Errata

Title & Document Type: 54111D/54112D Digitizing Oscilloscope Getting Started Guide

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HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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HP 54111/12

Getting Started Guide

HEWLETT PACKARD

Getting Started Guide

HP 54111D Digitizing Oscilloscope
HP 54112D Digitizing Oscilloscope

HEWLETT PACKARD

Publication 5954-2669

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Introduction

About this book...

There's a lot of power packed inside the HP 54111D and HP 54112D digitizing oscilloscopes, and we want to make sure you get the most out of whichever one you have. That's why we'd like you to invest some time going through this *Getting Started Guide*. Whether you're a novice oscilloscope user or just new to these models, this book will give you a working knowledge of the HP 54111D and HP 54112D so you can start using them to solve your measurement problems. It covers

- front-panel layout
- how to apply power to the instrument
- how to set up the scope to make a measurement
- how to use and interpret the display
- how to use the basic features

To make this book easier to use we have put the names of keys (**AUTO – SCALE**, **TIME/DIV**), as well as key labels in bold type And, we have highlighted actions (rotate the knob, press the **AUTO – SCALE** key) in color.

Because the HP 54111D and HP 54112D have so many features, and many of them overlap, we have included both oscilloscopes in one *Getting Started Guide*. Don't be alarmed if you are using one and seeing pictures of the other in the following pages. The front panels are very similar and performances, in many cases, are the same. When there are evident differences, we'll point them out to you.

If you have never used this type of instrument, we recommend you read *Feeling Comfortable with Digitizing Scopes* However, if you are very familiar with digitizing oscilloscopes you can probably "skim" through the first nine chapters. Starting with chapter 8 we'll guide you through some actual measurements and special HP 54111D and HP 54112D features. These exercises will make you more comfortable with the instruments, as well as demonstrate how they differ.

We didn't try to cover everything these oscilloscopes can do for you. That's the job of your *Front-Panel Operation Reference*

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What Can They Do?

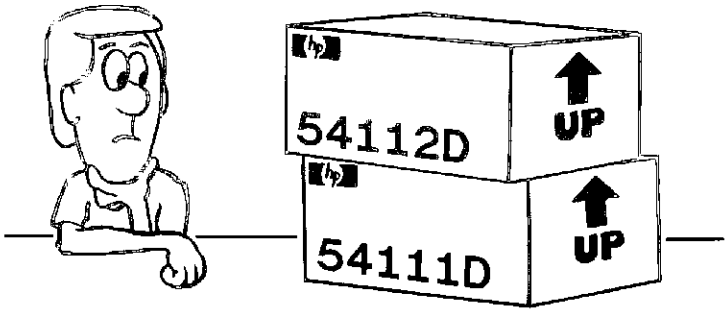
Key Features

The HP 54111D and the HP 54112D Digitizing Oscilloscopes have been developed to satisfy the need for single shot acquisition. Many signals have not been captured and evaluated because they only appeared once and the conditions were destroyed. Or the conditons never appeared again. Perhaps, a glitch appears only during initialization of certain loops of a program. A design engineer attempts to develop timing circuitry with four synchronized circuits. A technician tries to isolate a handshake error in a serial transmission line.

All are prime applications for the HP 54111D or the HP 54112D. If you need two-channel capability at extremely fast acquisition speeds, your answer is the HP 54111D. If you need four channel simultaneous acquisition with very deep memory, your solution is the HP 54112D.

Some of the key features common to both instruments are:

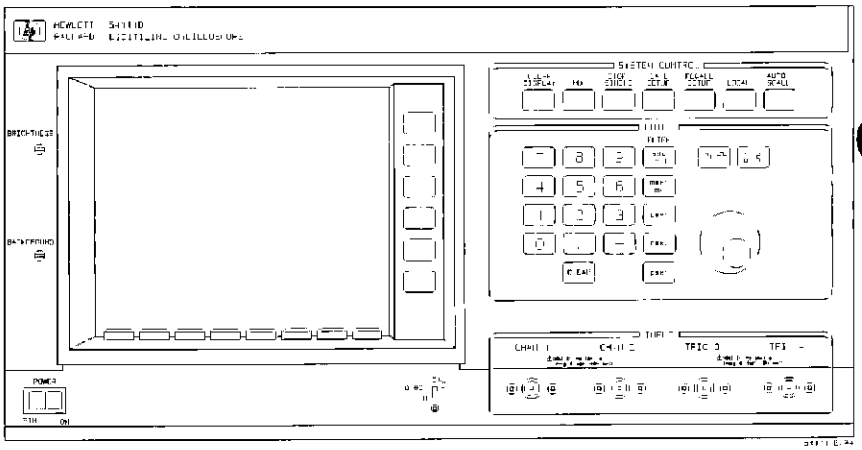
- Automatic parametric measurements
- Automatic waveform scaling
- Pre- and post-trigger viewing capability
- General purpose input coupling
- Full color display
- Hardcopy output to a printer or plotter
- Trigger delay by time or events
- Delta V and Delta t cursor measurements
- Front panel setup Save/Recall registers
- Waveform functions (A+B, A−B, invert)



What's the Difference?

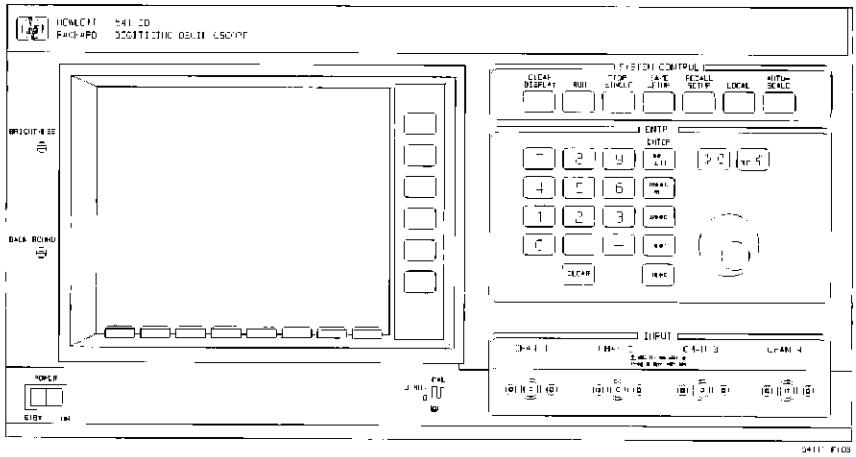
HP 54111D

- 1 gigasample/second digitizing rate
- Real-time bandwidth of 250 MHz
- Random repetitive bandwidth of 500 MHz
- 2 channel simultaneous acquisition
- 8k point memory depth per channel
- 2 external selectable triggers
- Selectable vertical resolution up to 8 bits
- Horizontal sensitivity from 500 ps to 1 s/div
- Vertical deflection from 1 mV to 5 V/div



HP 54112D

- 400 megasample/second digitizing rate
- Real-time and repetitive bandwidth of 100 MHz
- 4 channel simultaneous acquisition
- 8k or 64k point deep memory per channel
- 1 external trigger
- Horizontal sensitivity from 2 ns to 1 sec/div
- Vertical deflection from 5 mV to 5 V/div



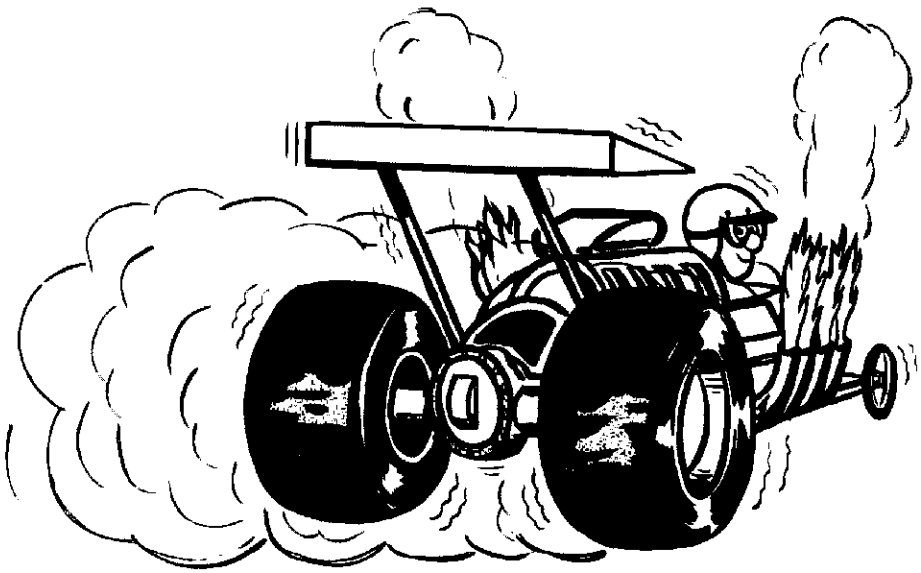
Applying Power

How to Power-up

To ensure safe operation, the following items should be checked before power is applied to the instrument

- Before connecting the instrument to an ac power source, ensure that the line select switch at the rear of the instrument is set to the appropriate position (110 or 220 V)
- Make sure you have the correct power cord and it provides chassis ground for your instrument when it is plugged into the power receptacle.

After the power cord has been connected to the instrument and to an appropriate power source, the front panel power switch and the rear panel circuit breaker must be in the ON position for the unit to operate. (0 indicates OFF and 1 indicates ON).



Power-up Self-Test

After the power switch is set to ON, a self-test of the oscilloscope is performed. While the self-test is in progress, several different patterns are displayed on the CRT which are meaningless to the user. When the oscilloscope completes the self-test, a message is displayed that tells you whether the oscilloscope has passed or failed the self-test.

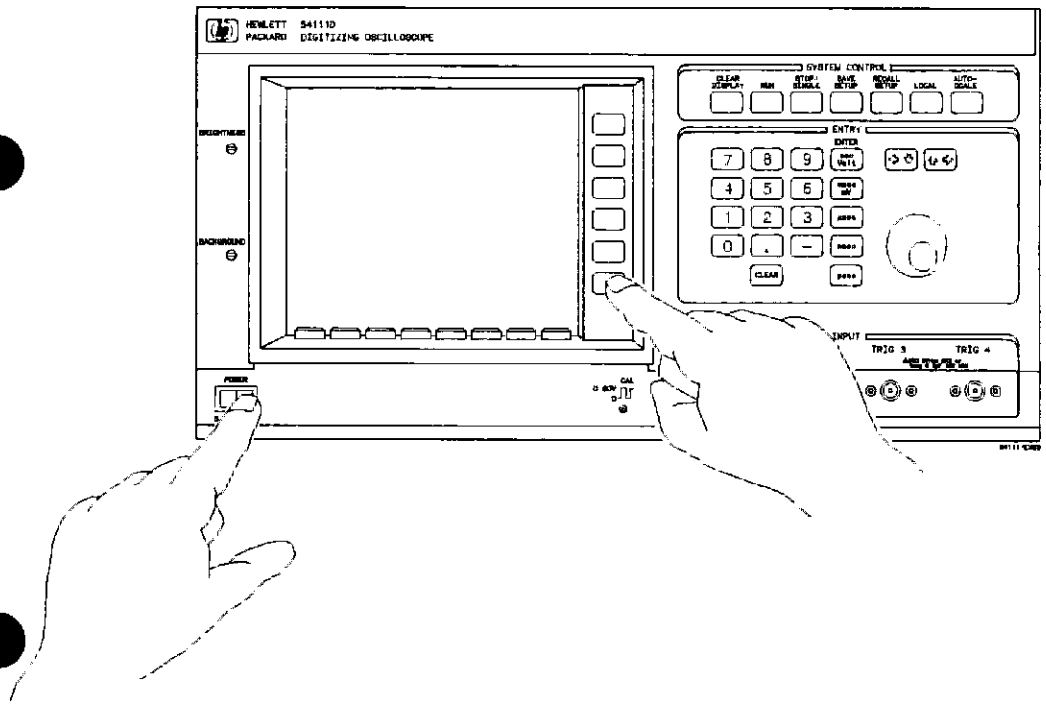
- The message "Powerup Self Test Passed !" means you can continue and use the instrument.
- The message "Instrument Warm-up in Progress 15:00" means the instrument was not calibrated during self-test. Although you can use the instrument during this time, some measurements might not be properly calibrated. During the 15:00 minute warm-up, the instrument will attempt to calibrate itself.
- If at the end of the 15:00 minute warm-up, the instrument still did not pass the self-test, the message "Powerup Self Test Failed !" will be displayed. This may indicate the instrument requires service. Refer to the *Front Panel Operation Reference*, Utility Menu, or the service manual Self Test/Troubleshooting section.

Instrument Preset

The one key-down power-up operation is an instrument preset. This simply means that the instrument will power up in a known state. It is not important for you to understand these conditions, however, you must complete this operation to ensure the state of the instrument is known for these exercises

To do a key-down power-up, turn the front panel power switch to STBY. Now press and hold the bottom function selection key. This is the bottom key on the right side of the instrument. This key MUST be held down until all test patterns have been completed and the "Power-up Self Test Passed" message is displayed on the CRT.

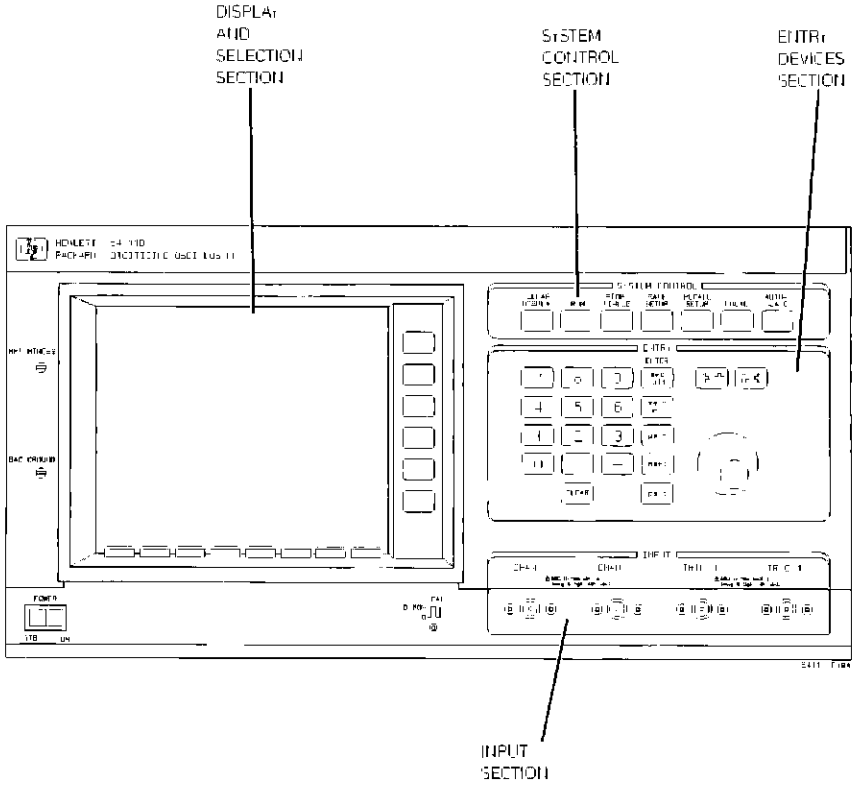
While holding the key down, turn the power switch to ON.



Becoming Familiar with the Front Panel

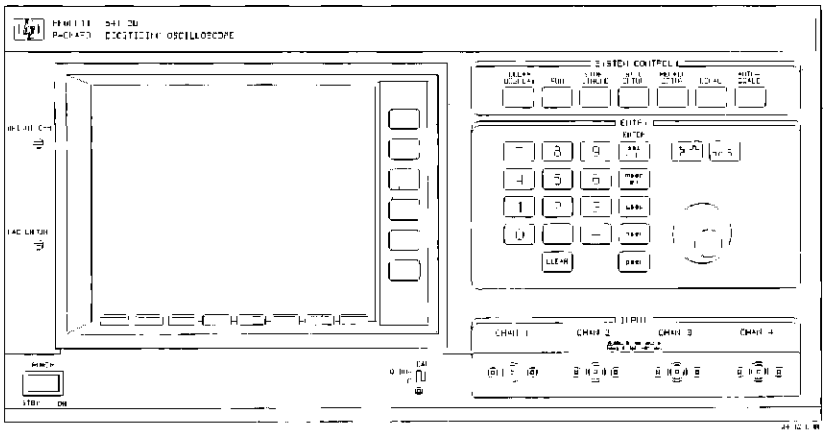
Introduction

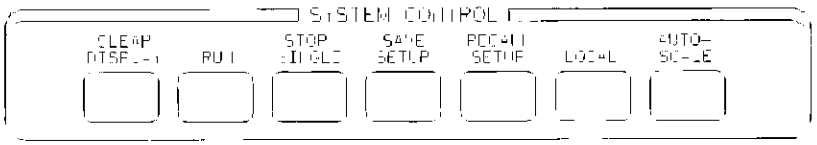
The front panels of the HP 54111D and the HP 54112D are organized into four functional areas. These are: system control, display and selection, entry devices, and input. Each of these areas is discussed in detail in the *Front Panel Operation Reference*, however, a brief description here will give you enough information to complete the exercises in this book and get you off to a good start.



System Control

The System Control area, on the top right of the instrument, contains seven system keys. These keys override all other functions, and when pressed, are immediately executed. **AUTO—SCALE** (far right) is the key used most often (this is discussed in detail in chapter 5).

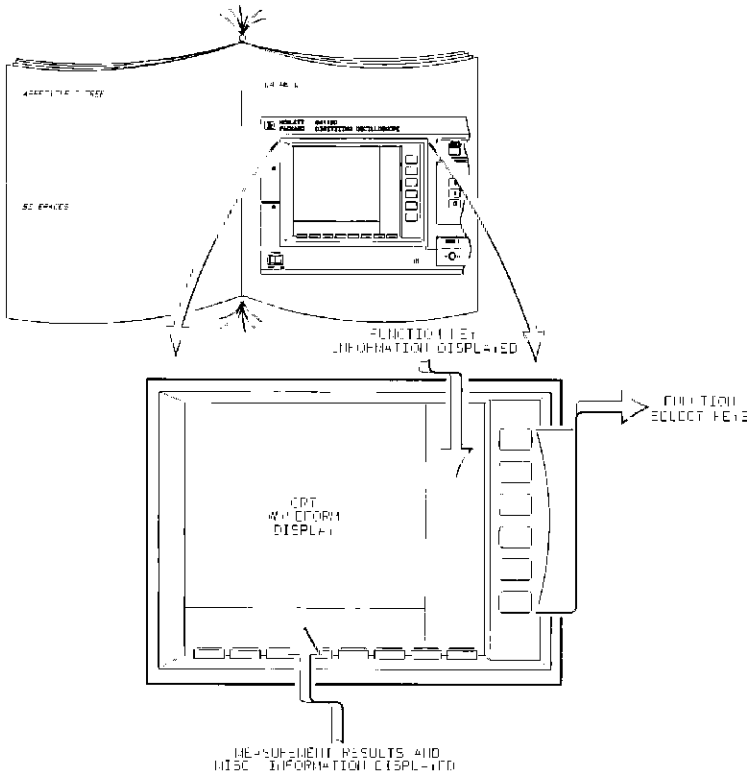




Display/Selection

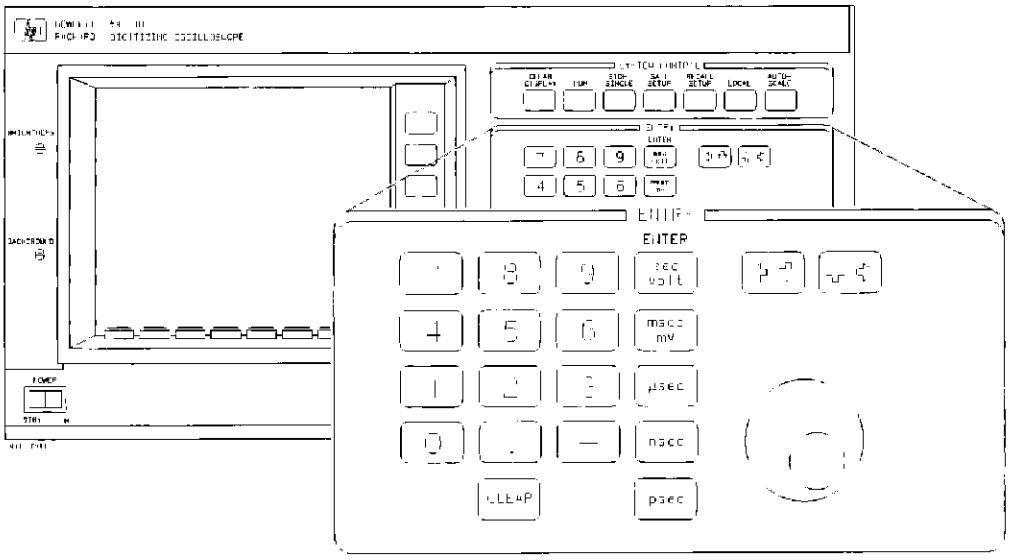
The display and selection section contains the CRT, menu selection keys, function selection keys, and two manual adjustments. The menu selection keys are at the bottom of the CRT. These keys allow you to select different sets of function keys that are displayed to the right of the CRT. The keys at the right of the CRT are the function selection keys. They allow you to select a specific function from that menu. The labels for the menu selection keys and function selection keys are displayed on the CRT.

Two adjustments are to the left of the CRT. The brightness and background adjustments may be set for the most comfortable viewing levels.



Entry Devices

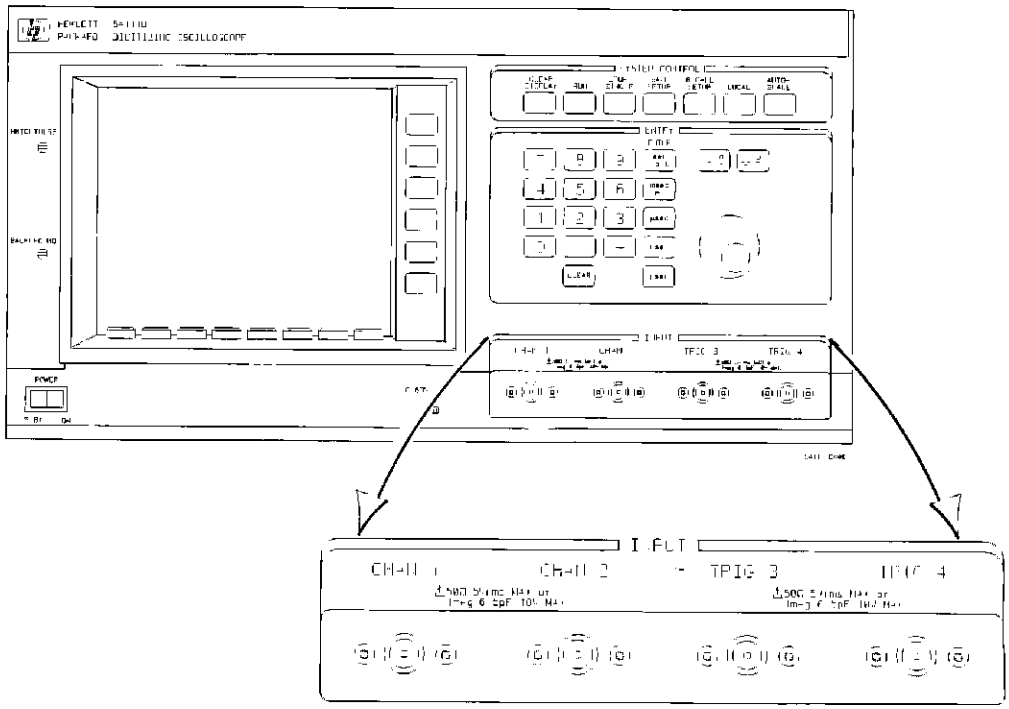
There are three types of entry devices: a knob, increment/decrement (step) keys, and a numeric keypad. The function of the entry devices is defined by the function selected. The label of a function selection key is displayed in all capital letters and will assign the entry devices to a function. The knob and increment/decrement keys change values in programmed steps, while the numeric keypad allows any legal value for a function to be entered. If a value is entered with the numeric keypad, one of the five enter keys, located beneath the ENTER label, must also be pressed to input that value.



Inputs

One of the primary differences between the HP 54111D and the HP 54112D is the number of vertical inputs. The HP 54111D has two vertical inputs with two trigger inputs. The HP 54112D has four vertical inputs with one external trigger input on the rear panel. All vertical inputs have selectable input coupling and input impedance that can be set as follows

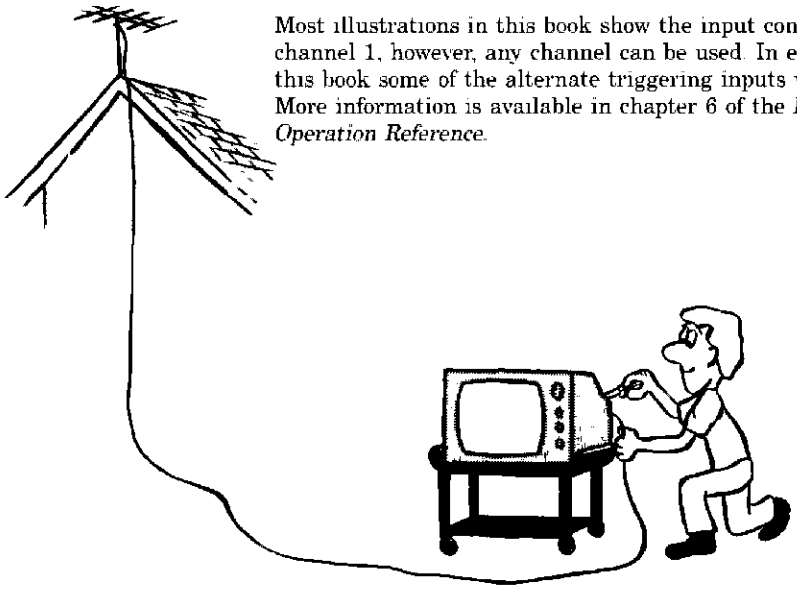
HP 54111D	HP 54112D
◦ ac at 1 MΩ	◦ ac at 1 MΩ
◦ dc at 1 MΩ	◦ dc at 1 MΩ
◦ dc at 50 Ω	◦ dc at 50 Ω
◦ ground	



Connecting a Signal

Input

The HP 54111D has two vertical signal inputs and two trigger inputs, however, the HP 54112D has four vertical inputs.



Most illustrations in this book show the input connected to channel 1, however, any channel can be used. In exercises later in this book some of the alternate triggering inputs will be used. More information is available in chapter 6 of the *Front Panel Operation Reference*.

Signal Source

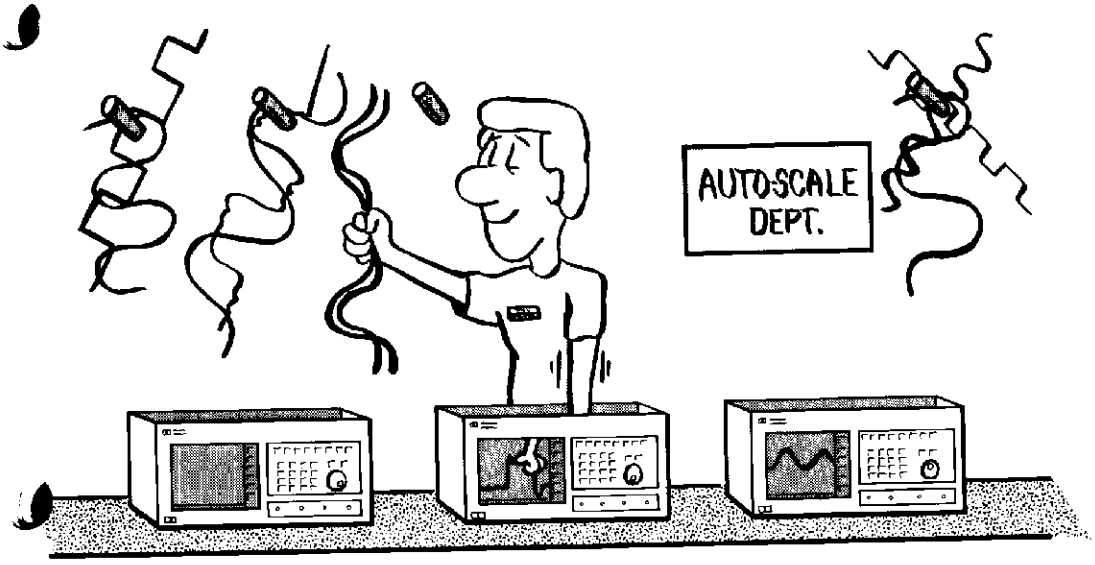
For most exercises in this manual the front-panel calibrator signal is used. The cal signal output is just below the CRT. Go ahead and connect the calibrator output (CAL) to the channel 1 input with one of the probes provided with the instrument.

5 Setting Up the Instrument with Auto-Scale

What Is Auto-Scale?

Auto-scale is a function built into each instrument that automatically displays one or more waveforms. When the **AUTO–SCALE** key is pressed:

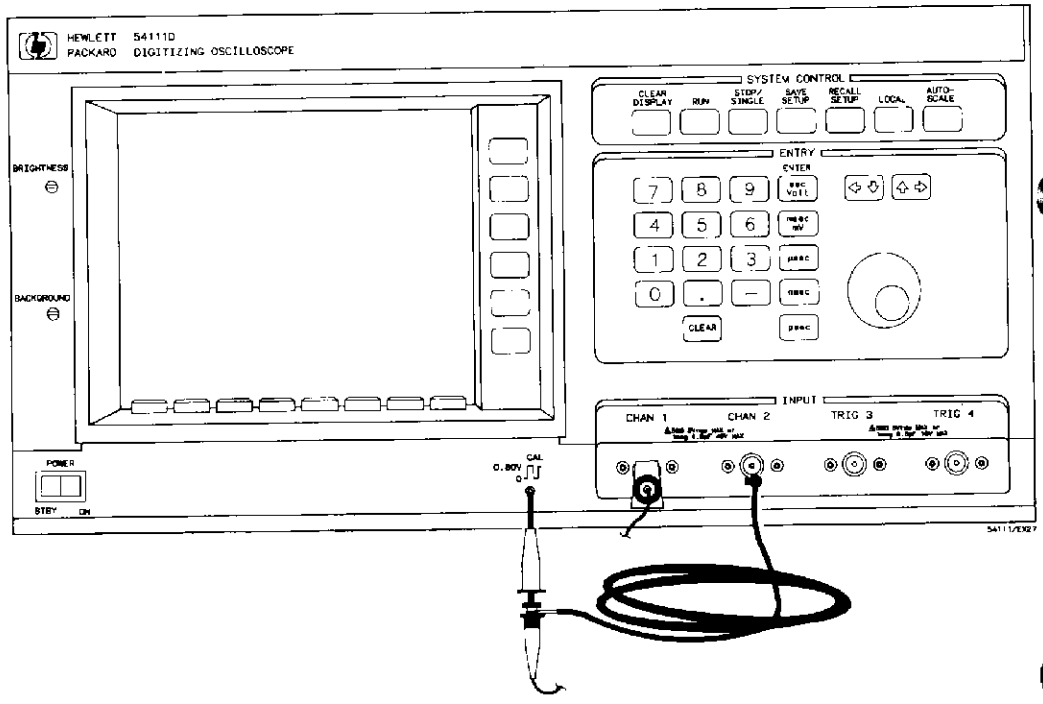
- the oscilloscope checks all channel inputs to determine whether a signal is present
- if a signal is found, the oscilloscope determines the amplitude and period of the input waveform
- it automatically sets the volts/division, sweep speed, offset, trigger level, and trigger slope
- it sets the trigger point to center screen and displays the incoming waveform in the repetitive mode



Getting a Signal to the Input

Use the front-panel CAL signal to demonstrate the **AUTO – SCALE** feature. The CAL signal is a square wave of approximately 800 mV, but it is accurate enough for the next few exercises and is certainly convenient.

To connect the calibrator to the input, simply connect a probe from the CAL output of the oscilloscope to the desired input and attach the ground clip to another input connector.



When a Signal Is Found

If a signal is found on any of the vertical inputs, the instrument checks the amplitude, offset, and frequency of the signal and automatically scales the vertical attenuator, offset, and horizontal sweep time to display the waveform on the CRT. The number of cycles displayed is normally between one and four complete waveforms. However, if a waveform with a narrow pulse and long repetition rate is found, the oscilloscope may not display an entire cycle.

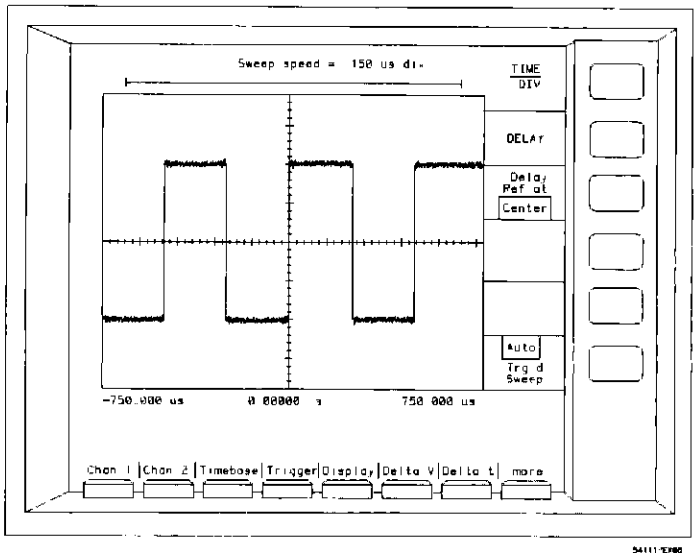
If there are signals present at channels 1 and 2 or channels 3 and 4, the oscilloscope will be set to dual screen and display the signals. If two or more signals are present in any other combination, the oscilloscope will be set to quad screen and be displayed from top to bottom.

Trigger Source

If a signal is present at two or more vertical inputs, the lowest numbered channel will be selected as the trigger source and will scale the horizontal sweep. If only one vertical input has a signal present, that signal is used as a trigger source, and the instrument is set to single screen mode.

Notice when the scaling is complete, the selected menu is **Timebase** and the selected function is **TIME/DIV**. This means that the entry devices are assigned to control the sweep speed of the oscilloscope. Try turning the knob and note how the sweep speed changes. As the sweep is changed, the signal expands and contracts in both directions from the center of the display. The center of the display is the trigger point, time zero on the display.

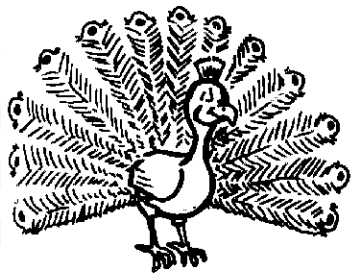
- Set the sweep speed to 150 μs by pressing the numeric keypad keys as follows 1, 5, 0, μsec. The display should look like the illustration below



If no signal is present on any of the vertical inputs, the oscilloscope prints the advisory "No signal found" on the CRT and places the oscilloscope in an auto triggering mode. The auto triggering mode allows the instrument to sweep without a trigger signal being present, and the baseline is displayed

Using the Display

Color Display



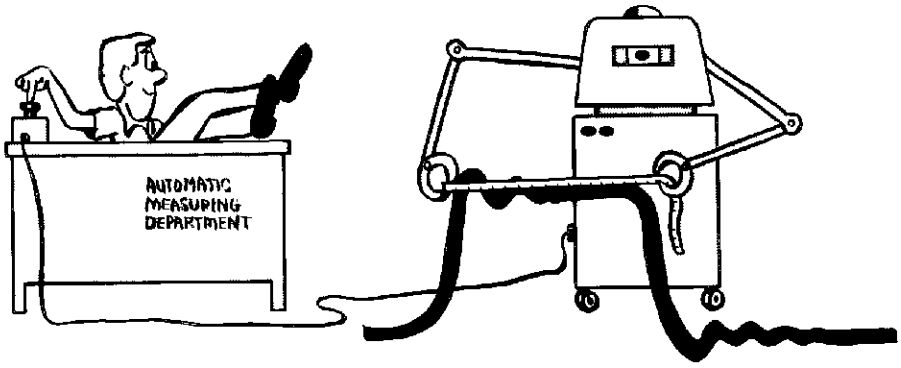
The full color display of the HP 54111D and the HP 54112D improves the usability and efficiency of the oscilloscopes. Sixteen separate colors are available for your use. Each channel is assigned a separate default color; channel 1 is yellow, channel 2 is green on both instruments. On the HP 54112D channel 3 is tangerine and channel 4 is pink. The factors associated with each color are displayed in that distinctive color. Some advantages of a full color display are:

- emphasizes or de-emphasizes waveforms
- reduces search time
- associates waveforms and labels with the same color
- distinguishes between separate waveforms
- reduces eye strain
- customizes colors to your preferences or needs

Making Automatic Parameter Measurements

Introduction

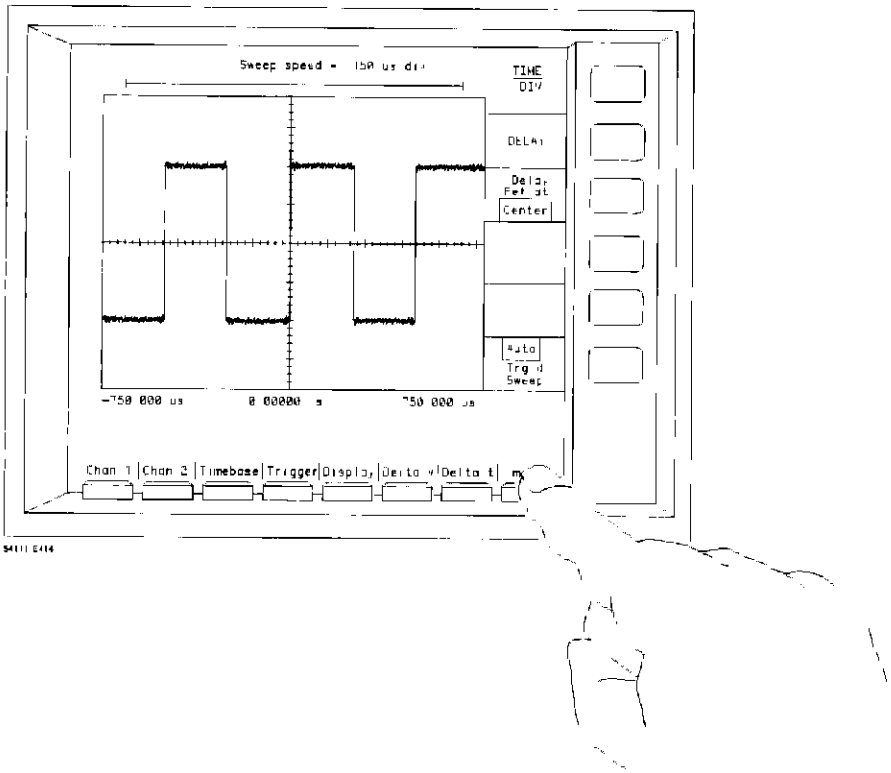
Automatic parameter measurements are functions built into the HP 54111D and HP 54112D that allow you to make parametric measurements on a displayed waveform. There are 12 automatic measurements you can make by pressing the appropriate key, or you can make all 12 of these measurements with the **All** key.



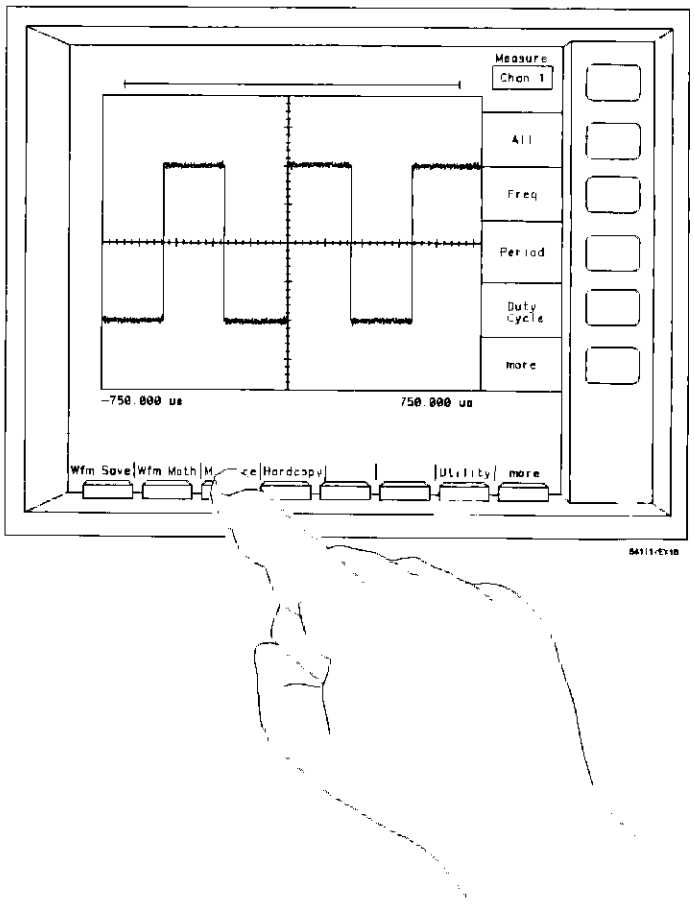
Setting Up the Measurement

To make automatic measurements, the signal must be displayed and triggered. The easiest way to accomplish this is to use the **AUTO–SCALE** key.

Once the signal is displayed and triggered, press the **more** menu select key at the bottom of the CRT. When this key is pressed, a new set of menu selections is displayed at the bottom of the CRT.



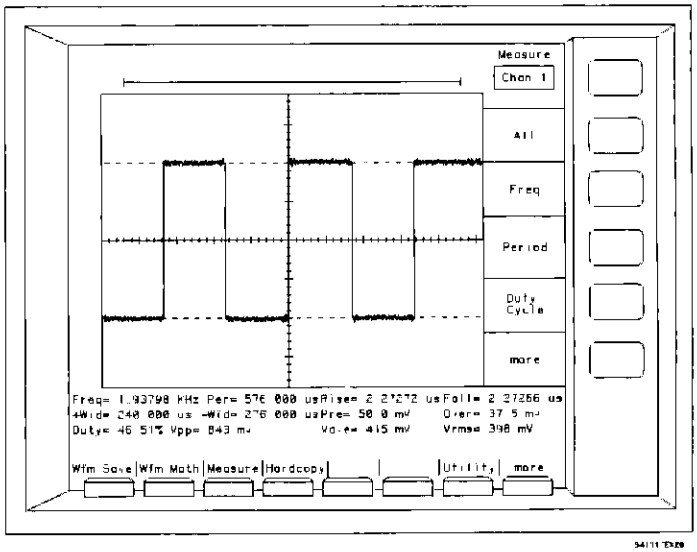
After you have pressed the **more** menu select key, the new menu includes the **Measure** key. Press the **Measure** key, and notice the function menu at the right of the CRT changes to the **Measure** menu.



Using the Measure Menu

When you press the **Measure** key at the bottom of the CRT, one of three measure menus appears at the right of the CRT. Press the more function selection key in the vertical menu until **Measure** is at the top of the function selection. The top key allows you to select the source of the waveform to be measured.

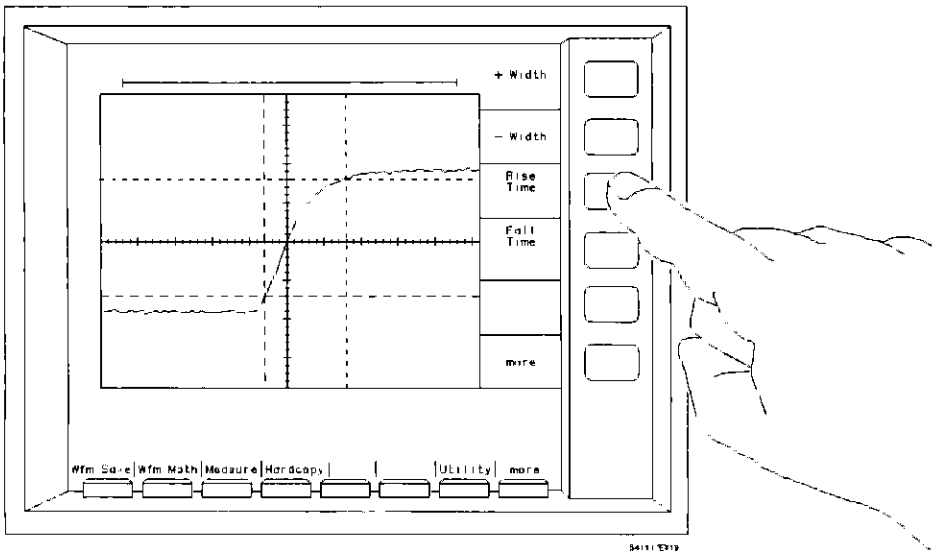
The other keys in the Measure menu select the measurements to be made. Pressing **Freq** causes the oscilloscope to measure and display the frequency of the displayed waveform. Pressing **Period** causes the oscilloscope to measure and display the period of the waveform. The results of the selected measurements are displayed below the waveform display area.



Making a Rise Time Measurement

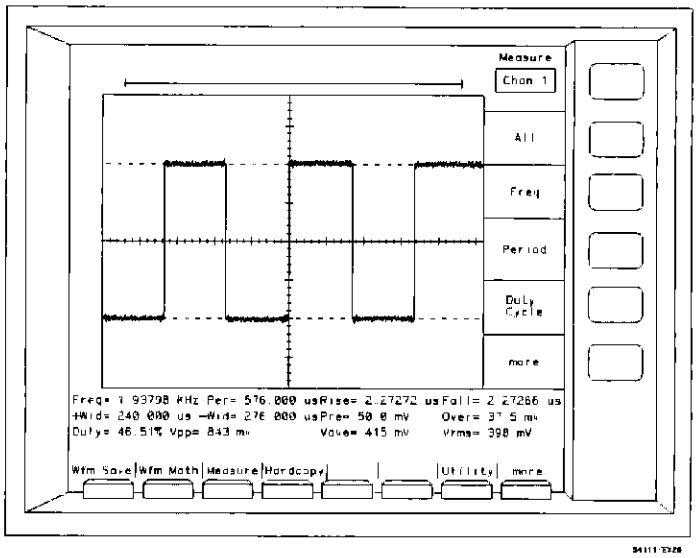
Press the **more** key on the vertical menu until the menu that includes the **Rise Time** key appears. Press the **Rise Time** key. Rise time is measured on the rising edge of the waveform and is the time it takes the waveform to transition between the 10% voltage point and the 90% voltage point.

The rise time value is printed on the CRT in the factors area below the waveform display area. For more information concerning accuracy of the measurements, see the *Front Panel Operation Reference*.



Making Other Auto Parameter Measurements

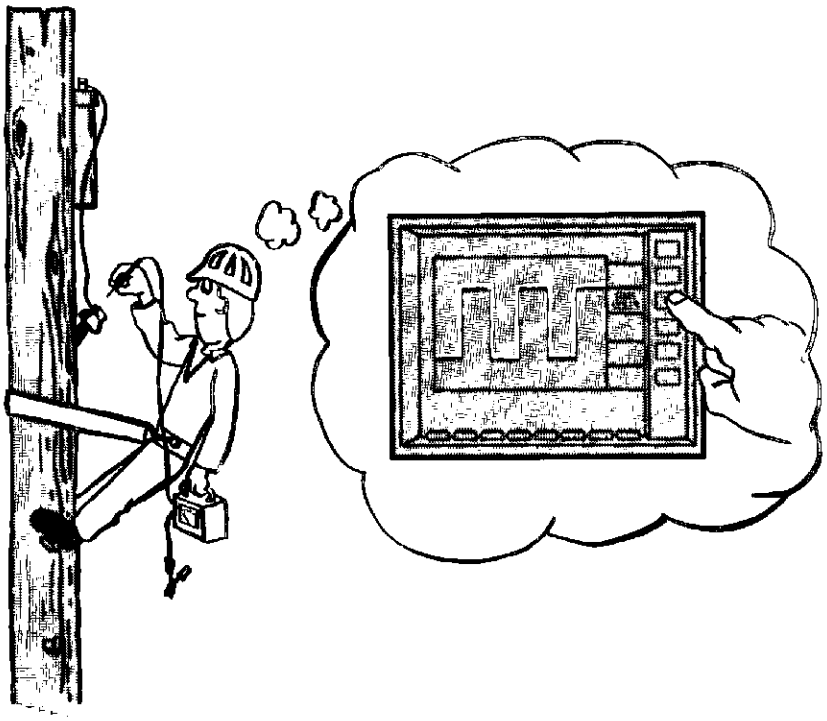
Make a few other measurements and note that the results for each measurement are added to the factors area as the measurement is made. Now, measure all 12 parameters with one key stroke, by pressing the **All** key.



Making Voltage Measurements

Introduction

The Delta V menu provides two voltage markers for making voltage measurements either automatically or manually. Automatic functions available in this menu find the top and base of a waveform. You may set the voltage markers to a percentage of the top-base value, or any value you prefer, or you may set the manual markers at any point on the waveform you desire. This menu allows you to determine the actual voltage value at each of the markers and determine the ΔV (voltage) value between the markers.



Automatic Voltage Measurements

This exercise teaches you how to use the voltage markers manually as well as how to use the automatic functions for finding several preset voltage levels. You will learn that making voltage measurements on a waveform is easy.

Please complete this exercise in the order described to ensure the illustrations presented are similiar to your results. Remember, if you should get lost, simply press the **AUTO–SCALE** key and return to the start of the exercise

1. Ensure the calibrator signal is connected to the channel 1 input, then press **AUTO–SCALE**

2. Sweep speed (**TIME/DIV**) is the selected function when **AUTO – SCALE** is complete. Set the sweep speed to 150 μs by entering the value with the numeric keypad

3. Select the **Delta V** menu. If you are using an HP 54112D, the Delta V menu is in the second level of menu selection keys.

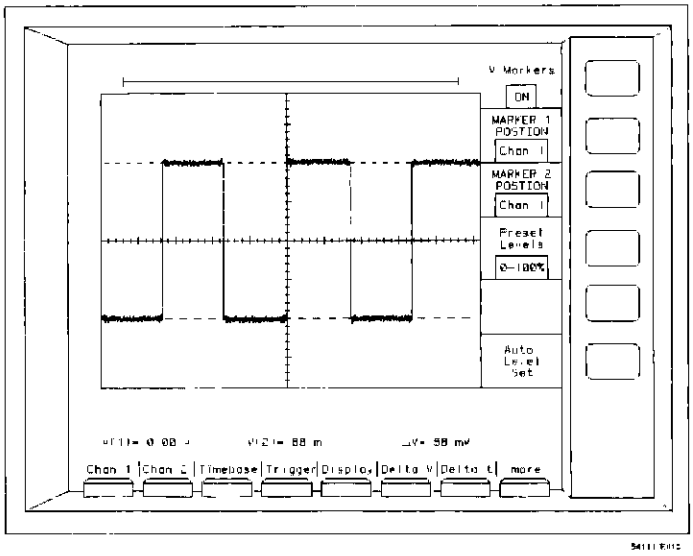
4. Press the **V Markers** key to turn the markers on (i.e. V Markers On/Off)

5. Ensure that channel 1 is the selected source of **MARKER 1 POSITION** and **MARKER 2 POSITION**.

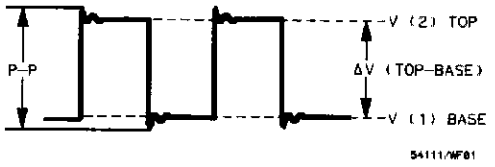
6. Press the **Preset Levels** function select key until 0-100% is selected.

7. Press the **Auto Level Set** key. This causes the instrument to locate the top and base of the input signal, then sets the V Markers to the selected percentage levels on the waveform. Marker 1 is at the lower level of the signal, and Marker 2 is at the upper level.

8 Read the voltage values of V(1), V(2) and ΔV in the waveform factors area V(1) is the voltage at V Marker 1 (long dash) on the base of the waveform. V(2) is the voltage at V Marker 2 (short dash) at the top of the waveform ΔV is the voltage difference between the top V(2) and base V(1) of the waveform



The difference between top and base voltage values of a square wave is typically not the same as the peak-to-peak value. These instruments determine top and base voltages by finding the flattest portions of the top and bottom of the waveform. The top and base values do not typically include preshoot or overshoot. The peak-to-peak voltages are the minimum and maximum voltages in a waveform record. Keep this in mind when selecting either manual or automatic measuring techniques. Refer to the *Front Panel Operation Reference* for more information.



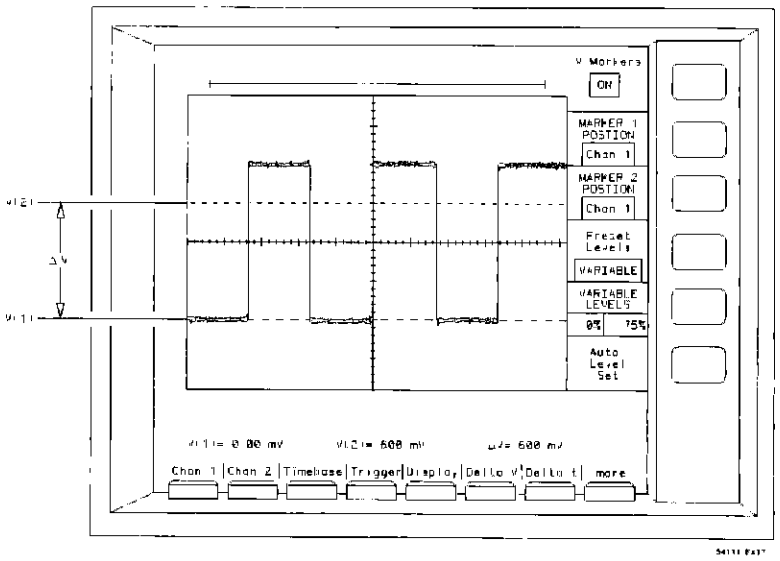
You can confirm this by selecting the **Measure** menu and measuring peak-to-peak voltage, preshoot, and overshoot. When you have finished, return to the **Delta V** menu (if you need a refresher, you can return to Chapter 7 and review the Measure menu).

9. Press the **Preset Levels** key several times until **Variable** is displayed. Notice that the V Markers move from the 0-100, 10-90, 20-80, 50-50, and variable percentage levels of the input signal. The fixed values set the markers to percentage levels shown with the top and base values as 0 and 100% references.

10. Press the **VARIABLE LEVELS** key to assign the knob to this function. Now, rotate the knob and notice that V Marker 1 moves, and the percentage value for V Marker 1 changes.

11. Press the **VARIABLE LEVELS** key and select the second value (V Marker 2). The range for the variable levels is −25% to 125%.

Notice as you toggle through the preset levels that the voltages in the waveform factors area change. They reflect the voltage levels of the V Markers on the waveform. ΔV represents the voltage difference between V Marker 1 and V Marker 2.



Manual Voltage Measurements

Voltage measurements can be made manually by moving the voltage markers to any desired location on the waveform and reading the values at V(1), V(2), and ΔV. Use the following procedure as a guide to setting the voltage markers.

1. Ensure that **MARKER 2 POSITION** is assigned to the channel of interest (channel 1). If more than one signal is displayed, the desired signal source can be selected by pressing the **MARKER 2 POSITION** key.

2. Now select V Marker 2, which you move by pressing the **MARKER 2 POSITION** (if it has not already been pressed). If this key is pressed more than once it changes the source selection, if more than one source is being used. When this key is pressed the first time, it assigns the entry devices to control the position of V Marker 2.

3 Press the decrement key and notice that each time it is pressed it steps down on the displayed signal. Determine the size of each step by pressing the increment/decrement keys and checking the V Marker 2 position (V2) value with each press

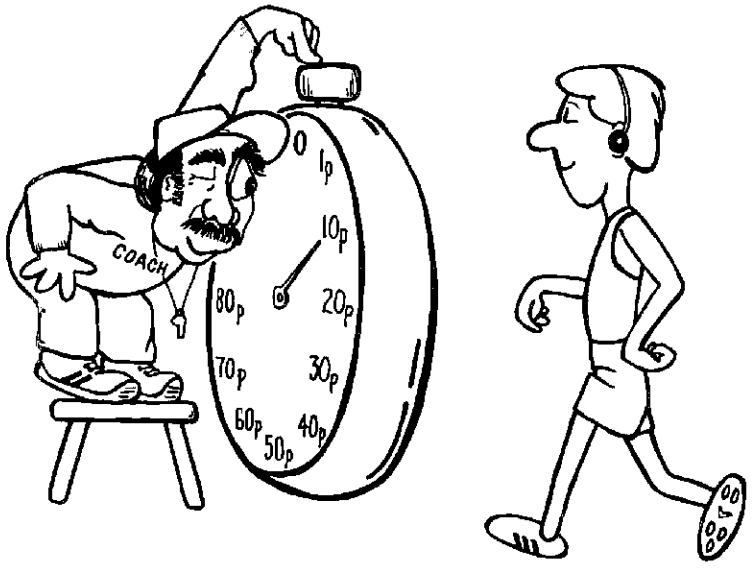
4 Now, rotate the knob and note that the marker also moves in steps with the motion of the knob. Enter some values (i.e. 470 mV, 610 mV) with the numeric keypad and the **msec-mV** key. Note, you are able to set the V Marker to values between steps by entering the desired value

9

Making Time Interval Measurements

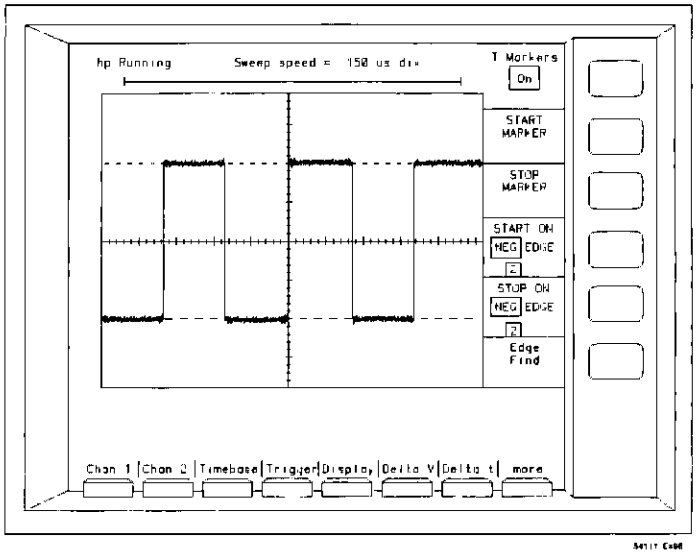
Introduction

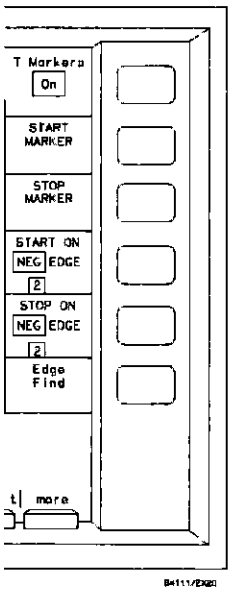
Time interval measurements are made with the start and stop markers. The time at these markers is measured from the trigger point, with the trigger point being time 0. The Delta time measurement is calculated by subtracting the time at the start marker from the time at the stop marker. If the stop marker is positioned in time before the start marker, the Delta time calculation will be a negative value. Time measurements can be made by manually setting the markers to desired points, or by allowing the oscilloscope to set the markers. To find waveform edges automatically on the HP 54111D or HP 54112D, you must position the voltage markers on the waveform so the waveform actually crosses the voltage markers.



Automatic Time Measurements

1. Enter the **Delta V** menu.
2. Select the **Delta V** menu and press the **V Markers** key if they are not already on
3. Set **Preset Levels** to 20-80%.
4. Press the **Auto Level Set** key. This sets the V Markers at the 20% and 80% levels of the waveform. The V Markers can be set at these levels because when the **Auto Level Set** key is pressed the instrument immediately checks the top and base levels and calculates the Preset Levels from those points.
5. Enter the **Delta t** menu and turn on the T Markers
6. Press the **START ON POS EDGE** key.



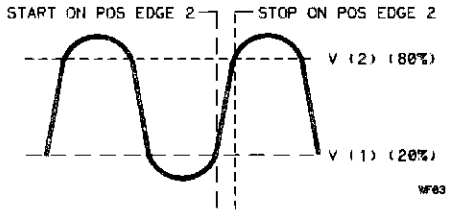


7. Rotate the knob until the key label is **START ON POS EDGE 1**. The start marker (long dash) will move (jump) to the first positive-going edge. Read the time displayed for the start marker.

8. Press the **START ON POS EDGE 1** key again. Notice that the key label changes to **START ON NEG EDGE 1** and the start marker jumps to the negative edge.

9. With the entry devices (i.e., key pad, increment/decrement keys, or knob) set **START ON NEG EDGE** value to 2. If you use the key pad to enter this variable, make sure you press an ENTER key to complete the selection.

10. Place both the start and stop markers on Pos Edge 1 and notice the Δt reading is not 0, even though the markers appear to be together. The displayed ΔV value is not an error, it is just very difficult to see what is really happening. The oscilloscope places the start marker on the intersection of the waveform edge and V Marker 1, and the stop marker on the intersection of the waveform edge and V Marker 2. You have just made a 20-80% rise-time measurement. Refer to the figure to see what is really happening. For more information on risetime and measurement accuracy, see the *Front Panel Operation Reference*.



Manual Time Measurements

This portion of the exercise illustrates how to manually set the time markers to make measurements. If you get lost in this exercise, press **AUTO—SCALE** and start over

1. Ensure the oscilloscope CAL signal is connected to channel 1 and press **AUTO—SCALE**. Set the sweep speed to 150 μs.

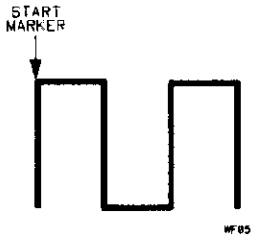
2. Set Delta V **Preset Levels** to 50-50%.

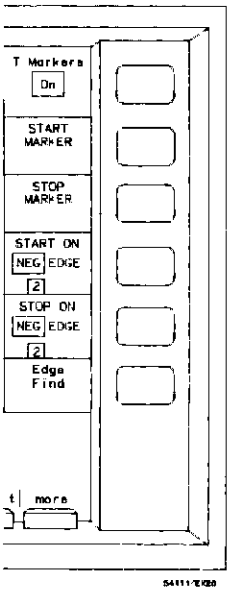
3. Enter the **Delta t** menu and turn on the T Markers

4. Select the **START MARKER** key and rotate the knob until the start marker (long dash) intersects the positive-going edge of the waveform that is displayed first The time at the start marker should be approximately -500 μs The time is negative because the trigger (time 0) is at center screen

Note

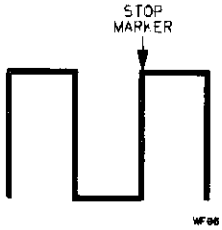
If you wish to confirm your reading, select the ***Display*** *menu and press the* ***Graticule*** *key until* ***Grid*** *is highlighted, then return to the* ***Delta t*** *menu Multiply the number of divisions from center screen (trigger point) to the start marker by the sweep speed (****TIME/DIV****) of the oscilloscope The result of this multiplication should be approximately the same as the start reading The sweep speed is displayed on the lower left of the CRT*



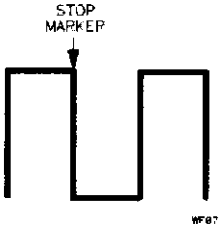


5. Press the **STOP MARKER** key and set the stop marker (short dash) to intersect the second rising edge by rotating the knob.

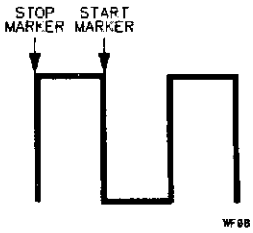
6. Read the period length of the waveform. In this measurement, Δt is the waveform period (stop-start). The instrument is triggering at the second positive-going edge, therefore, the waveform period is about 500 μs.



7. Move the stop marker to the first displayed falling edge. The positive pulse width of the waveform is the Δt value.



8. Move the stop marker to the first rising edge and the start marker to the first falling edge. The Δt should be approximately -240 μs. Pulse width CANNOT be negative! The minus sign simply means the stop marker is in front of the start marker.



Measuring Complex Signals

For this part of the exercise use a 40 MHz square wave as the base frequency. This signal is gated (burst mode) to produce 20 pulses in each burst and set to start 1 μs after the start of the preceding burst. An HP 8116A Pulse/Function Generator is recommended. If you are using some other waveform source, set the controls to produce the signal described above

1. Select the square wave
2. Set the function generator frequency to 40 MHz by selecting FRQ and pressing the Auto Vernier keys until 40.0 MHz is displayed.
3. Set the function generator amplitude to two volts by pressing the AMP key, then pressing the Auto Vernier keys until 2.00 V is displayed
4. Ensure the offset voltage is set to 000 mV by pressing the OFS key If some value other than 000 mV is displayed, use the Auto Vernier keys to set offset to 0 mV.
5. Select the internal burst mode by pressing the mode key with I.BUR in the column above it. When I.BUR is selected, two more keys become available, RPT and BUR
6. Set the number of pulses in the burst to 20 by pressing BUR, then pressing the Auto Vernier keys until 20 is displayed This causes 20 cycles of 40 MHz square waves to be produced within each burst.
7. Set the burst repeat rate to 1 μs by pressing the RPT key, then press the Auto Vernier keys until 1.00 μs is displayed
8. Connect the Trig Output of the function generator to an external trigger input of the oscilloscope. On the HP 54111D that can be Trig 3 or Trig 4 on the front panel, or on the HP 54112D the EXT TRIG IN on the rear panel.
9. Connect the OUTPUT of the function generator to the channel 1 input of the oscilloscope.
10. Press the DISABLE key on the function generator, if necessary, to enable the waveform output. The disable light must be off.

Setting Up the Oscilloscope

Now that you have a signal to the oscilloscope, set the oscilloscope controls as follows:

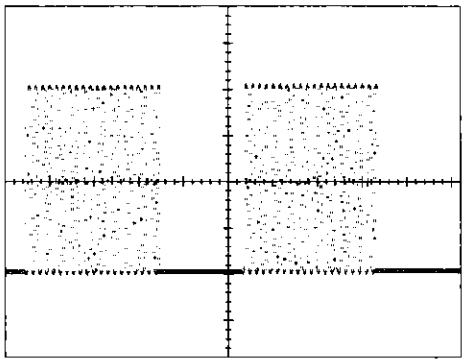
1. Press **AUTO—SCALE**. When the **AUTO—SCALE** operation is complete, the instrument will be left in the **Timebase** menu with **TIME/DIV** selected

2. Set the sweep speed to 200 ns/division. The sweep speed is displayed just above the waveform display area.

3. Press the **Delay Ref at** key until **Left** is displayed in the inverse video window. This sets the trigger point to the left side of the screen.

4. Enter the **Trigger** menu by pressing the **Trigger** key on the menu display area (below the CRT). Press **Trg Src** until the display corresponds with the external trigger you have selected. Press **TRIGGER LEVEL** and set the level to gain a triggered response. About 2.50 volts should be adequate. The display should resemble the figure below

5. Press the **Chan 1** key and set **Input Coupling** to **ac**.



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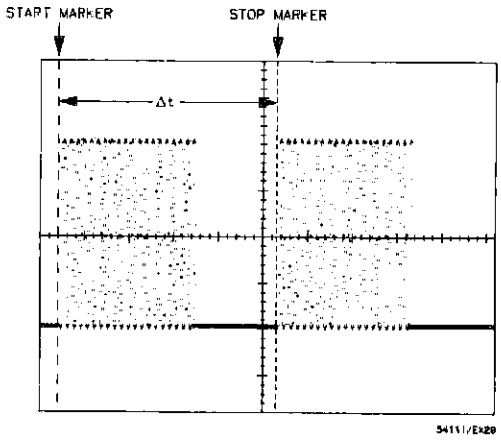
Now that you have set up the function generator and oscilloscope, you are ready to continue with the exercise. If you would like to get a closer look at the waveforms in the burst, select the **Timebase** menu and increase the sweep speed until you can see the waveforms. Reset the sweep speed to 200 ns/division before you continue.

Measuring Time between Bursts

This part of the exercise shows you how to make a time interval measurement between two bursts of pulses with some automated features of the oscilloscope. Remember, you can press **AUTO–SCALE** to get back to a known starting point at any time. If you do press the **AUTO–SCALE** key, you will need to repeat the previous section "Setting Up the Oscilloscope."

1. Enter the **Delta V** menu.
2. Set the V Markers to 50-50% and press **Auto Level Set**.
3. Press the **Delta t** menu selection key.
4. Press the **START ON EDGE** function select key and set it to read **START ON POS EDGE 1**. The polarity of the edge can be changed by pressing the **START ON EDGE** key again. The number of the edge can be changed with the entry devices. Set the edge to positive since the first waveform edge in the burst is positive.
5. Select the **STOP ON EDGE** function selection key. Set it to Pos and select edge 21. Positive edge 21 is the first edge in the second burst.

At this time the start marker (long dashed line) is at the first pulse of the first burst and the stop marker (short dashed line) is at the first pulse of the second burst.



6 Read the burst repetition time in the factors area of the display. The burst repetition time is the time between the start and stop markers (Δt). This should be approximately the same time as the RPT value set on the function generator (1 μs).

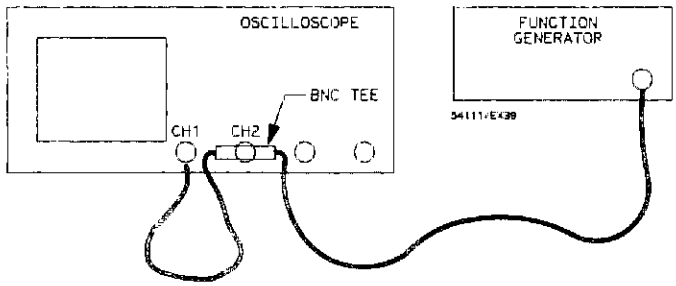
10 Trigger Operation

Introduction

The HP 54111D and the HP 54112D have several trigger modes. This exercise will help you learn how to use the most basic trigger mode, edge trigger. The *Front Panel Operation Reference* has exercises on all trigger modes. In this exercise you will set up the function generator to produce a short duration pulse and observe the trigger in the mode.

Connecting the Equipment

Connect the HP 8116A Pulse/Function Generator to the oscilloscope as shown in the figure below. You will need one BNC tee and two 1-metre BNC cables.



1. Connect one BNC cable from the output of the function generator to the BNC tee, then connect the BNC tee to the channel 2 input of the oscilloscope. Now connect the other BNC cable to the BNC tee and the channel 1 input of the oscilloscope

Setting Up the Function Generator

Set the function generator to produce a 10 ns positive pulse at a 5 MHz rate as follows:

1. Select the pulse mode by pressing the pulse (⎍) key.
2. Set the pulse width to 10 ns by pressing the width (WID) key, then the Auto Vernier keys until 10.0 ns is displayed.
3. Set the frequency to 5 MHz by pressing the FRQ key, then the Auto Vernier keys until 5.00 MHz is displayed.
4. Set the pulse amplitude to two volts by pressing the amplitude (AMP) key, then the Auto Vernier keys until 2.00 V is displayed.
5. Press the DISABLE key on the function generator, if necessary, to enable the waveform output (disable light must be off).

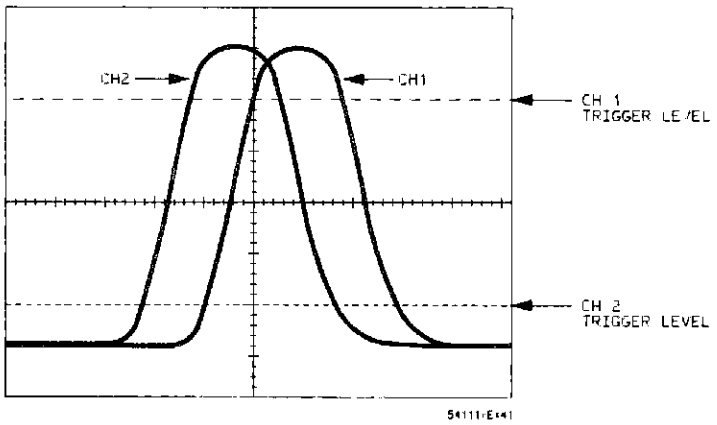
Setting Up the Oscilloscope

So you can observe the triggering better, the channel 1 and channel 2 waveforms will be on one screen. The trigger level for channel 1 will be set toward the top of the channel 1 waveform and the trigger level for channel 2 will be set toward the bottom of the channel 2 waveform. Proceed with the oscilloscope setup as follows:

1. Press **AUTO–SCALE**.
2. Set the screen to single by pressing the **Display** menu selection key, then press the **Screen** function selection key until the inverse video label is **Single**.

3. Set sweep speed to 5 ns by pressing the **Timebase** menu selection key, then rotate the knob until **Sweep Speed = 5.00 ns/div** is displayed above the waveform display area.

The displayed waveforms should now resemble the figure below.



4. Set the channel 1 trigger level slightly below the crossing of the channel 1 and channel 2 waveforms by pressing the **Trigger** menu selection key, then the **TRIG LEVEL** function selection key. Rotate the knob until the channel 1 trigger level line is below the crossing of the waveforms. This trigger level value will be approximately 200 mV

5. Set the channel 2 trigger level near the base of the waveforms by pressing the **Trig Src** function selection key, then rotate the knob until the value displayed is approximately 500 mV. The position of the trigger level lines is shown in the figure above

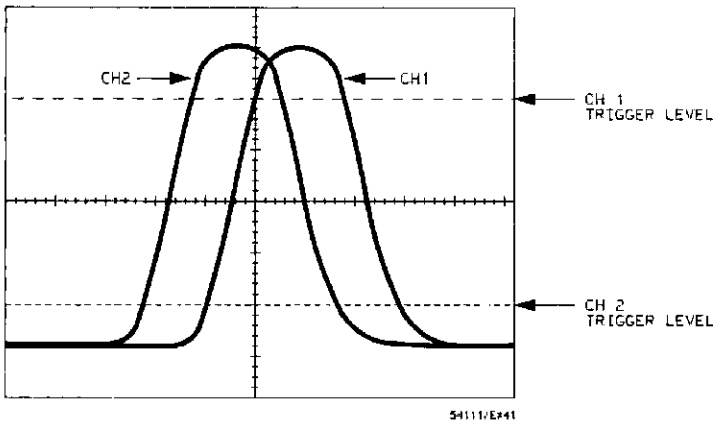
Edge Trigger Mode

Now we can observe the oscilloscope triggering in the edge mode.

1. Select channel 1 as the trigger source by pressing the **Trg Src** function selection key until **Chan 1** is displayed.

Notice that the channel 1 signal crosses the trigger level line at the center line of the display. The center line of the display is time zero (trigger point) and you have set up the trigger on the positive-edge crossing of the channel 1 signal at the trigger level value.

2. Select **TRIG LEVEL** and rotate the knob. Observe that the waveform moves on the display in order to maintain the trigger point (where the positive-going waveform edge crosses the trigger level line) at center screen. If the trigger level is set above or below the waveform, the trigger is lost.



3. Return the trigger level to its original value (approximately 200 mV).

4. Change the trigger slope to negative by pressing the **Slope** function selection key.

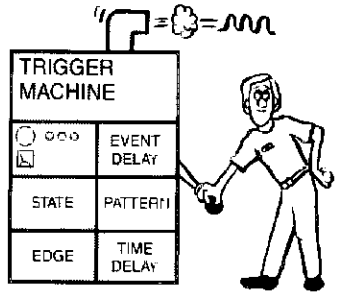
The trigger is now produced when the negative-going edge of channel 1 crosses the trigger level line of channel 1.

5. Reset the trigger slope to positive.

6 Set the trigger source to channel 2 by pressing the **Trig Src** function selection key.

Now the trigger is produced when the channel 2 signal crosses the trigger level value of channel 2 in the positive direction.

7. Change the trigger slope to negative and notice where the oscilloscope triggers.



11 Display Memory Operation

Introduction

Digitizing oscilloscopes with large memory capabilities enhance any single shot acquisition. Data that is captured can be manipulated and evaluated many times over, even if captured under destructive conditions. With the HP 54111D and two channel simultaneous acquisition you can capture over 16k points of data at one gigahertz. With the HP 54112D and four channel acquisition, you can capture 64k on each channel, or 256k points of data

In this chapter you will capture a square wave signal with a single shot acquisition, learn to "pan" and "zoom" through the stored data and look at a single cycle. Then, you will look at the difference in memory capacities between the HP 54111D and the HP 54112D.

Setting Up the Signal Generator

Set the HP 8116A Pulse/Function Generator for a 5 MHz square wave signal of 2 volts. On this function generator the selections are active when the LED associated with that function is lighted.

1. Ensure the HP 8116A is set to NORM mode
2. Set the pulse mode of the HP 8116A to the square wave function.
3. Set the HP 8116A to 5 MHz by pressing the FRQ key and pressing the Auto Vernier keys until 5 MHz is displayed.
4. Set the signal amplitude to 2 volts by pressing the AMP key, then Auto Vernier keys until 2.00 volts is displayed.
5. Ensure offset is still 0 by selecting the OFS key and verifying the setting is 0.
6. Press the DISABLE key on the function generator, if necessary, to enable the waveform output (disable light must be off).

Setting Up the Oscilloscope

Connect the output of the function generator to the channel 1 input of the oscilloscope and the Trig Output of the function generator to an external trigger input. On the HP 54111D this can be Trig 3 or Trig 4. On the HP 54112D this is the EXT TRIG IN on the rear panel.

1. Press **AUTO—SCALE**
2. Set the oscilloscope sweep speed to 50 ns/division by rotating the knob until **Sweep Speed = 50.0 ns/div** is displayed above the waveform display area.
3. While in the **Timebase** menu, set the **Delay Ref at** to **Left**.
4. Press the **Trigger** menu selection key, then press the **Trig Src** until the trigger source selection corresponds to the trigger input already connected.
5. Set the trigger level for triggering at 2.5 volts by rotating the knob until **External Trigger Level = 2.50 V** is displayed above the waveform display area.
6. Press **Chan 1** to enter the channel 1 menu.
7. Set the input coupling to 50 Ω dc by pressing the **Input Coupling** key until the label is **dc**. When dc is selected, **Input Impedance** becomes available just below the **Input Coupling** window. Press **Input Impedance** until **50 Ω** is selected.
8. On the HP 54112D, set the channel memory to 8k by pressing the **Display** key and checking the **Record Length** display window. If it is set at **64k**, press the key and change it to **8k**.

9. Ensure the real time acquisition mode is selected. If real time is not selected, press the **Disp Mode** key until **Real Time** appears.

10. Press the **STOP/SINGLE** key to stop acquiring data.

11. Press the **CLEAR DISPLAY** key to clear the waveforms from the display. At this time no waveform information is displayed.

12. Press the **STOP/SINGLE** key once. When the key is pressed, the oscilloscope will acquire all data in a single acquisition.

This exercise demonstrates the single-shot feature. We have repeatedly acquired and stopped acquiring data, and then cleared the display. We then captured one waveform in a single shot and stored it in memory. The instrument is not acquiring data when in this mode; however, we can manipulate, look at portions of the data or take measurements of all or part of the data.

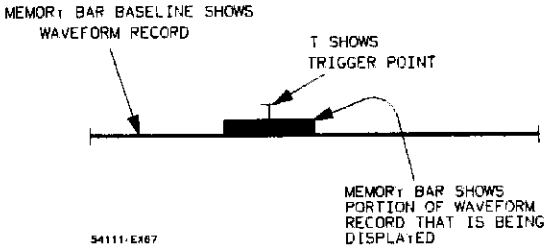
Memory Operation

A memory bar is displayed at the top of the waveform display area to indicate what portion of the waveform is displayed on the CRT. The memory bar marker expands and contracts as the waveform display is "zoomed" to indicate how much of the total data is displayed. The memory bar represents the total waveform record and the memory bar marker represents the screen width (displayed portion of the waveform).

1. Display a small portion of the captured waveform by pressing the **Timebase** menu select key, then the **TIME/DIV** key (the **TIME/DIV** is now operating as a zoom function), and finally by rotating the knob clockwise.

As the knob is rotated, watch the memory bar. The memory bar shows that you are looking at a smaller and smaller portion of the total waveform.

2 Display a portion of captured memory by pressing the **DELAY** key, then rotating the knob. This time as the knob is rotated, notice that the memory bar marker moves from center screen to show which portion of the total waveform is being displayed.



3 Display approximately two cycles of the waveform by using the pan (**DELAY**) and zoom (**TIME/DIV**) functions. Zoom (by turning the knob clockwise) until only two cycles are displayed.

4. Measure the frequency, period, positive pulse width, negative pulse width, rise time, and fall time of the displayed waveform by selecting the **Measure** menu and pressing the proper keys.

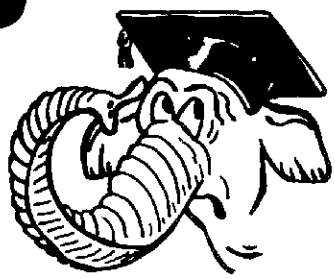
Display all the data that was captured by compressing the entire contents of memory. Use the following procedure.

5. Zoom (**TIME/DIV**) the display to 5 μs/div. The oscilloscope is triggering on the first positive pulse on the left side of the display and has acquired 8k of data in the single-shot mode.

6. Measure the duration of the display using the **Delta t** technique discussed in chapter 9. The measurement should be approximately 20 μs.

7. Press **RUN** to resume acquiring data.

Deep Memory



Deep, or extended memory, expands memory on the HP 54112D to 64k per channel simultaneously on all four channels. To illustrate this, use the function generator setup from the previous exercise.

1. Select the 64k deep memory by pressing **Display** and then pressing the **Record Length** key. It should now display 64k in the inverse video window.
2. Press the **STOP/SINGLE** key to stop acquiring data.
3. Press the **CLEAR DISPLAY** key to erase all waveform data from the display.
4. Press the **STOP/SINGLE** key one time. The HP 54112D acquires all data single-shot.
5. Zoom (**TIME/DIV**) the display to 20 μs/div. The oscilloscope is triggering on the first positive pulse on the left side of the display and represents 64k of memory acquired in the single-shot mode.
6. Measure the duration of the display. The measurement should be approximately 160 μs.

If we compare the measurement made from the 8k acquisition to the measurement made on the HP 54112D at 64k, it is easy to recognize the deep memory capability.