* manual, part number 54111-90913
- *Programming Reference* manual, part number 54111-90914

* all late model HP 54111D oscilloscopes already have the 54111-66519 microprocessor board and appropriate manuals. You can check your HP 54111D for the correct microprocessor board by entering the Display menu to find the **Ch1 & Ch2 2GSa/s** key. If the key is displayed on the menu your oscilloscope is equipped with the correct board.

Service

The following section provides service information for the HP 54114A. The instrument is very simple and requires little maintenance. There is no other service documentation besides that provided in this manual.

Testing

About the only thing that can fail on the HP 54114A is the value of the resistors in the input splitter. Excessive input signal that changes their resistance (or the 50Ω resistances at the input of the HP 54111D) results in inaccurate signal amplitudes and incorrect termination of the signal input.

The HP 54114A power splitter resistance should be checked whenever the HP 54111D is tested. No major equipment other than that needed for testing the HP 54111D is needed for this test. Results of the test can be entered in the Performance Test Record for the HP 54111D.

Parts

A parts list is given following the resistance test. Use the same ordering procedures given in the Replaceable Parts section for the HP 54111D. Included are drawings showing location of parts.

Power Splitter Resistance Test

A four-wire resistance measurement verifies accuracy of the 50 Ω resistors in the power splitter. If the 54114A is being tested with an HP 54111D, do this test when doing the 54111D Input Resistance test.

Specification: 50Ω ±1%

Equipment Required:

EQUIPMENT	CRITICAL SPECIFICATIONS	RECOMMENDED MODEL
Multimeter	Measure resistance to 0.25% accuracy	HP 3468A
Cables (2)	BNC	HP 10503A
Adapter	BNC Tee (m)(f)(f)	HP 1250-0781
Adapter (2)	Banana (m) to BNC (f)	HP 1251-2277
Adapter	BNC Barrel (f)(f)	HP 1250-0080
Coaxial short circuit	BNC (m)	HP 1250-0929

Procedure:

1. Set up the multimeter to make a 4-wire resistance measurement and connect the equipment as shown in the figure below.

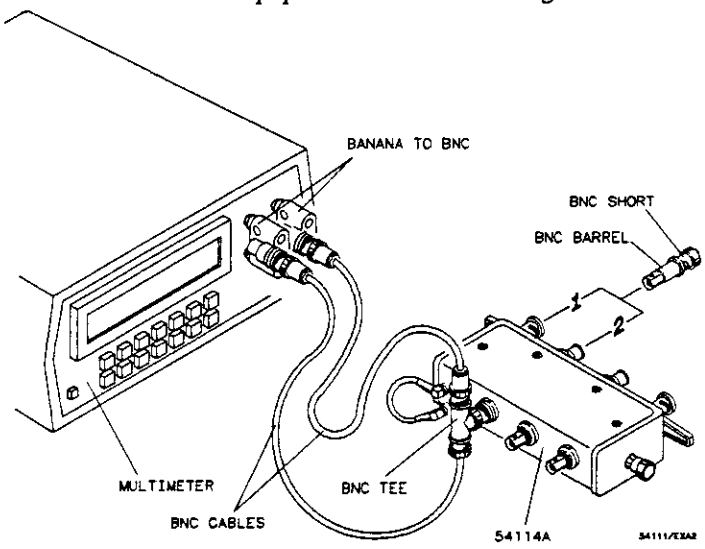


Figure 16-4. Input Resistance Test Connections

2. Be sure that one of the SMA cables (supplied with the HP 54114A) is connected between the connectors on the front of the HP 54114A.

3. Connect the BNC barrel and short circuit combination to the connector that normally goes to the CHAN 1 input of the HP 54111D.

4. Verify that the meter reads 50Ω ±0.5Ω.

5. Connect the BNC barrel and short circuit combination to the connector that normally goes to the CHAN 2 input of the HP 54111D.

6. Verify that the meter reads 50Ω ±0.5Ω.

Parts List

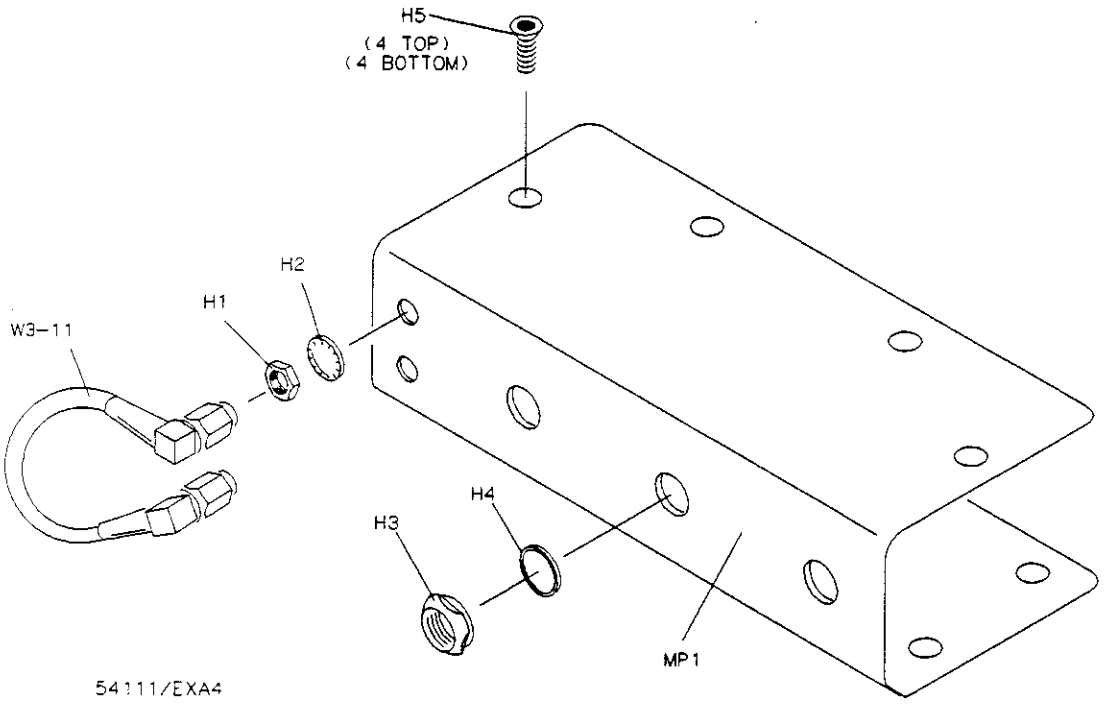


Figure 16-5. Parts Locator, Part 1

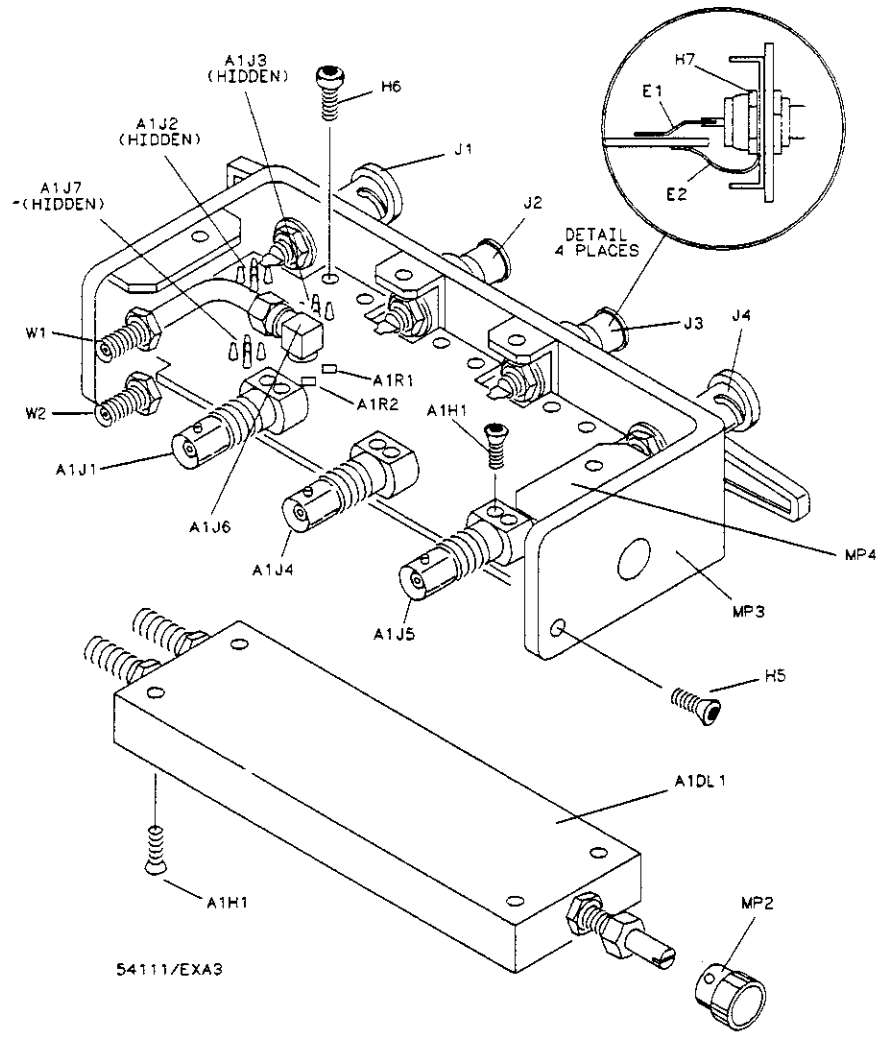


Figure 16-6. Parts Locator, Part 2

REF. DESIG.	PART NO.	QUAN.	DESCRIPTION
A1	54114-66501	1	PC BOARD (Not including A1DL1,J3,J7)
E1	54114-06101	4	SOLDER LUG
E1	0360-1632	4	SOLDER LUG
H1	2950-0196	2	NUT-HEX 1/4-36
H2	2190-0084	2	WASHER-INTERNAL LOCK 1/4-INCH
H3	5081-7683	3	NUT-HEX SHOULDER
H4	3050-1229	3	WASHER-FLAT STAINLESS STEEL
H5	0515-1035	10	SCREW-MACH M3 8MM-LG FLAT-HD T10
H6	0515-0374	6	SCREW-MACH M3 10MM-LG PAN-HD T10
H7	2950-0043	4	NUT-HEX 3/8-32 0.093
J1, J4	54114-67601	2	CONNECTOR RF BNC WITH LEVER
J2, J3	1250-1798	2	CONNECTOR RF BNC
MP1	54114-04101	1	COVER
MP2	0370-1121	1	KNOB
MP3	54114-07701	1	BASE
MP4	54114-00201	1	SUB PANEL
W3	54114-61603	1	CABLE EXTERNAL BROWN 78MM
W4	54114-61604	1	CABLE EXTERNAL RED 101MM
W5	54114-61605	1	CABLE EXTERNAL ORANGE 120MM
W6	54114-61606	1	CABLE EXTERNAL YELLOW 135MM
W7	54114-61607	1	CABLE EXTERNAL GREEN 145MM
W8	54114-61608	1	CABLE EXTERNAL BLUE 155MM
W9	54114-61609	1	CABLE EXTERNAL VIOLET 170MM
W10	54114-61610	1	CABLE EXTERNAL GREY 189MM
W11	54114-61611	1	CABLE EXTERNAL WHITE 212MM

A1			PC BOARD ASSEMBLY
A1DL1	54114-61615	1	DELAY LINE ADJUSTABLE
A1H1	0515-1320	10	SCREW-MACH M2 13MM-LG FLAT-HD T6
A1J1,J4,J5	1250-0524	3	CONNECTOR RF BNC
A1J2,J6	1250-2218	2	CONNECTOR RF SMA FEMALE RHT-ANGLE
A1J3,J7	1250-2219	2	CONNECTOR RF SMA MALE RHT-ANGLE
A1R1,R2	0699-2625	2	RESISTOR 50 OHM SURFACE MOUNT

Schematic

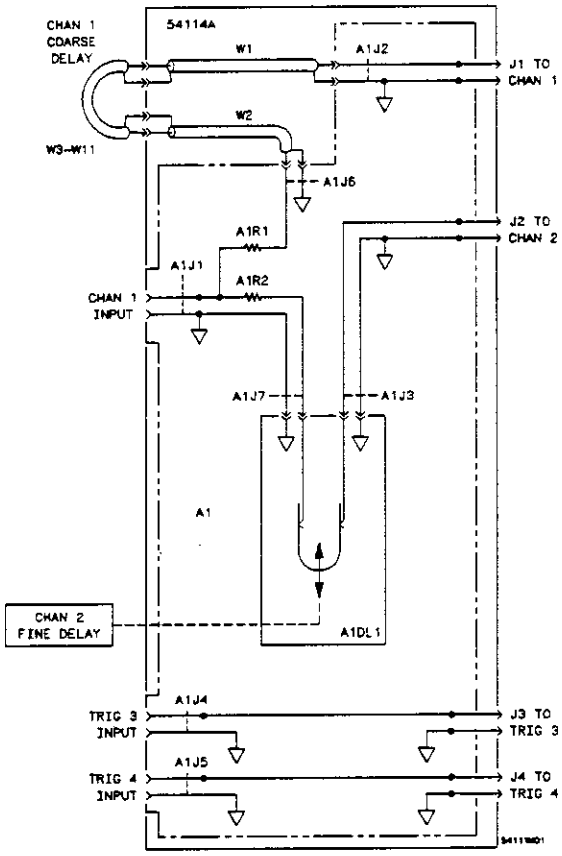


Figure 16-7. Schematic

Increasing Vertical Resolution A

Evaluation of an A/D converter's system resolution should never be limited to its rated number of bits. Rather, a system's vertical resolution should be evaluated in terms of its signal-to-noise ratio or effective bits. Effective bits is a means of specifying a system's vertical performance as compared to a perfect A/D (i.e., a perfectly linear and distortionless A/D). The family of curves in Figure A-1 plot an A/D's system resolution in effective bits as a function of input and amplifier signal-to-noise ratio and the converter's number of bits. Effective bits may also be computed using the sine wave curve fit test and the following formula:

$$\textit{effective bits} = N - \log^2 \textit{rms error (actual)/rms error (ideal)}$$

The rms error (actual) is the error measured relative to the best fit perfect sine wave. The rms error (ideal) is the theoretical error from a perfect N-bit converter. See Product Note 5180-2 (HP part number 5952-7629) for details.

A microprocessor-based digital architecture oscilloscope allows use of internal software routines to perform digital filtering that can improve vertical resolution. These filters allow more precise waveform reconstruction by trading bandwidth for resolution.

In an ideal system (with no noise), digital filtering cannot improve vertical resolution. However, all systems have inherent noise above dc. The quantization process by itself generally appears as white noise to the Nyquist frequency. This may or may not be the dominant source of noise. However, other noise sources contribute to the total noise in any real system. If this total noise is white in composition, effective resolution can actually be improved beyond the A/D's ideal performance with digital filtering. What separates the HP 54111D from other digitizing oscilloscopes is that this instrument not only uses digital filtering, but it also employs a vertical dithering scheme to ensure that the total noise is white in composition for the full frequency spectrum of the instrument, including dc.

The dithering scheme is achieved by staggering the referencs of the four-phase A/D converters. Each A/D is vertically referenced 1/4 LSB apart. Even though a conventional six-bit converter results in only 64 unique quantization levels, the HP 54111D's four-phased converters have 256 unique quantization levels; the same number of unique levels found in an eight-bit converter.

The four staggered A/Ds appear as one A/D with high frequency noise injected. As with any linear system having noise content that is white in composition, the rms noise voltage is proportional to the square root of the system bandwidth. By limiting the system bandwidth to 1/4 the Nyquist frequency with digital filtering, the system (including the $\pm 1/2$ LSB quantization error) can be reduced by a factor of two. Provided the signal content is within the bandpass of the filter, the signal-to-noise ratio is the same as that generated by an n + 1 bit A/D converter. This is analogous to filtering with an analog low pass filter. However, with digital filtering, not only is system noise reduced, but the quantization error is reduced as well, hence improving vertical resolution. Another effective bit will be gained by lowering the bandwidth by another factor of four.

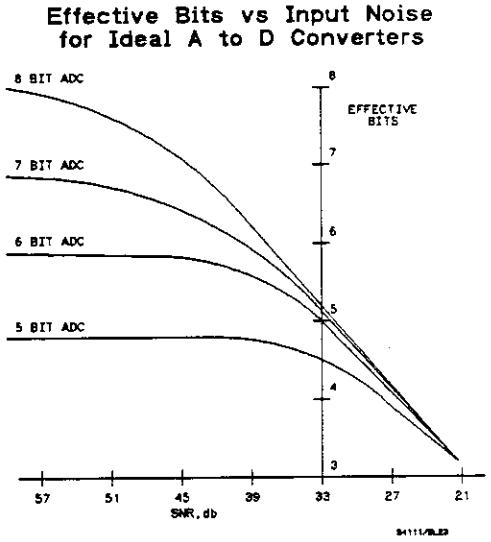


Figure A-1. Effective Bits vs. Input Noise

Inside the HP 54111D B

Hybrid Approach Overcomes Technology Barriers

Different IC technologies have distinct advantages and disadvantages. Often, when pushing performance limits beyond the capability of any one technology, combining ICs from different processes achieves synergy, permitting optimum performances from each technology. To develop a digitizing oscilloscope with a maximum sampling rate of 1 gigasample/second required the capability of GaAs and silicon. HP chose a hybrid solution to solve the problem with today's advanced integrated circuit processes.

The hybrid approach takes greatest advantage of the strength of each process. GaAs ICs with MESFET (metal semiconductor FET) transistors and companion GaAs Schottky diodes are ideally suited for implementing a high speed track-and-hold function. On the other hand, high-speed silicon bipolar offers higher resolution for flash converters operating beyond 100 megasamples/second. High-speed memory requirements are still best handled by MOS processes due to VLSI capability at minimum power levels. The HP 54111D data acquisition system fully utilizes all of these technologies using a hybrid approach.

Front End Technology Offers Performance and Versatility

For general purpose applications, a general-purpose front end is needed to handle a wide range of input signals. Attenuation provided by the attenuator and preamp hybrids allows control of vertical sensitivities from 1mV/div to 5 V/div with continuous ranging.

The input thickfilm hybrid provides electromechanical selection of three decades of attenuation at 1 MΩ input impedance. Miniaturization of the contact system and hybrid layout allow a nominal input capacitance of 6.5 pF. A 50 Ω termination is selectable on the hybrid for transmission line applications. The thickfilm attenuation drives a preamp/trigger hybrid, whose primary component is a custom bipolar IC chip that provides additional attenuation control and trigger signal generation.

GaAs Track and Hold Circuits for Silicon Converters

The track-and-hold embodies a four-phase, two rank sampling technique that allows the input signal to be sampled in the first rank at 1 gigasample/second and fanned out in the second rank as four sampled analog outputs, each shifted in phase by 1 ns and clocking at 250 megasample/second. When reassembled, data from the four A/Ds is equivalent to that of one A/D clocking at 1 gigasample/second.

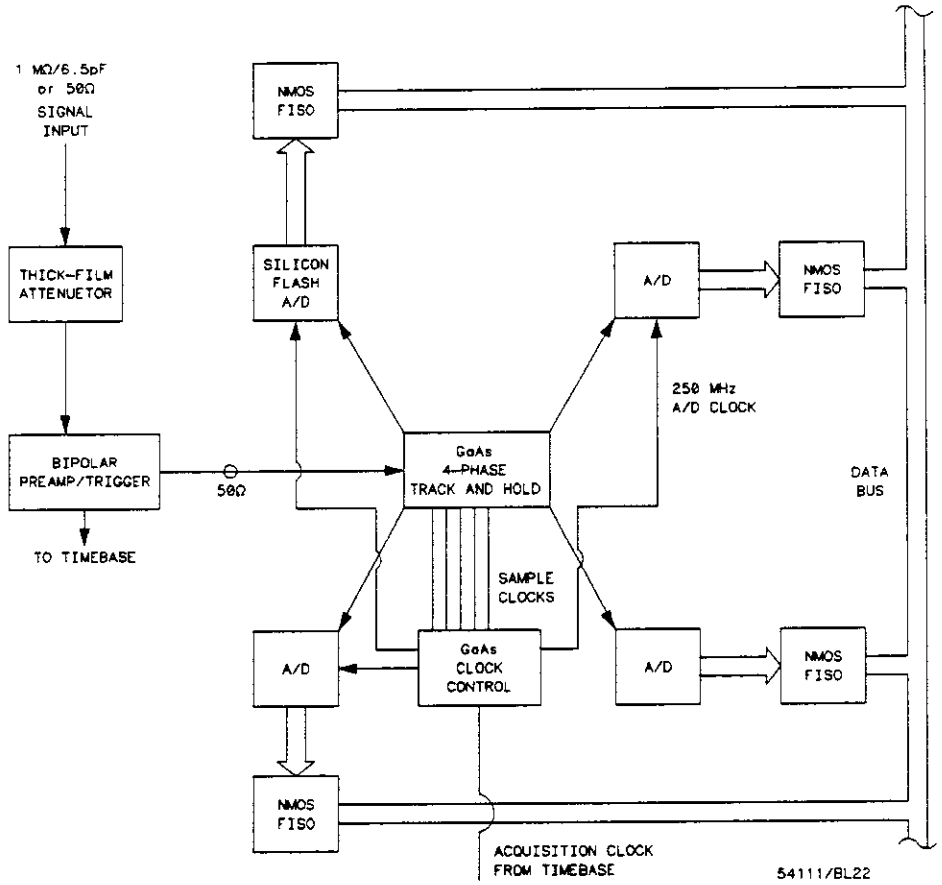


Figure B-1. HP 54111D Signal Acquisition

Deeper Memory with Another Internal HP Process

For a digitizing oscilloscope, the waveform memory must be capable of fast write cycles. Although static ECL RAM can take data from each A/D at 250 megasample/second, power constraints prevent its use. A high-speed, fast-in-slow-out (FISO) VLSI memory chip was developed by Hewlett-Packard and fabricated in a 1.7 micron gate NMOS process. The design is capable of input data rates exceeding 250 megasample/second with a memory depth of 2 kbytes. Using one of these memory chips per A/D gives a total memory depth of 8 kbytes per channel, allowing an 8 μs waveform record at the full 1 gigasample/second sampling rate.

Automatic Parametric Measurements C

Introduction

One of the HP 54111D's primary features is its ability to make parametric measurements on displayed waveforms. This chapter provides details on how automatic measurements are performed and some tips on how to improve automatic measurement results.

Measurement Setup

Measurements typically should be made at the fastest possible sweep speed to obtain the most measurement accuracy possible. For any measurement to be made, the portion of the waveform required for that measurement must be displayed on the oscilloscope. That is:

- **period or frequency measurement**-at least one complete cycle must be displayed.
- **pulse width measurement**-the entire pulse must be displayed.
- **risetime measurement**-the leading (positive-going) edge of the waveform must be displayed.
- **falltime measurement**-the trailing (negative-going) edge of the waveform must be displayed.

Making Measurements

If more than one waveform, edge, or pulse is displayed, the measurements are made on the first (leftmost) portion of the displayed waveform that can be used.

When any of the defined measurements are requested, the oscilloscope first determines the top (100%) and base (0%) voltages of the waveform. From this information, it can determine the other important voltage values (10% voltage, 90% voltage, and 50% voltage) required to make the measurements. The 10% and 90% voltage levels are used in the risetime and falltime measurements. The 50% voltage level is used for measuring frequency, period, pulse width, and duty cycle.

Automatic Top-Base

Top-Base is the heart of most automatic parametric measurements. It is used to find V_{top} and V_{base}, the 0% and 100% voltage levels at the top and the bottom of the waveform. From this information the oscilloscope can determine the 10, 50, and 90% points, which are used in most automatic measurements. The Top or Base of the waveform is not necessarily the maximum or minimum voltage present on the waveform. Consider a pulse that has a slight amount of overshoot. It would be wrong to select the highest peak of the wave as the to since thw waveform normally rests below the perturbation.

Top-Base performs a histogram on the waveform and finds the most prevalent point above and below the waveform midpoint. The most prevalent point is one that represents greater than approximately 5% of the total display points (501) and is considered to be either the top or base. If no point accounts for more than 5% of the total, then the top is chosen as the absolute maximum and base is chosen as the absolute minimum.

Measurement Algorithms

Frequency

The frequency of the first complete cycle on screen is measured using the 50% levels. The algorithm used is:

if

the first edge on screen is rising

then

frequency = 1/(time at second rising edge - time at first rising edge)

else

frequency = 1/(time at second falling edge - time at first falling edge)

Period The period is measured at the 50% level of the waveform. The algorithm for this measurement is:

if

the first edge on screen is rising

then

period = (time at second rising edge - time at first rising edge)

else

period = (time at second falling edge - time at first falling edge)

Duty Cycle The positive pulse width and the period of the displayed signal are measured. Then the duty cycle is calculated using the following formula:

duty cycle = (+ pulse width/period) X 100

Positive Pulse Width (+ Width) Pulse width is measured at the 50% voltage level. The algorithm for this measurement is:

if

the first edge on screen is falling

then

width = (time at second falling edge - time at first rising edge)

else

width = (time at first falling edge - time at first rising edge)

Negative Pulse Width (- Width)

Negative pulse width is the width of the first negative pulse on screen using the 50% levels. The algorithm used is:

if
    the first edge on screen is rising
then
    width = (time at second rising edge - time at first falling edge)
else
    width = (time at first rising edge - time at first falling edge)

Risetime

The risetime of the first displayed rising (positive-going) edge is measured. To obtain the best possible measurement accuracy, set the sweep speed as fast as possible while leaving the leading edge of the waveform on the display. The risetime is determined by measuring the time at the 10% and 90% voltage points on the rising edge, and then the risetime is calculated using the formula:

risetime = (time at 90% point - time at 10% point)

Falltime

Falltime is measured between the 10% and 90% points of the falling (negative-going) edge. To obtain the best possible measurement accuracy, set the sweep speed as fast as possible while leaving the falling edge of the waveform on the display. The falltime is calculated using the following formula:

falltime = (time at 10% point - time at 90% point)

Peak-to-Peak Voltage

The maximum and minimum voltages for the selected source are measured. Then the peak-to-peak voltage is calculated using the formula:

$$V_{pp} = V_{max} - V_{min}$$

where V_{max} and V_{min} are the maximum and minimum voltages present on the selected source.

RMS Voltage The rms voltage is computed over one complete period with the following formula:

$$Vrms = [1/n\Sigma^{j=n}_{j=1}V_j^2]^{1/2}$$

Average Voltage The average voltage of the first cycle of the displayed signal is measured. If a complete cycle is not present, the instrument will average the data points on screen.

Preshoot Preshoot measures the first edge on screen using the following algorithm:

```
if
    the first edge on screen is rising
then
    preshoot = Vbase - Vmin
else
    preshoot = Vmax - Vtop
```

Preshoot is measured on the top of a waveform if the first edge on screen is a falling edge. Also, V_{max}, V_{top}, V_{base}, and V_{min} are measured using all the data on screen.

Overshoot Overshoot measures the first edge on screen using the following algorithm:

```
if
    the first edge on screen is rising
then
    overshoot = Vmax - Vtop
else
    overshoot = Vbase - Vmin
```

Overshoot is measured on the base of a waveform if the first edge on screen is a falling edge. Also, V_{max}, V_{top}, V_{base}, and V_{min} are measured using all the data on screen.

Index

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

Q

R

S

T

U

Scans
By
Outsource-Options
(NR1DX)

Outsource-Options
Suite 2M
187 Depot Road,
Hollis, NH 03049

nr1dx@arrl.net or Henderson@outsource-options.com

"High resolution scans of obsolete technical manuals"

If you purchased this manual from us (typically through our Ebay name of NR1DX) thank you very much. If you received this from a well-meaning "friend" for free we would appreciate your treating this much like you would "share ware". By that we mean a donation of at least $5-10 per manual is appreciated in recognition of the time, energy and quality of effort that went into preserving this manual. Donations via PayPal go to: nr1dx@arrl.net or can be mailed to us the address above. This is not a hobby for us but a semi-retirement business used to augment our diminished income in the face of the current degraded world economy.

Typically the scans in our manuals are done as follows;

1) Typed text pages are typically scanned in black and white at 300 dpi.
2) Photo pages are typically scanned in gray scale mode at 600 dpi
3) Schematic diagram pages are typically scanned in black and white at 600 dpi unless the original manual had colored high lighting (as is the case for some 70's vintage Tektronix manuals).

Original pages, which exceed the 8.5 x 11 format, are scanned with enough overlap so that they can be printed and pieced. This is done for primarily for two reasons, the time involved in post processing these to their original size is not trivial and most people do not have the ability to print 11 X 17 pages anyway.

If your looking for a quality scanned technical manual in PDF format please drop us a line at nr1dx@arrl.net. and we will be happy to email you a current list of the manuals we have available. If you don't see the manual you need on the list drop us a line anyway we may still be able to point you to other sources. If you have an existing manual you would like scanned please write for details, This can often be done very reasonably in consideration for adding your manual to our library.

Thanks

Dave Henderson, NR1DX

Dave Henderson
Outsource-Options