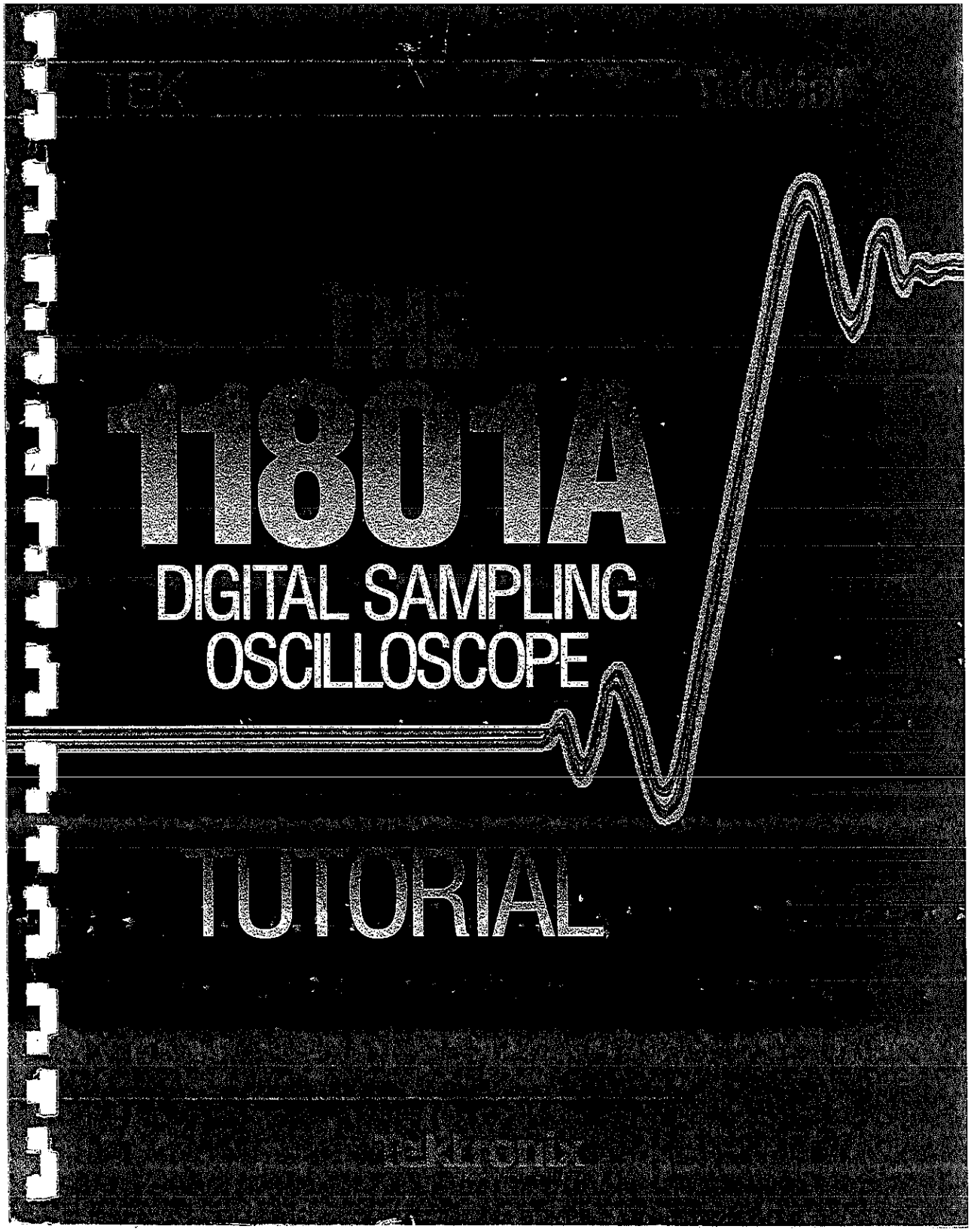
1180TA
DIGITAL SAMPLING
OSCILLOSCOPE
TUTORIAL

TEK **Tutorial**

Part No. 070-8025-00
Product Group 47

THE 11801A DIGITAL SAMPLING OSCILLOSCOPE

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Instrument Serial Numbers

Each instrument manufactured by Tektronix has a serial number on a panel insert or tag, or stamped on the chassis. The first letter in the serial number designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B010000	Tektronix, Inc., Beaverton, Oregon, USA
G100000	Tektronix Guernsey, Ltd., Channel Islands
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J300000	Sony/Tektronix, Japan
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Instruments manufactured for Tektronix by external vendors outside the United States are assigned a two digit alpha code to identify the country of manufacture (e.g., JP for Japan, HK for Hong Kong, etc.).

Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077

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About This Manual

Welcome to the 11801A Digital Sampling Oscilloscope. Read this manual to familiarize yourself with the 11801A and to learn about its capabilities. There are examples in this manual that will help you learn how to use the 11801A.

If you are unfamiliar with the 11801A, you will want to read this manual first.

The first section presents operator information about physically installing the 11801A, installing sampling heads, and connecting cables to it. Examine this information carefully, it contains important safety information. In particular, the discussion about SMA-compatible connectors is critical to accurate operation of the 11801A. The remainder of this manual presents a series of examples that will help you quickly learn the capabilities of the 11801A.

Related Manuals

Other manuals that complete the documentation set for the 11801A Digital Sampling Oscilloscope are:

- The *11801A User Reference* (Tektronix part number 070-8025-00) covers all aspects of front-panel operation. Use this manual to quickly gain information about a specific topic, or to get an overview of the menu system.
- The *CSA 803 and 11801A Programmer Reference* (Tektronix part number 070-7738-01) describes using a computer to control the 11801A through the GPIB or RS-232-C interfaces.
- The *CSA 803 and 11801A Command Reference* (Tektronix part number 070-7720-01) describes the commands used to program the 11801A.
- The *11801A Service Reference* (Tektronix part number 070-8024-00) provides information to maintain and service the 11801A, and provides a complete board-level description of 11801A operation.

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Operator Overview

This section describes the safety precautions, power and signal connections, and procedures you should follow when you install the 11801A.

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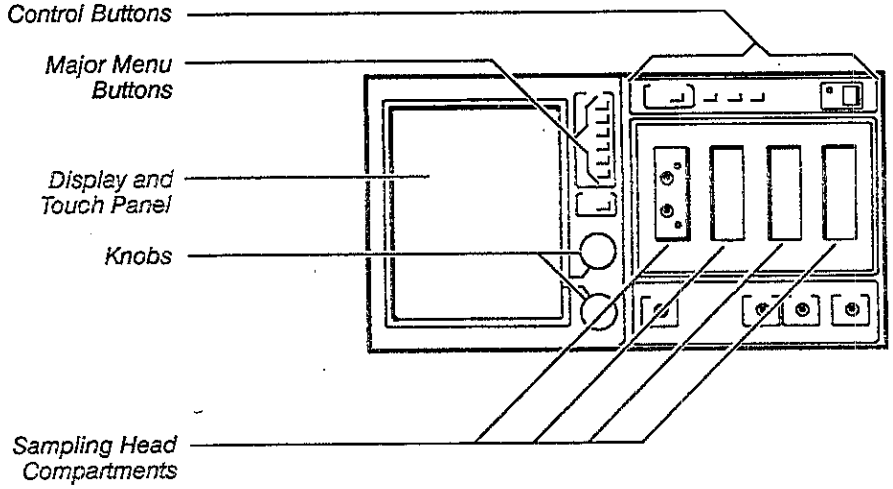
11801A Description

The 11801A Digital Sampling Oscilloscope provides unprecedented capabilities in capturing and accurately measuring high-speed electrical events. Some of the main features of the 11801A are:

- Fast rise time and wide bandwidth, as determined by sampling head.
- Sweep speeds from 1 picosecond per division to 5 milliseconds per division, adjustable in calibrated 1 picosecond per division steps.
- 200 kHz sampling rate for high system throughput and real-time display.
- Digital trace capture, display, and storage. Provides a bright stable display even with signals of low repetition rate.
- Traces are captured with 8-bit vertical resolution, and can have from 512 to 5120 points each.
- Simultaneous display of up to eight traces. Each trace can represent a single input channel, or a complex expression that mathematically combines multiple input channels, or an expanded window of another trace.
- Time or voltage histograms displayed on-screen and updated continuously as trace data are collected.
- Mask testing for easy "go/no-go" testing and error rate measurements.
- Color grading provides a third dimension, sample density, to displayed data and allows histogram and mask analysis after collecting data.
- Full-function DC coupled pulse trigger to 2.0 GHz.
- Single-ended and differential TDR measurements are available on all channels using SD-24 sampling heads.

- Automatic measurement capability that allows a wide variety of complex measurements on a signal and gives real time updating. Twenty-four measurements are available, including rise time, fall time, rms voltage, delay, width, duty cycle, and frequency. Measurement statistics provide the mean and standard deviation of your measurements. Measurements can be based on data in the color grading database, for example, fully automatic noise and jitter measurements.

- A unique statistical measurement mode that allows pulse parameter measurements on random data (for example, eye diagrams) as well as accurate timing measurements in the presence of jitter.



- An Autoset function that allows quick adjustment of settings by pressing a single button.
- Menu driven touch-screen operation that simplifies operator control of the 11801A. It disables invalid selections and indicates to the operator which choices are logical at any time.
- Programmable control of the 11801A that allows it to be run from an attached computer or instrument controller via the RS-232-C or GPIB interfaces.
- Continuous self-calibration system that ensures accurate, stable trace data and measurement results.

Description of Sampling

A traditional analog oscilloscope displays a trace dynamically as a beam is swept across the display horizontally. The 11801A Digital Sampling Oscilloscope separates a trace into discrete digital samples. The 11801A captures a sample before any amplification or attenuation is used to manipulate the signal. This technique provides very high bandwidth for repetitive signals and makes bandwidth a function solely of the sampling head. Thus, as higher bandwidth sampling heads are introduced, you can increase the capability of the 11801A just by adding a new sampling head.

The 11801A Digital Sampling Oscilloscope uses sequential sampling to sample one data point of the trace each time a trigger event occurs (up to 200K samples per second). Each successive trigger event samples the next point to the right of (occurring later than) the previous points sampled. Once the entire trace has been sampled and all data points are accumulated, the display shows the entire trace result.

Safety

The following safety information is provided for your protection and to prevent damage to the 11801A. This safety information applies to all operators and service personnel.

Terms in Manuals

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

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

Terms on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols in Manuals

Static Sensitive Devices

Symbols on Equipment

DANGER
High Voltage

Protective ground (earth) terminal

ATTENTION
Refer to manual

Power Source

This product is intended to operate from a power source that will not apply more than 250 V rms between the supply conductors or between either supply conductor and ground.

Grounding the 11801A

The 11801A is grounded through the power cord. To avoid electric shock, plug the power cord into a properly wired receptacle where earth ground has been verified by a qualified service person. Do this before making connections to the input or output terminals of the 11801A.

Without the protective ground, all parts of the 11801A are shock hazards. This includes knobs and controls that may appear to be insulators.

Use the Proper Fuse

Using an improper fuse can create a fire hazard. Always use fuses that exactly meet the specifications in the 11801A parts list. Match fuse type, voltage rating, and current rating.

Do Not Operate In Explosive Atmospheres

The 11801A provides no explosion protection from static discharges or arcing components. Do not operate the 11801A in an atmosphere of explosive gases.

Do Not Remove Covers or Panels

CAUTION

Operating the 11801A without the covers in place may cause overheating and damage.

To avoid personal injury, do not operate the 11801A without the panels or covers.

Electrical Connections

SMA-Compatible Connectors

CAUTION
Do not over-tighten SMA-compatible connectors.

You must attach cables to SMA-compatible connectors carefully to prevent damage to the cable or the instrument connector.

When attaching a cable to or removing a cable from an SMA-compatible connector, do not turn the cable, turn only the nut. Align the two connectors carefully and engage the connector nut over the exposed threads on the other connector. Use only finger pressure to make this initial connection. Then use a torque wrench *only* to tighten the connection to the range of 7–10 lb-in (79–112 N-cm).

There are two types of SMA-compatible connectors on the 11801A:

- Standard SMA connectors with plastic insulating material between the center lead and the outer shield. An example is the **INTERNAL CLOCK** output connector.
- High-precision APC 3.5 connectors, which have air insulation between the center lead and outer shield. An example is the **CALIBRATOR** output connector.

The APC 3.5 connectors are of closer mechanical tolerance than the standard SMA connector. Attaching a worn or damaged SMA cable to an APC 3.5 connector may damage the APC 3.5 connector.

Electrostatic Discharge

CAUTION
Applying a voltage outside the range printed on the sampling head can result in damage. Static electricity is also a hazard.

The input diodes used in the sampling heads are very susceptible to damage from overdrive signal or DC voltages, and from electrostatic discharge. Never apply a voltage outside the range printed on the front of the sampling head. Operate the 11801A only in a static-controlled environment.

Connect the wrist strap provided with the 11801A to the **ANTI-STATIC CONNECTION**, as shown on the next page.

Front Panel

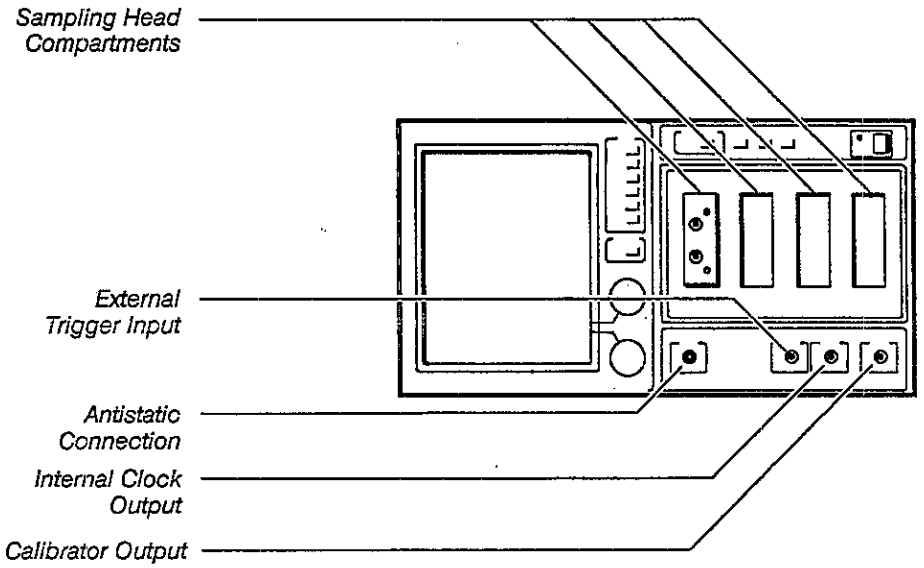
CAUTION

Never install or remove a sampling head with the 11801A power on.

The front panel has two compartments for sampling heads. At least one sampling head must be installed in a 11801A configuration to allow the 11801A to sample signals. To install a sampling head, place it into a compartment and push it in with firm pressure. Once it is seated, turn the screw shaft on the sampling head to tighten the head into place.

Two additional compartments, labeled **AUXILIARY POWER ONLY**, provide power for non-acquisition heads, such as a trigger countdown or optical-electrical converter. These compartments cannot be used to acquire signals.

The **TRIGGER INPUT**, the **INTERNAL CLOCK** output, and the **CALIBRATOR** output connector are located below the sampling heads. The tutorial procedures throughout this manual describe the use of these connectors.



Front Panel Connectors

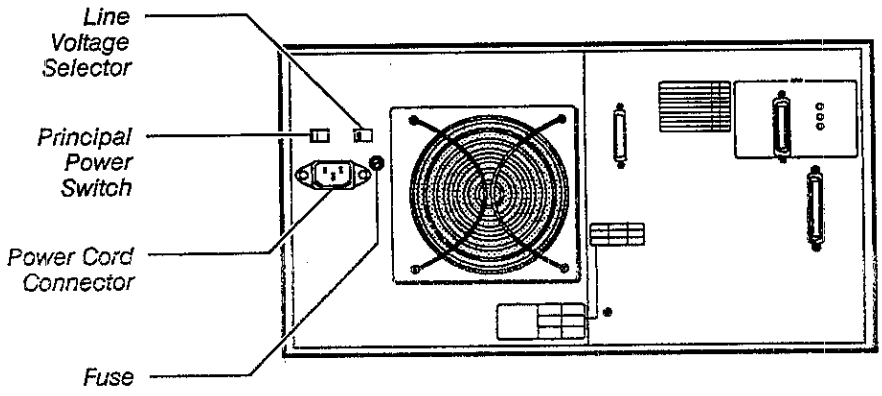
Rear Panel

The **POWER** plug provides AC power to the 11801A. The plug is an IEC-style connector; the separate power cord supplied with the 11801A should match the physical configuration of electrical outlets in your country.

CAUTION

Set the **LINE VOLTAGE SELECTOR** switch before connecting the 11801A to power.

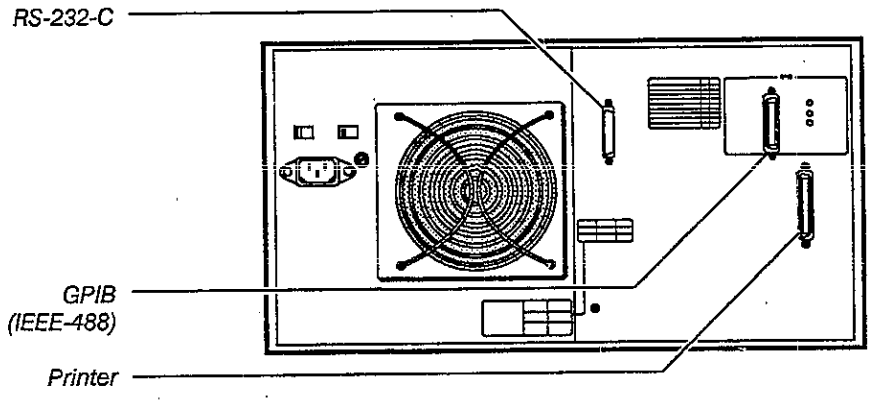
Before connecting the power cord between your electrical outlet and the 11801A **POWER** plug, make sure that the adjacent **LINE VOLTAGE SELECTOR** switch is set to match the voltage range of the electrical system of your country. The main fuse is near these controls, as is the **PRINCIPAL POWER SWITCH**.



Rear Panel Power Connectors and Switches

The **PRINTER** connector provides a Centronics-style interface, so you can connect a printer to the 11801A. This lets you make a paper copy of the display by pressing the **HARDCOPY** button on the front panel.

The **RS-232-C (DCE)** connector lets you connect a computer, terminal, or modem to the 11801A. The GPIB section similarly has an **IEEE STD 488 PORT** connector. Both of these connectors let you make the 11801A part of an automated test and measurement system. Hardcopy information can also be routed through either the **RS-232-C** or the **IEEE STD 488 PORT** connector.

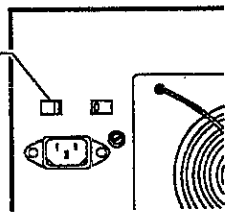


Rear Panel Printer and Data Connectors

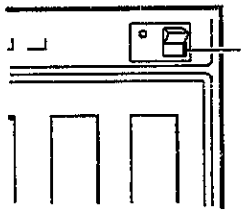
Installation

Follow this sequence when you install the 11801A:

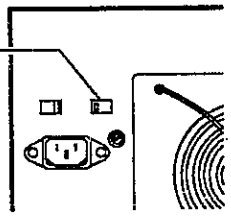
☐ **Step 1:** Set the **PRINCIPAL POWER SWITCH** to **OFF.**



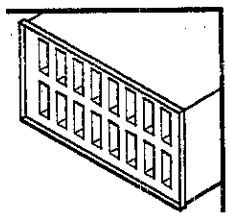
☐ **Step 2:** Set the front-panel **ON/STANDBY** switch to **STANDBY.**



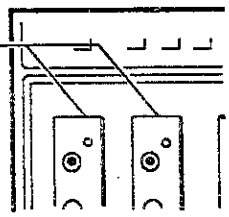
☐ **Step 3:** Set the **LINE VOLTAGE SELECTOR** to the proper range for your system.



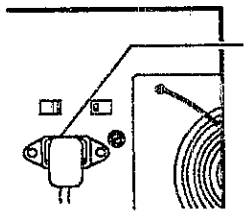
☐ **Step 4:** If you have optional SM-11 Multi-Channel Units, see the *SM-11 Installation/User Guide* and connect them now.



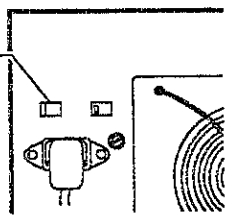
☐ **Step 5:** Install sampling heads in the front-panel compartments.



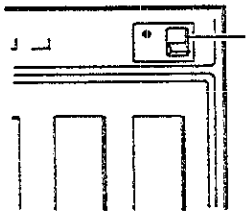
☐ **Step 6:** Connect the power cord from the **POWER** connector to your power system.



☐ **Step 7:** Set the **PRINCIPAL POWER SWITCH** to **ON.**



☐ **Step 8:** Set the front panel **ON/STANDBY SWITCH** to **ON.**



Once the 11801A is installed, use the **ON/STANDBY** switch as a power switch.

Getting Started

This section presents four examples that illustrate how to use the 11801A Digital Sampling Oscilloscope. You will learn about:

- Using the front-panel buttons, touch panel and on-screen menus
- Creating and removing traces
- Using signal inputs
- Setting up triggering
- Using the automatic set-up features
- Using the knobs and assigning knob functions
- Establishing a dual-graticule display
- Creating window (delayed sweep) traces

Once you have completed these examples, you can begin working on your own, or examine the other examples in this manual that pertain to your specific work.

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Example 1: Displaying a Trace

This example shows how quickly you can display a meaningful trace on the display. You will also become familiar with the basic front-panel controls.

For this example you will need an 11801A with at least one sampling head installed, and one SMA connecting cable.

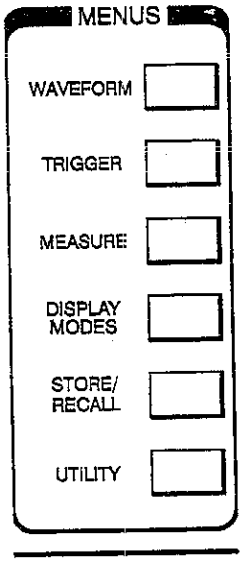
CAUTION

Read the Operator Overview section for information on installing your 11801A.

Major Menu Buttons

You will begin by initializing the 11801A to its default settings. Each example in this manual begins with this step.

To the right of the display is a column of six buttons grouped under the title **MENUS**. Each button has an indicator light that shows which button was pressed last. Associated with each button is a major menu at the bottom of the display.



You may wish to press different major menu buttons and observe the changes on the display. Each major menu presents a group of controls that are related to each other.

- **WAVEFORM** controls trace definition, sampling head control and acquisition control.
- **TRIGGER** controls triggering.
- **MEASURE** controls the automatic measurement system.
- **DISPLAY MODES** controls histograms, mask editing and testing, and other display features.
- **STORE/RECALL** controls storage and recall of trace data and 11801A settings.
- **UTILITY** controls general 11801A parameters such as display colors, GPIB and RS-232-C settings, and the clock. You can access the enhanced accuracy system, which performs internal calibrations of the 11801A and installed sampling heads, through the Utility major menus.

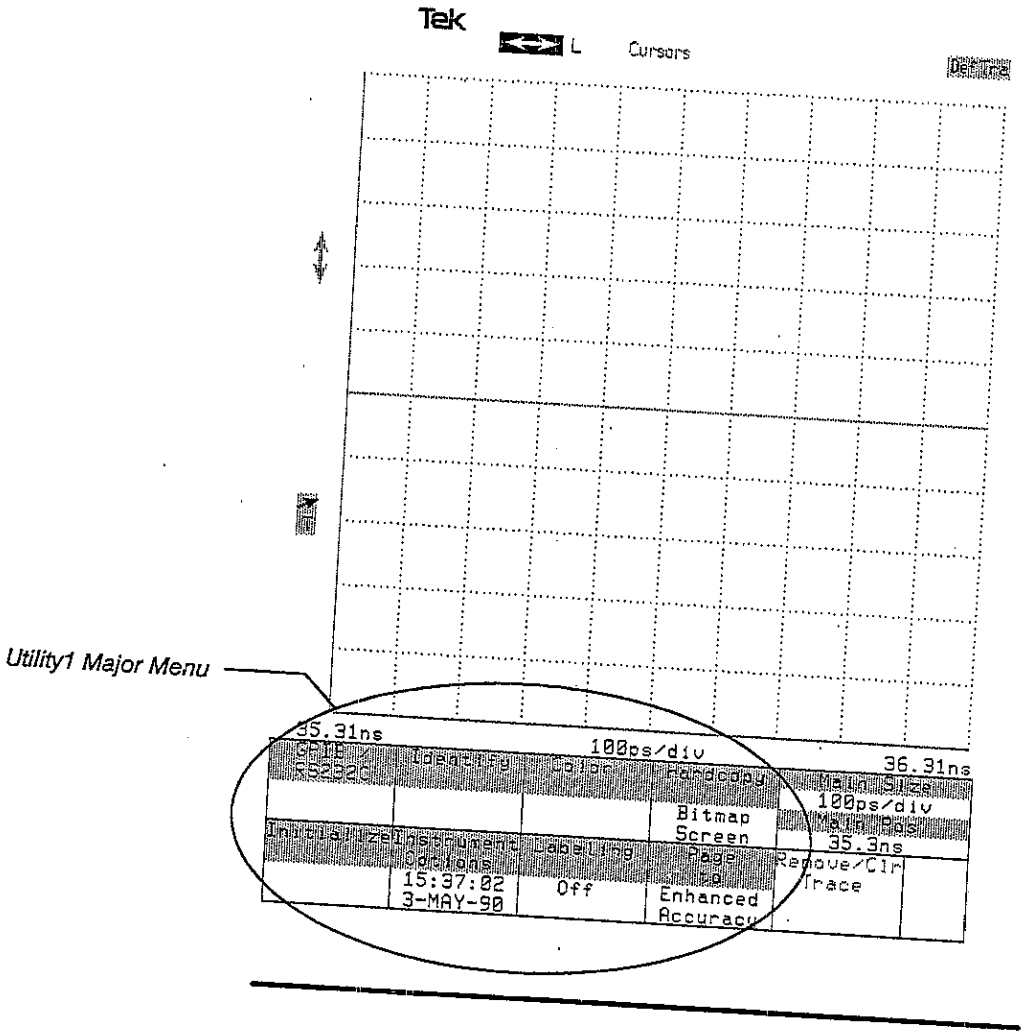
Example 1: Displaying a Trace

The Waveform major menu has two pages and the Utiiity major menu has three pages. Press the appropriate menu button to display the first page of the major menu. Press the same button a second time to display the second page of the menu.

Initialize the 11801A to default settings using the **Initialize** selector, which appears in the Utility1 major menu.

☐ Step 1: Press the major menu **UTILITY** button, located in the **MENUS** column. If you see a different major menu than that shown on the opposite page, press the **UTILITY** button again to change the page.

This illuminates the **UTILITY** button's light and displays the Utility1 major menu, as shown on the next page.


Tek
L
Cursors
Utility1 Major Menu
35.31ns
100ps/div
36.31ns
Identify
Color
Hardcopy
Main Size
100ps/div
Bitmap
Screen
35.3ns
Instrument Labeling
Page
Remove/Clr
Trace
15:37:02
3-MAY-90
Off
Enhanced
Accuracy

Example 1: Displaying a Trace

The Touch Panel

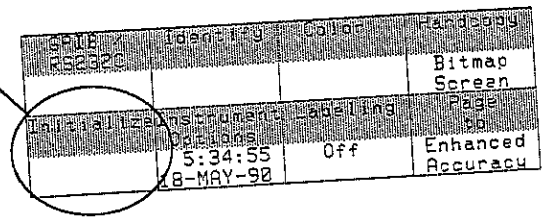
The 11801A does not perform any operation until you *remove* your finger from the display.

You make selections from menus by touching the appropriate area. Until you remove your finger from the display, the 11801A indicates your potential selection by outlining that selector. You can change your potential selection by dragging your finger to the desired selector before withdrawing it.

Menu Selectors

The Utility1 major menu has eight selectors in ruled boxes. The top half of each selector shows the name of the selector with a shaded background, while the bottom displays the current status on a black background.

Initialize *Selector*



Selectors can be normal brightness, like the ones you see in the Utility1 major menu. A selector appears very dim if it cannot be selected in the current state. Bright appearance indicates a selector is already selected or being used.

Be sure that the light beside the **TOUCH PANEL** button says **ON**. This button is below the major menu buttons.

The **Initialize** selector operates when you touch it and withdraw your finger:

☐ Step 2: Touch the **Initialize** selector in the major menu area. Then touch the **Initialize** selector that is displayed in the pop-up menu.

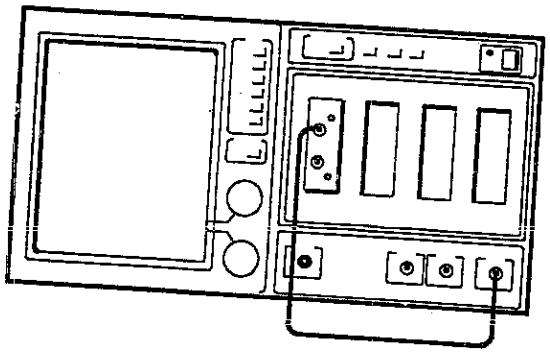
This sequence, pressing the **UTILITY** button and then touching the **Initialize** selector, will always set the 11801A to a default state.

Connecting Cables

To view the calibrator signal, you must connect a cable from the **CALIBRATOR** output to any sampling head input connector.

CAUTION
Read the Operator Overview section for information about SMA-compatible connectors.

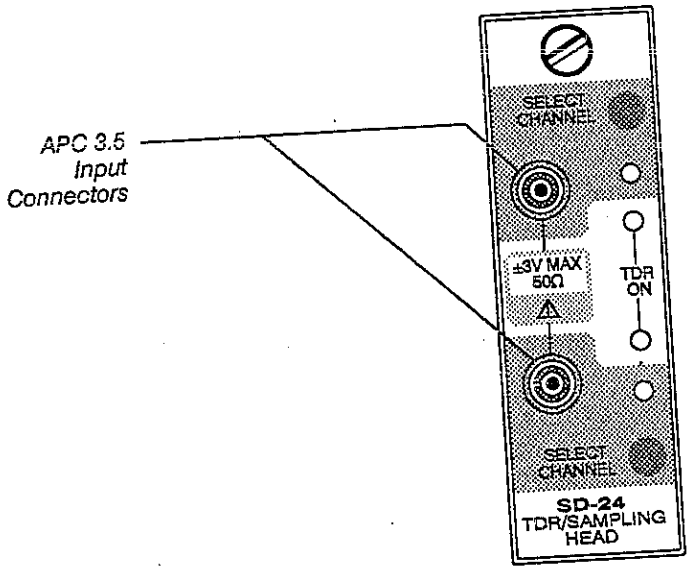
☐ Step 3: Connect an SMA cable from the **CALIBRATOR** output to either input connector of any installed sampling head.



Cable from the **CALIBRATOR** *Output to a Sampling Head Input*

Beside each sampling head input is a small **SELECT CHANNEL** button. Pressing it is a quick way to display that channel. The resulting yellow light near the button tells you that the channel is being displayed.

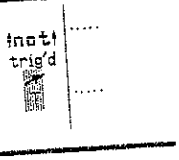
Example 1: Displaying a Trace



Sampling Head Control Panel (SD-24 shown)

☐ Step 4: Press the **SELECT CHANNEL** button nearest the sampling head input you have connected to the calibrator.

The yellow light on the sampling head blinks, indicating that the channel is being displayed.



You don't see a trace on the display because the trace is not triggered. The trigger icon ( ) at the left of the graticule shows **!not!** above it meaning the 11801A is not triggered. This icon always shows you the trigger status.

The 11801A has an internal clock, which is synchronized with the calibrator output. You will use this clock to trigger the trace. To set triggering, you need to use the Trigger major menu.

☐ Step 5: Press the **TRIGGER** major menu button in the **MENUS** column.

This displays the Trigger major menu. The **Source** selector indicates that the current trigger source is the External Direct. You need to change the source to Internal Clock.

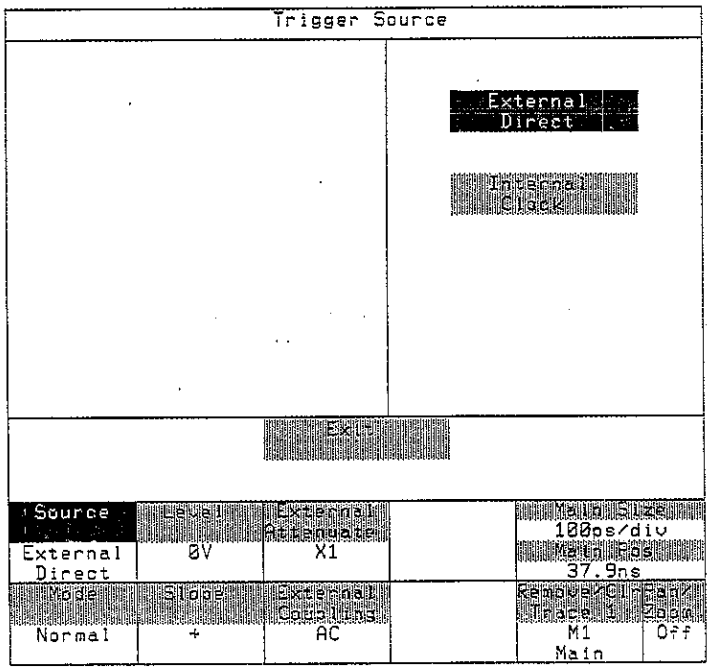
Pop-Up Menus

Touching the **Source** selector demonstrates a common operation of selectors: they display pop-up menus. These menus are a temporary dialog with you, and cover a portion of the graticule. Most pop-up menus disappear automatically when you make a selection. Most pop-up menus also provide an **Exit** or **Cancel** selector so you can remove them.

If you inadvertently display a pop-up menu and wish to remove it, you can also remove it by touching the selector that displayed the pop-up menu. This selector is highlighted during the time that the pop-up menu is displayed. Or, you can touch a part of the graticule that has no traces on it.

☐ Step 6: Touch the **Source** selector in the major menu.

The Trigger Source pop-up menu appears and the **Source** selector itself is highlighted.



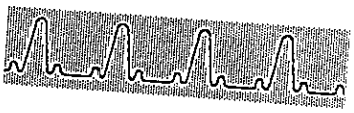
The Trigger Major Menu and **Source** *Pop-Up Menu*

Now that the **Source** pop-up menu is displayed, you can specify the internal clock trigger source:

☐ Step 7: Touch the **Internal Clock** selector in the pop-up menu.

This selects **Internal Clock** as the trigger source. Notice that the **Source** selector in the major menu now indicates **Internal Clock.**

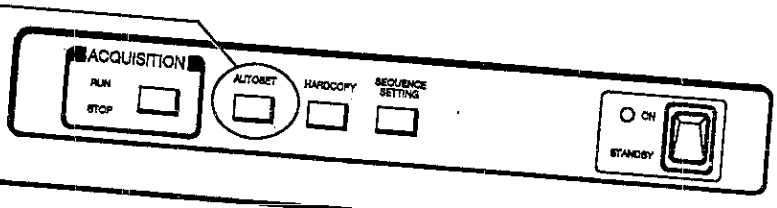
☐ Step 8: Touch **Exit** to remove the pop-up menu.



Autoset

You now see a flat trace on the display. However, it does not show the "interesting" part of the trace. To quickly show the desired data, use the autoset feature. The **AUTOSET** button, located above the sampling heads just to the right of the major menu buttons, automatically sets the horizontal, vertical, and trigger parameters to display the desired portion of the trace.

The **AUTOSET** *Button*

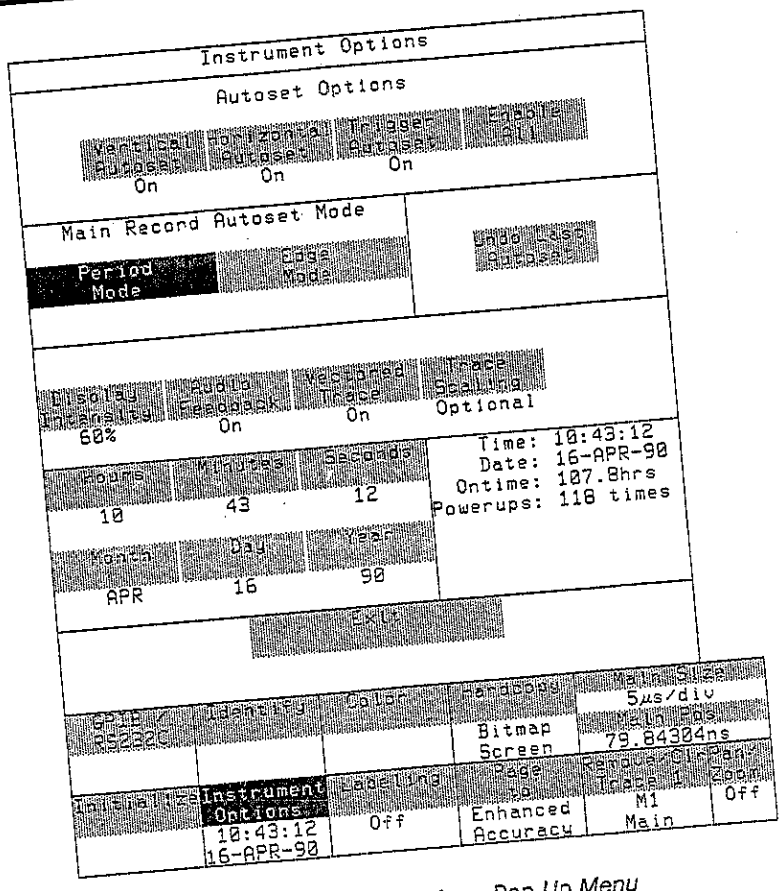


☐ Step 9: Press the **AUTOSET** button above the sampling heads.

You will see rising edge of the calibrator signal on the display.

Autoset Options

You have used autoset to the rising edge of the calibrator signal. The **Instrument Options** pop-up menu of the Utility1 major menu controls autoset operation.



The **Instrument Options** *Pop-Up Menu*

☐ Step 10: Press the **UTILITY** major menu button in the **MENUS** column and touch the **Instrument Options** selector in the major menu. (If you see a different major menu than the Utility1 menu, press the **UTILITY** button again.)

The **Instrument Options** pop-up menu controls autoset with the following groups of selectors:

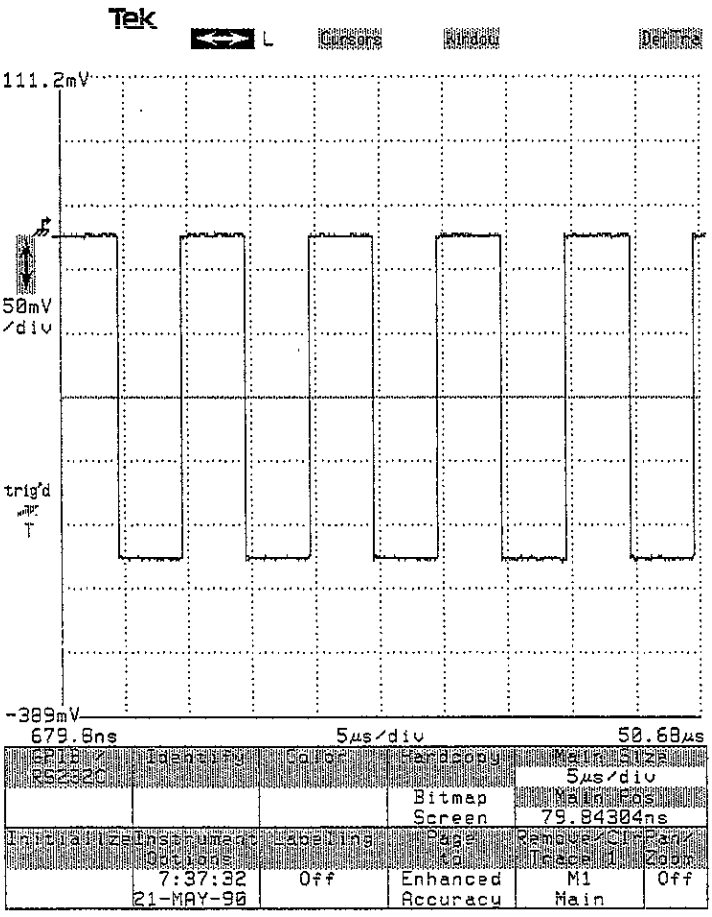
- Under **Autoset Options** you can turn on or off **Vertical Autoset**, **Horizontal Autoset** and **Trigger Autoset**, which determine whether performing an autoset will alter those types of parameters. If you want to set all three parameters to On, use the **Enable All** selector.
- Under **Main Record Autoset Mode** you can select **Period Mode** (which displays several cycles of a trace) or **Edge Mode** (the initialize default).
- The **Undo Last Autoset** selector restores the 11801A to the settings that existed before you pressed the **AUTOSET** button.

You want to display several cycles of the calibrator signal.

☐ Step 11: Touch the **Period Mode** selector in the pop-up menu and press the **AUTOSET** button above the sampling heads.

A display should appear similar to the illustration on the next page.

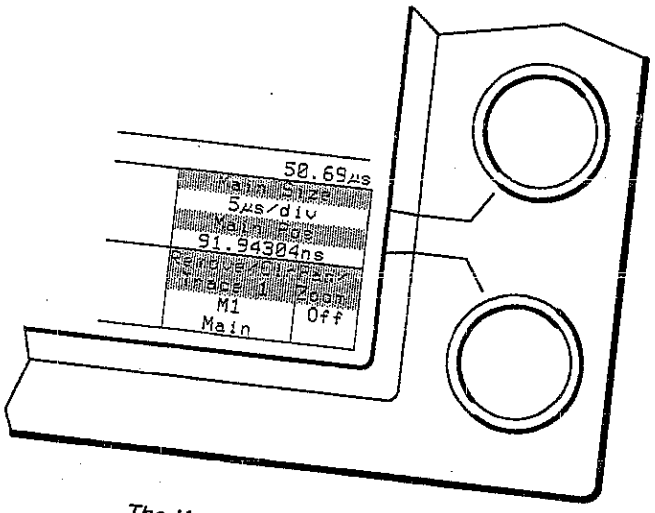
Example 1: Displaying a Trace



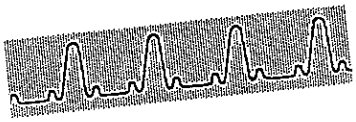
The Calibrator Signal After Pressing **AUTOSET** *in Period Mode*

The Knobs

There are two control knobs to the right of the display and below the major menu buttons. They adjust different things at different times. You can always look at the Knob menu to see what the knobs will adjust. This is called the current *knob assignment*. The Knob menu appears on the display to the right of the major menu.



The Knobs and the Knob Menu



The top two selectors of the Knob menu are half-height and always show the current knob assignment. At present they show that the top knob controls the **Main Size** (time per division) parameter, and the bottom knob **Main Pos** (main time base position). The bottom half of each selector shows the current value of that parameter.

Always glance at the knob labels before using the knobs.

Selectors may perform specific tasks, or assign the knobs, or do both. Each knob assignment remains in effect until you change it with another selector or a major menu button.

When you turn the knobs, you will feel clicks instead of smooth motion. Each click represents a minimum change; the 11801A "counts clicks" to measure knob motion. Depending on the value the knobs are assigned to, each click changes the value by some linear increment, a multiplicative factor, or the next number in a 1-2-5 sequence.

☐ Step 12: Turn each knob left and right, observing the trace changes. When you are done, restore the trace to its original appearance by turning the knobs or by pressing the **AUTOSET** button above the sampling heads.

Icons

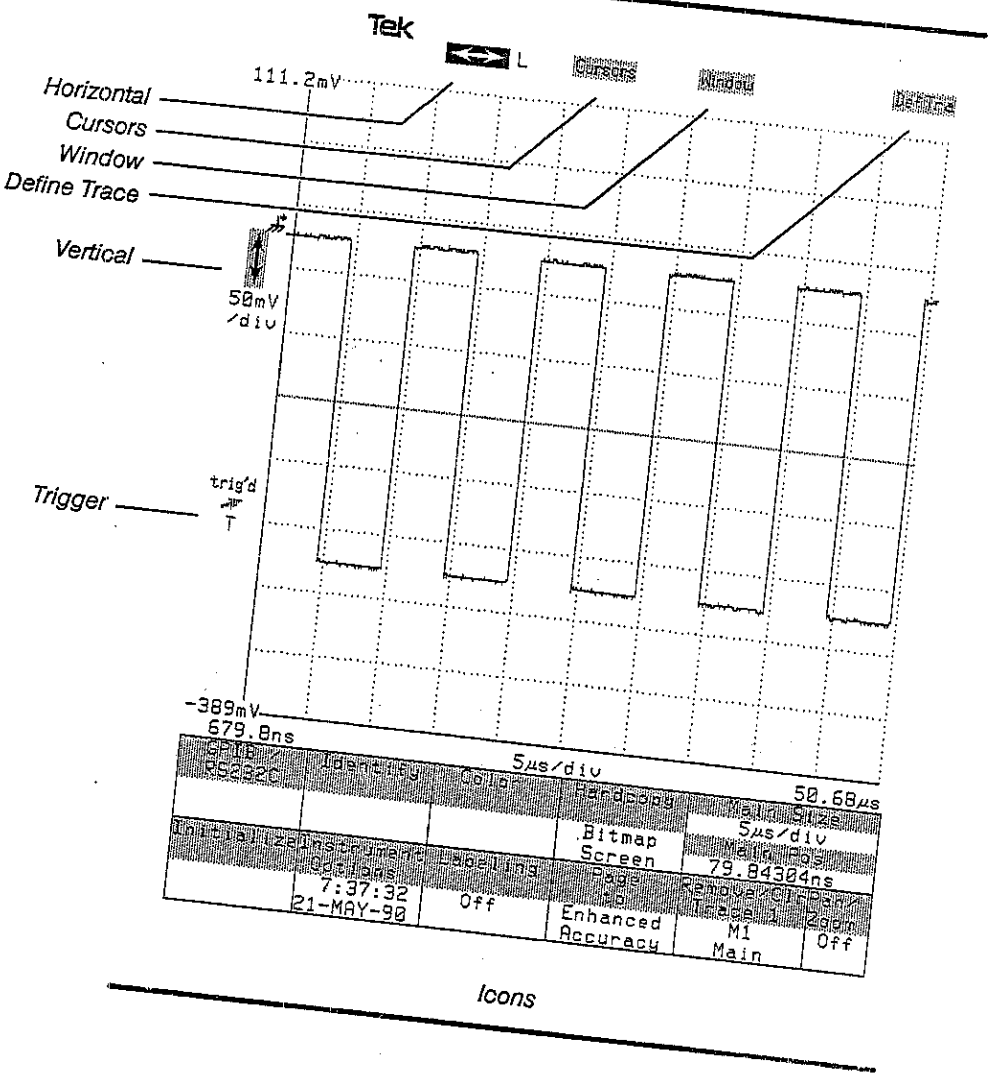
To control the vertical size and offset of a trace, you need to reassign the knobs. You will use an icon to do this.

The trigger icon is presently unselectable because you cannot adjust the internal trigger level.

Above and to the left of the graticule are several icons. These icons are always available on the display regardless of which major menu is being shown. The trigger icon ( ), the vertical icon ( ), and the horizontal icon ( ) assign the knobs. Since the current knob assignment is horizontal (main) size and position, the horizontal icon ( ) is highlighted.

Touching the vertical icon ( ) changes the knob assignments, as shown in the Knob menu labels. Turning the knobs shows that the vertical characteristics of the trace are altered.

☐ Step 13: Touch the icon and turn each knob left and right. Observe the changes in the trace.


Tek
L
Cursors
Window
Define
111.2mV
Horizontal
Cursors
Window
Define Trace
Vertical
50mV
/div
Trigger
trig'd
-389mV
679.8ns
5µs/div
50.68µs
Identify
Color
Hardcopy
Main Size
Bitmap
Screen
5µs/div
Main Pos
79.843084ns
Page
Remove Cl Par/
Enhanced
Accuracy
M1
Main
Off

Icons

Keypad Pop-Up Menu and Knob Resolution

The knobs can be adjusted to finer or coarser resolution with the Keypad pop-up menu. This menu also allows numeric entry of a parameter assigned to a knob. The Keypad pop-up menu is displayed by touching either knob label selector in the Knob menu.

☐ Step 14: Touch the **Vert Offset: M1** knob label selector. (If you connected your signal to a different channel, you may see a different channel number.)

The two selectors across the top of the Keypad pop-up menu allow you to change the knob parameter.

The **Knob Res** section has selectors for **Coarse**, **Medium**, and **Fine** resolution. Vertical offset does not support medium resolution, so that selector is dimmed. The other two selectors show the knob click increment: coarse will set the knob to add or subtract 5 mV for each knob click, while fine sets the knob increment to 500 µV. The **Coarse** selector is highlighted to show that it is the current selection.

☐ Step 15: Touch the **Fine** selector in the pop-up menu, and turn the bottom knob.

Observe that the trace movement is now finer than it was before.

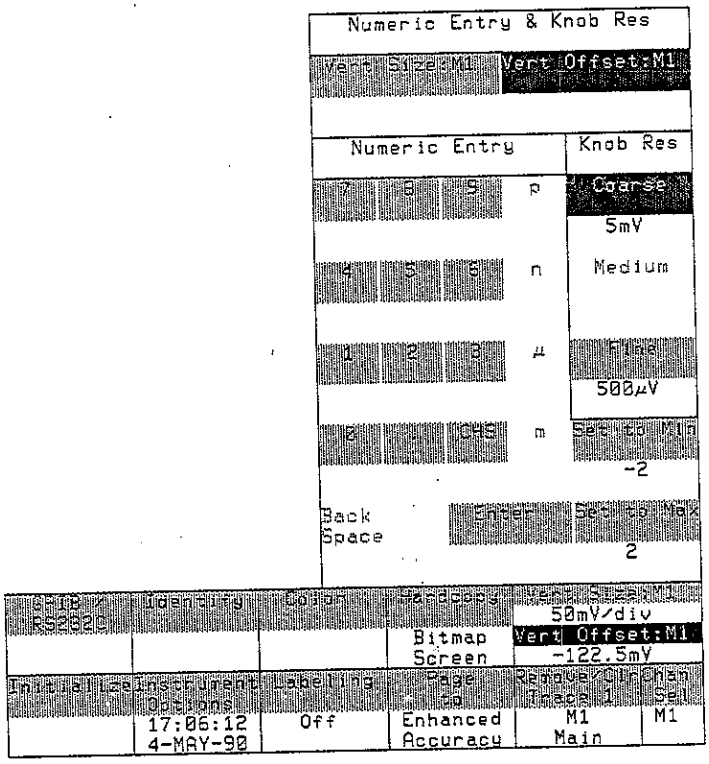
The Keypad pop-up menu can also set a parameter to its minimum or maximum, using the **Set to Min** or **Set to Max** selectors.

Look at the **Set to Min** and **Set to Max** selectors to see the valid range of any parameter.

☐ Step 16: Touch the **Vert Size: M1** knob label. Then touch the **Set to Max** selector in the Keypad pop-up menu.

Vertical size is now the maximum volts per division, producing the smallest height trace possible.

You can directly enter any value you wish using the Keypad pop-up menu.



The Knob Menu and Keypad Pop-Up Menu

☐ Step 17: Touch the **Vert Size: M1** knob label. Then touch the following selectors: **5 0 m** . Notice the entry line being formed above the **Numeric Entry** label in the pop-up menu. Use **Back Space** to remove incorrect entries. Touch **Enter** to complete entry.

Vertical size is now set to 50 mV per division.

Major Menu Knob Assignments

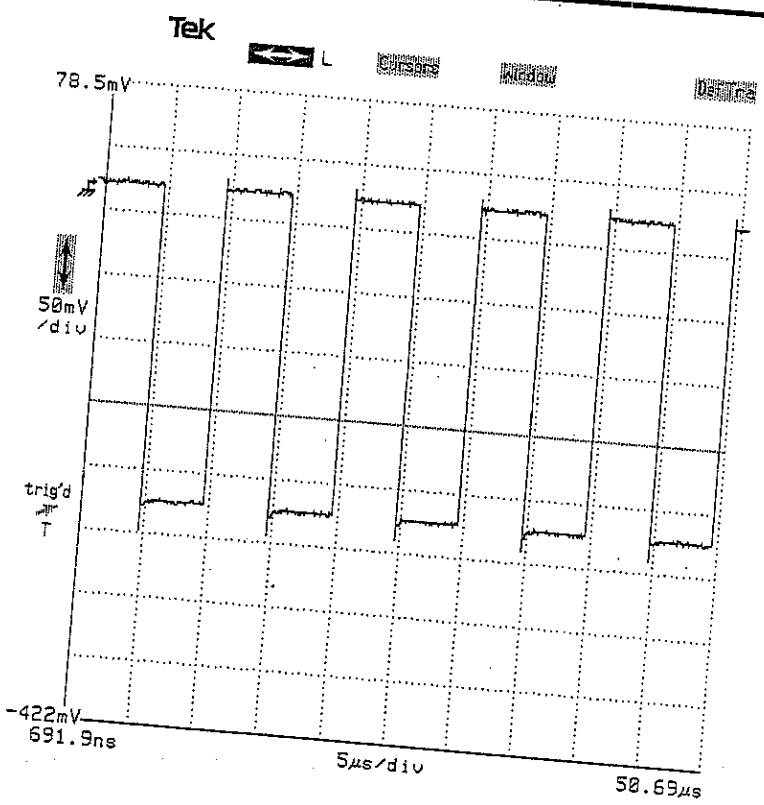
Each major menu assigns the knobs to different parameters. Whenever you select a major menu, the knob assignments will be the assignments that were in effect when that major menu was active last.

Major menu buttons perform knob assignments.

For example, you have the Trigger major menu selected. The current knob assignments are **Vert Size: M1** and **Vert Offset: M1** (you may be using a different channel number).

☐ Step 18: Press the **WAVEFORM** major menu button in the **MENUS** column.

The knob assignment changes to **Main Size** and **Main Pos**, because that was the last assignment made using the Waveform major menu.



The Acquired Calibrator Signal

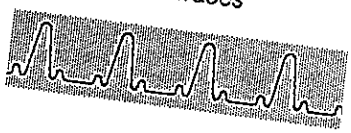
Adding Another Trace

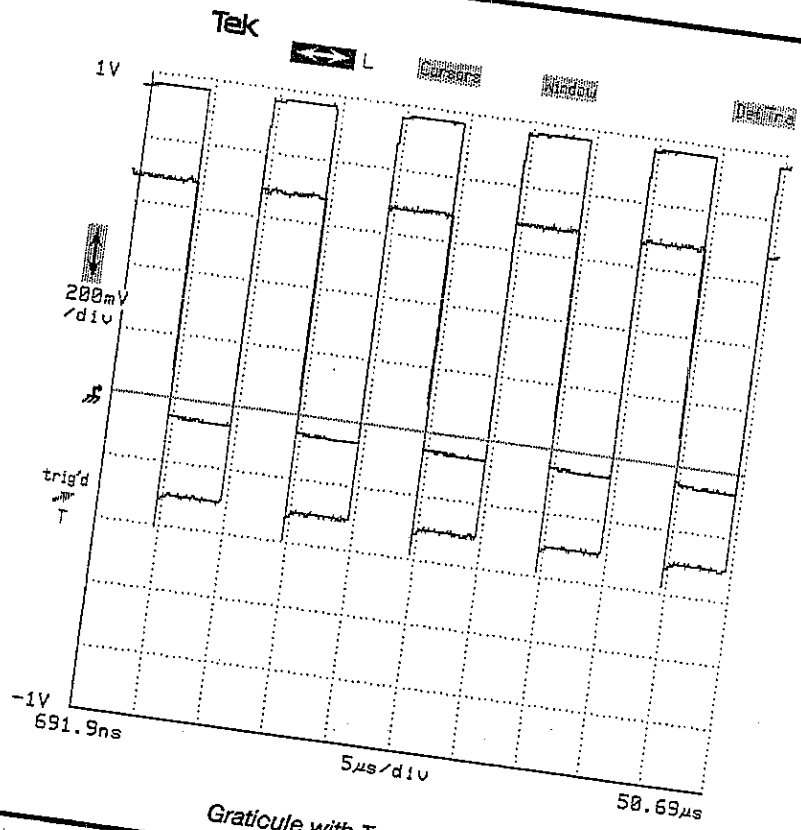
Adding another trace to an existing display is easy: press the **SELECT CHANNEL** button of the sampling head channel you wish to add.

☐ Step 9: Press the sampling head channel button of the signal from the **INTERNAL CLOCK** output.

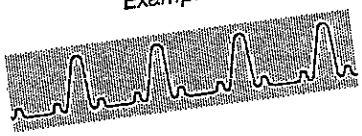
You should be aware of several important points about this display.

- Both traces share the same time base, and so both traces display the same span of time. The horizontal axis labels apply to both traces. This may not hold true for the vertical axis.
- While the 11801A can display up to 8 traces at once, there is always one *selected* trace. The selected appears brighter than other traces. Most menu selectors, the knobs, the status displays, and autoset all operate on the selected trace. When more than one trace is displayed, each additional trace is displayed in a different color.
- The graticule axes and the axis labels are the same color as the selected trace.
- The channel lights on the sampling head are lighted to show that both channels are being displayed. The light for the selected trace blinks.





Graticule with Two Traces



Selecting Traces by Touch

To select a different trace simply touch the desired trace. An outline box indicates your potential selection. If only one trace passes through that outlined area when you withdraw your finger, it will become the selected trace. If several traces pass through the outlined area, repeatedly touching the same area will select successive traces.

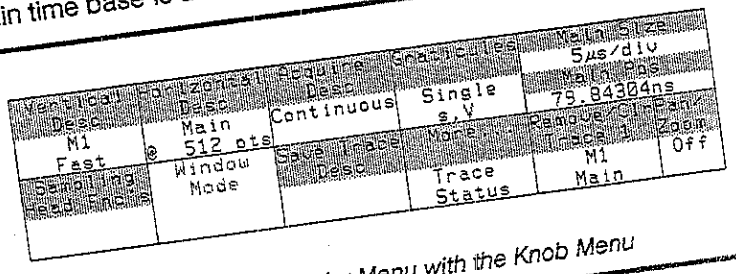
☐ Step 10: Touch the traces to change selections. Try touching an area with one trace, and an area where both appear together.

The Waveform major menu shows status of the selected trace. The **Vertical Desc** selector shows the trace expression of the selected trace.

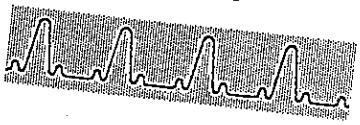
☐ Step 11: Press the **WAVEFORM** major menu button in the **MENUS** column and observe (don't touch) the **Vertical Desc** selector.

If the selected trace displays mainframe channel 1 then the **Vertical Desc** selector will show **M1**. (**Fast** is a trace parameter that is described in Example 3.) Channels can be combined in a single trace, for example M1 + M3, as you will see in Example 3.

The **Remove/Clr Trace n** selector of the Knob menu also shows the expression of the selected trace. (It also indicates that the Main time base is used.)



The Waveform Major Menu with the Knob Menu



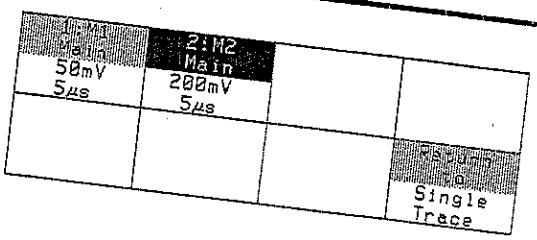
The number **n** in the **Remove/Clr Trace n** selector is the trace number assigned by the 11801A when the trace is created. It should not be confused with the trace expression. Trace numbers range from 1 through 8. This selector always shows the number of the selected trace.

☐ Step 12: Select each trace by touch, and observe the **Vertical Desc** and **Remove/Clr Trace n** selectors and the sampling head lights.

Selecting Traces Using the Trace Status Menu

Another method of selecting traces presents information about all displayed traces simultaneously. The Waveform major menu has an alternate "Trace Status" menu. The **WAVEFORM** button is lit when either alternative is displayed. The **More . . .** selector of the standard Waveform major menu displays this alternate.

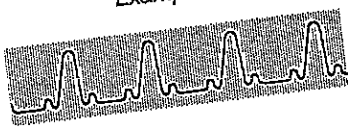
☐ Step 13: Touch the **More . . .** selector in the major menu to see the Trace Status menu.



The Trace Status Menu

The Trace Status menu has a **Return to Single Trace** selector to return you to the normal Waveform major menu—or just press the **WAVEFORM** major menu button.

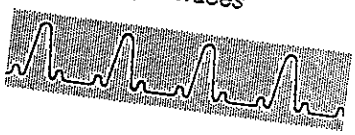
Example 2: Managing Multiple Traces



The Trace Status menu presents one selector for each displayed trace. These selectors show status information about the trace they represent. The selector for the selected trace is highlighted. You can make any trace the selected trace by touching its selector. This highlights the new trace and the representative selector in the Trace Status Menu.

☐ Step 14: Touch the trace selector that is not highlighted. Notice that it becomes highlighted and that its trace is brightened on the graticule.

☐ Step 15: Return to the normal Waveform major menu, either by touching the **Return to Single Trace** selector in the major menu or by pressing the **WAVEFORM** major menu button in the **MENUS** column.



Labeling Traces

You can label traces to help you keep track of them. You can specify a label of up to 10 characters for each trace, and you can have these labels displayed with the traces on the graticule. You can use letters of the alphabet (upper or lower case), Greek symbols, graphic symbols or numbers in your label. The trace label moves with the trace as the signal changes. You can change the position of the label relative to the trace. Use the **Labeling** pop-up menu in the Utility1 major menu to control labels.

☐ Step 16: Press the **UTILITY** button to display the Utility1 major menu.

☐ Step 17: Touch the **Labeling** selector in the Utility1 major menu.

The **Display** selector in the **Labeling** pop-up menu turns on or off the display of all trace labels. Display is currently turned off.

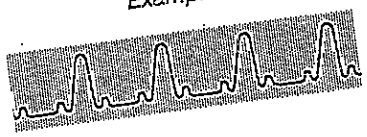
☐ Step 18: Touch the **Display** selector to turn display of trace labels on.

☐ Step 19: If it is not already highlighted, touch the **Displayed Traces** selector.

There is a selector for each displayed trace. Each selector shows a trace number, the trace expression, and the time base for that trace.

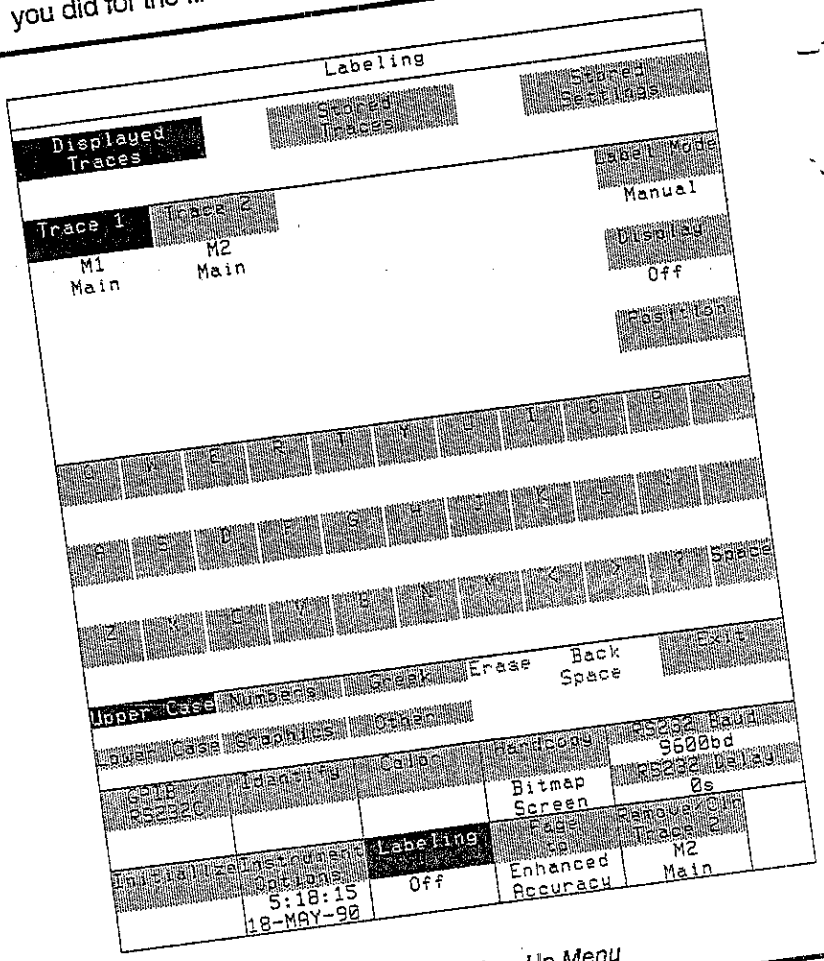
☐ Step 20: Touch the selector for **Trace 1**.

The lower portion of this pop-up menu displays selectors that let you type the label. The selectors along the very bottom let you select the set of characters from: **Upper Case**, **Lower Case**, **Numbers** (which includes most punctuation), **Greek** (the Greek alphabet), **Graphics** (mathmatical symbols and more), and **Other** (characters from non-English alphabets). **Back Space** lets you correct errors. **Exit** removes the pop-up menu.

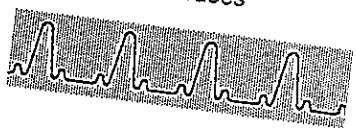


☐ Step 21: Use the keyboard selectors to type in your own label, for example **CAL**.

☐ Step 22: Touch the selector for **Trace 2**. Type in a label as you did for the first trace. Finish by touching the **Exit** selector.



The **Labeling** *Pop-Up Menu*



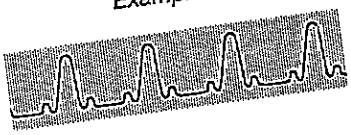
Once a label is established, it moves with the trace. You can control the position of the label relative to the trace. The **Position** selector in the **Labeling** pop-up menu to assigns the knobs to set the position of the label.

Trace labels will always stay on the graticule. If the position or the movement of the trace would take a label off the display, the edge of the graticule limits the movement of the label.

☐ Step 23: Touch the **Labeling** selector in the major menu area, and touch the **Position** selector in the pop-up menu.

☐ Step 24: Use the knobs to position the labels horizontally and vertically. To select the label to move, simply touch it as you would touch a trace to select it.

Note that each label is the color of its associated trace. When you touch a label, you select that trace.



Displaying Dual Graticules

The **Graticules** selector can create a dual-graticule display. You can place traces on either graticule.

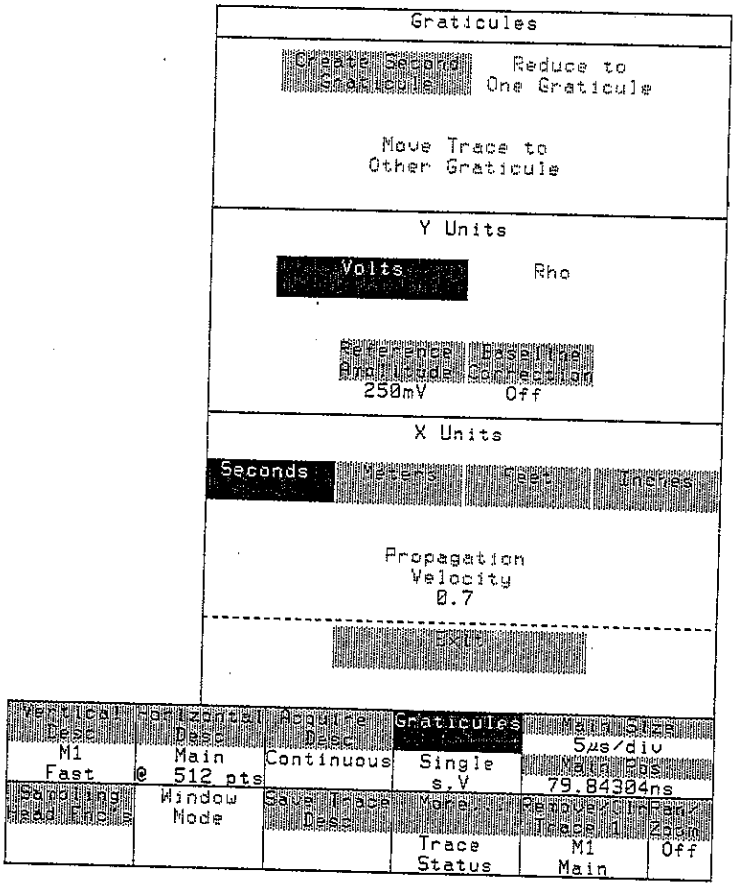
☐ Step 25: Press the **WAVEFORM** button to display the Waveform major menu.

☐ Step 26: Touch the **Graticules** selector in the major menu, and touch **Create Second Graticule** in the pop-up menu.

The selected trace appears on the graticule with the horizontal (↔) and vertical (↕) icons; this is called the active graticule. If you select a trace on the other graticule, it will make that graticule the active graticule.

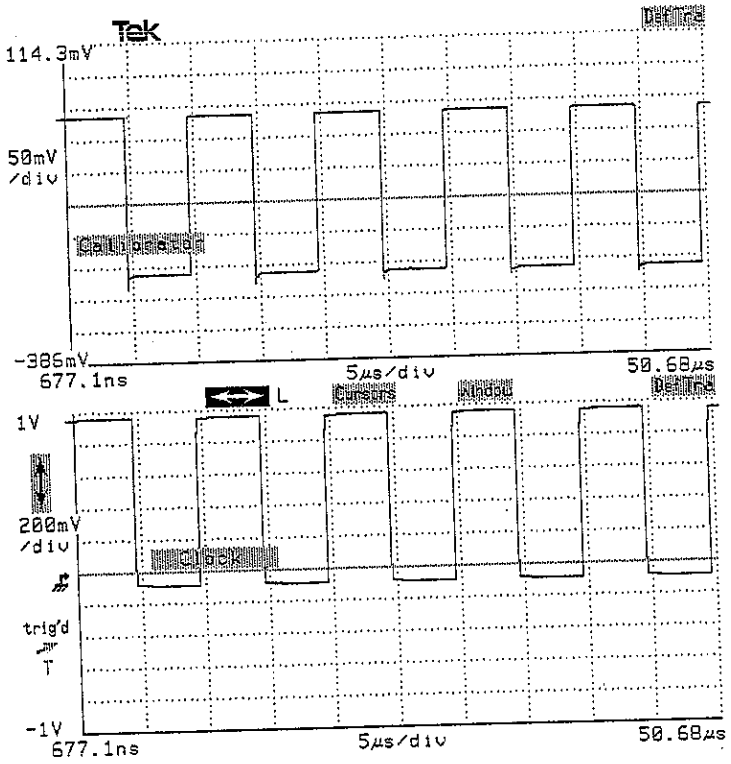
☐ Step 27: Touch the **Lower Graticule** selector of the major menu (it was **Graticules**). Touch **Move Trace to Other Graticule**, and observe the selected trace move to the other graticule.

☐ Step 28: Touch the **Upper Graticule** selector of the major menu (it was **Lower Graticule**). Touch **Reduce to One Graticule**.



The **Graticules** *Pop-Up Menu*

Example 2: Managing Multiple Traces



A Dual-Graticule Display

Removing Traces

☐ Step 29: Below the knob labels, touch the **Remove/Clr Trace n** selector, and then **Remove Trace n** in the pop-up menu.

This will remove one of your traces, leaving one on the display. You could remove the remaining trace with **Remove/Clr Trace n** again. Since the trace is already selected, it can also be removed by pressing the **SELECT CHANNEL** button on the sampling head.

The sampling head channel light can have three states: off (channel not displayed), on steady (channel displayed only on non-selected traces), or blinking (the selected trace displays this channel). The operation of the channel button depends on the light:

- If the yellow light is off (channel not displayed), pressing the button creates a trace of that channel.
- If the yellow light is on steady (channel displayed but not part of the selected trace) then pressing the button selects that trace, causing the light to blink.
- If the yellow light is blinking (channel is part of the selected trace), pressing the button will entirely remove *all* traces displaying that channel.

☐ Step 30: Press the sampling head **SELECT CHANNEL** button beside the blinking light to remove the remaining trace.

Example 2: Managing Multiple Traces

Example 3:
Defining Complex Traces

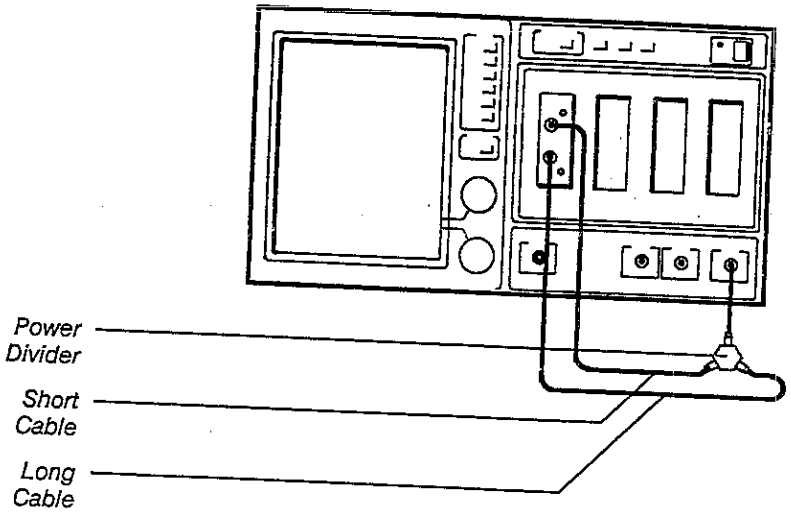
This example shows how you can create traces that combine signals from more than one channel.

For this example you will need a 11801A with at least one dual-channel sampling head installed. Also, a power divider and two SMA cables of different length will be used (2 ns and 5 ns cables are recommended). You may substitute a signal-splitting T adapter for the power divider.

☐ Step 1: Initialize the 11801A (press the **UTILITY** button in the **MENUS** column, touch **Initialize** in the major menu, and touch **Initialize** in the verification pop-up menu).

☐ Step 2: Attach the power divider to the **CALIBRATOR** output connector of the 11801A.

☐ Step 3: Connect cables from each branch of the power divider to sampling head input connectors.



Connections for Example 3

☐ Step 4: Press the **TRIGGER** button in the **MENUS** column, and touch **Source** in the major menu and **Internal Clock** in the pop-up menu. Touch **Exit** to remove the menu.

☐ Step 5: Press the **SELECT CHANNEL** button on each channel that you have connected the calibrator signal to.

☐ Step 6: Turn the top knob to the left until the horizontal scale is 5 ns/div. *Don't use the* **AUTOSET** *button!*

You should see the calibrator trace on the display twice. Because of the different lengths of the cables you are using, the edges of these traces will be separated by 3 ns.

Trace Expressions

You wish to display a trace that represents the difference between the two signals. Up to now, you have pressed the sampling head channel button to display a trace. This is a shortcut method limited to single-channel traces.

The **Vertical Desc** selector and the **DefTra** icon operate differently, though they both display the same pop-up menu.

The **DefTra** icon creates new traces. It is located above each graticule's upper right corner. Touching the icon displays a pop-up menu that covers the full display. The same pop-up menu is presented by the **Vertical Desc** selector of the Waveform major menu. The menu selector allows you to view and change the expression of an existing trace, while the **DefTra** icon creates a new trace.

☐ Step 7: Touch the **DefTra** icon.

The selectors in this pop-up menu are keystrokes that you use to build a trace expression. As you enter keystrokes, the expression is shown at the top of the menu. These selectors are available:

You don't need to display the source traces to create a complex trace.

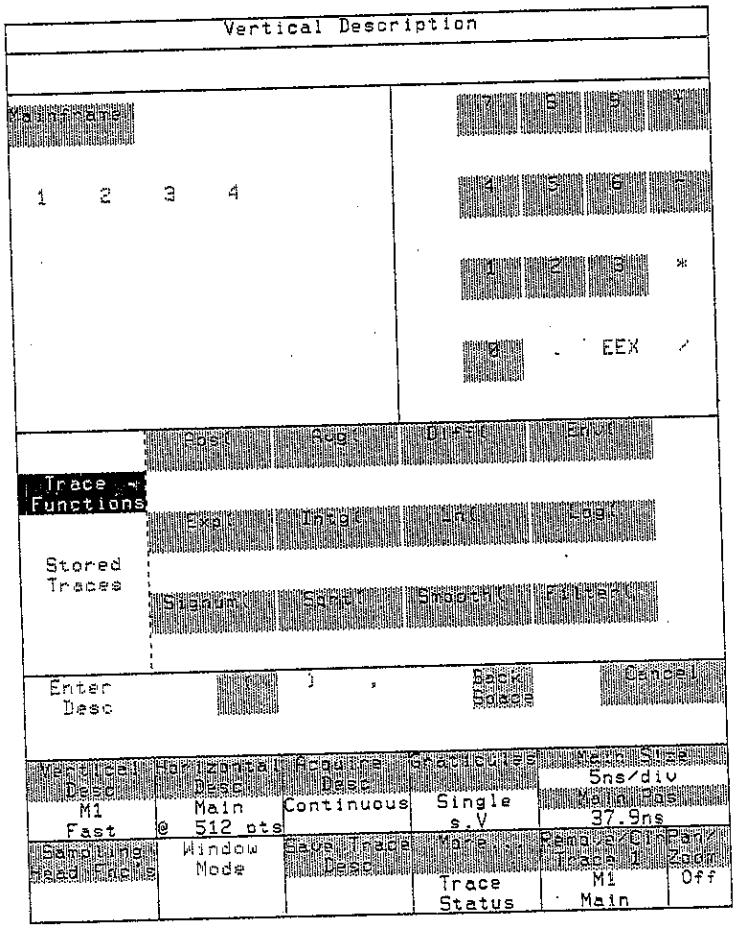
- **Channel Selectors** specify an input channel.
- **Numeric Keypad** allows entry of numeric constants and arithmetic operators of addition, subtraction, multiplication, and division.
- **Trace Functions** specify functions such as logarithms, differentiation, and averaging.
- **Stored Traces** specify a previously stored trace.
- **Syntax** includes parentheses, **Back Space** (which can be used for successive entries), and **Enter Desc** (which enters your completed expression, removes the pop-up menu, and creates the trace). **Cancel** removes the pop-up without defining a trace.

You want to enter a difference expression M1-M2. (If you are using different channels you will use different numbers. This example uses M1 for the channel the short cable is connected to.)

☐ Step 8: Touch **1** (under **Mainframe**) **-** (in the numeric keypad area) **2** (under **Mainframe**) and **Enter Desc**, all in the pop-up menu.

The difference trace is created. Notice that on the sampling heads, both of the yellow lights for the source channels are blinking, indicating that both channels are represented in the selected trace.

Example 3: Defining Complex Traces



The **DefTra** *Pop-Up Menu*

Vertical Adjustment of Complex Traces

You can change the vertical size and offset of only one input channel at a time, even if the selected trace represents several inputs.

☐ Step 9: Make the selected trace the single-source trace from the short cable. Select this trace by touching it. Check the **Vertical Desc** selector to see that **M1** is the trace description. If necessary, touch the same area again to select the right trace.

☐ Step 10: Touch the vertical icon (⇕). The knobs are set to Vertical Size and Offset of the channel indicated in the knob labels, which is also the channel of the selected trace.

☐ Step 11: Turn the top knob right to set the vertical scale to 100 mV/div. Turn the bottom knob to the left to move a *part* of the trace off the graticule.

The selected trace will change to be twice as high. The difference trace will also change, becoming quite ragged.

This aberration is caused by a component signal being off the graticule. The selected trace is off the bottom edge of the display, and this means that the complex trace that depends on it is affected as well.

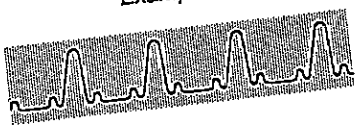
☐ Step 12: Turn the bottom knob to the right until the selected trace is completely on the graticule. You will see the "noise" disappear from the difference trace.

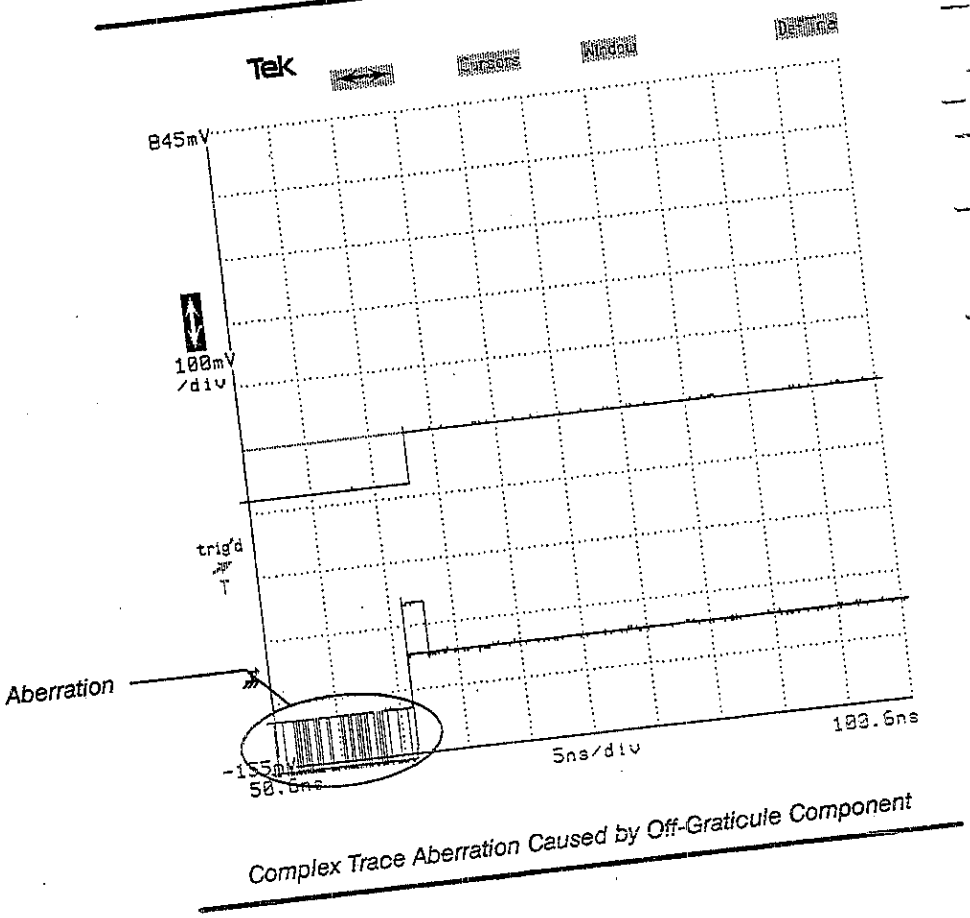
Unless all component traces have the same vertical size, a "Fast" complex trace will have undefined vertical units. (High Precision traces don't have this limitation.)

☐ Step 13: Continue to move the trace up to the top half of the display and observe that as it moves, the difference trace moves up as well.

☐ Step 14: Turn the top knob to the left to return the selected trace to its original size of 200 mV/div.

Example 3: Defining Complex Traces





Complex Trace Aberration Caused by Off-Graticule Component

Example 2: Managing Multiple Traces

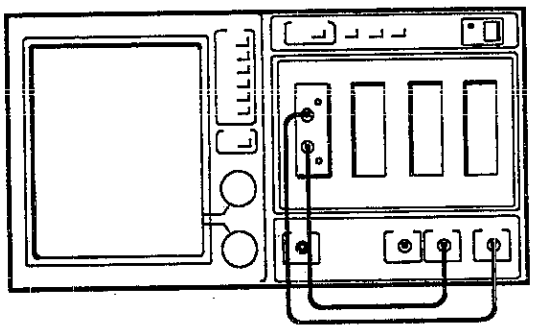
This example demonstrates multiple traces and graticules on the display. It also shows how to select and manage multiple traces.

For this example you will need an 11801A with at least one sampling head installed and two SMA connecting cables.

☐ Step 1: Press the **UTILITY** major menu button in the **MENUS** column, touch the **Initialize** selector in the major menu, and touch **Initialize** in the pop-up menu.

☐ Step 2: Connect the **CALIBRATOR** output to any sampling head input.

☐ Step 3: Connect the **INTERNAL CLOCK** output to any available sampling head input.



Connections for Example 2

Display the trace coming from the calibrator:

☐ Step 4: Press the **SELECT CHANNEL** button of the channel you have the **CALIBRATOR** output connected to.

Example 2: Managing Multiple Traces

You will need to set the trigger source to Internal in order to display the calibrator signal.

☐ Step 5: Press the **TRIGGER** button to display the Trigger major menu.

☐ Step 6: Touch the **Source** selector in the major menu area, and select **Internal Clock** in the **Source** pop-up menu. Select **Exit** to remove the pop-up menu.

☐ Step 7: Press the **UTILITY** button to display the Utility major menu. Touch the **Instrument Options** selector in the major menu area, and select **Period Mode** in the pop-up menu. Touch **Exit** to remove the pop-up menu.

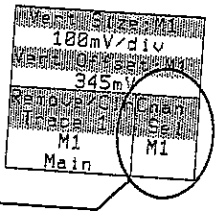
☐ Step 8: Press the **AUTOSET** button (above the sampling heads).

You should see several cycles of the calibrator signal on the display.

In the last few steps, you have moved the complex trace by selecting and moving one of the component traces. Since you have the component traces on the display this is easy to do. Usually, when you display a complex trace, you will not be displaying all the traces that represent the individual channel signals.

You can select this complex trace and move it with the knobs. However, when you do this you are actually moving only one component input channel of the complex trace.

Whenever the knobs are set to vertical size and offset, the Knob menu selector at the lower right corner of the display becomes a **Chan Sel** selector. Touch this selector to choose which channel you wish to move. Repeatedly touching the selector lets you choose from all of the input channels that make up the complex trace.



Chan Sel *Selector*

The **Chan Sel** *Selector in the Knob Menu*

☐ Step 15: Touch the difference trace to make it the selected trace.

☐ Step 16: Observe the **Chan Sel** selector in the Knob menu, and then turn the top knob to the right to set the vertical size to 100 mV/div. You may need to turn the bottom knob to position the trace completely on the gratucule.

☐ Step 17: Touch **Chan Sel** in the Knob menu to select the other input channel. Observe that the knob labels reflect the channel change.

☐ Step 18: Turn the top knob to the right to set the vertical size to 100 mV/div. You may need to turn the bottom knob to position the trace completely on the graticule.

Now the input channel traces and the complex difference trace are double their original size.

High Precision Traces

If your complex trace is a *high precision* trace, you can move it vertically using the knobs without changing the offset of any component channel. High precision traces are calculated using floating-point arithmetic. The complex trace you have created and moved in this example is not a high precision trace; this is indicated by the notation of **Fast** in the **Vertical Desc** selector. High precision traces will show **High Prec** in the **Vertical Desc** selector.

You can specify that all traces you create in the future will be high precision traces: Press the **UTILITY** button, and touch the **Instrument Options** selector. In the pop-up menu, touch the **Trace Scaling** selector until it shows **Forced**. This does not affect any trace already on the screen, but will cause all traces you create in the future to be high precision traces. For this example, leave **Trace Scaling** set to **Optional**.

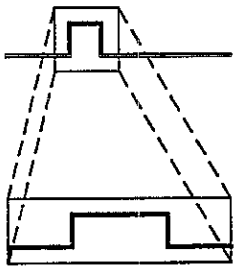
The remainder of this example will be clearer without multiple traces on the display.

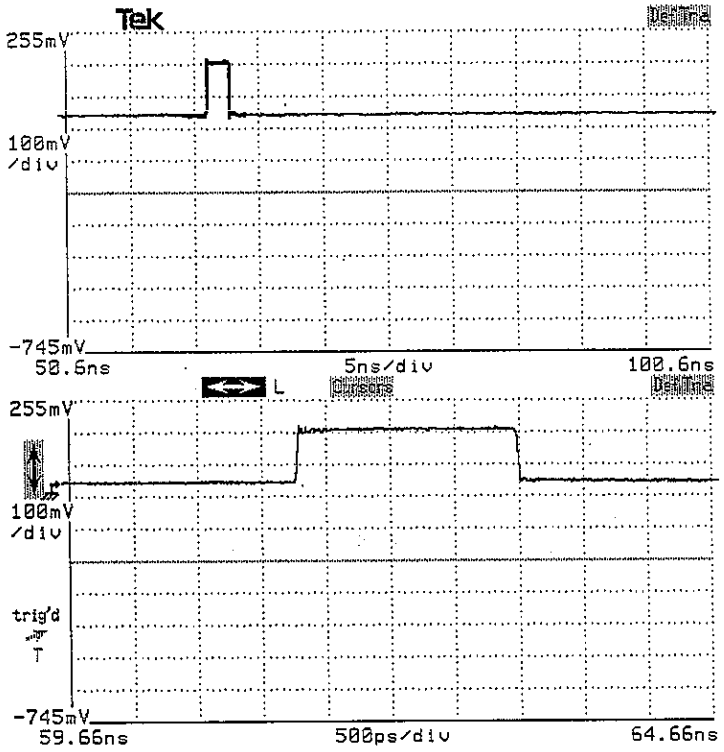
☐ Step 19: Select and remove each of the simple traces that represent a single input channel. Use the **Remove/Clr Trace n** selector of the Knob menu.

Windows

A window is a trace that represents a horizontally magnified portion of another trace. A window trace is sampled separately from the main trace it is magnifying. Windows are created by touching the **Window** icon above the graticule.

☐ Step 20: Touch the **Window** icon.





A Window Trace Display

Example 3: Defining Complex Traces

Window traces can be moved from one graticule to another, or combined into a single graticule display.

The 11801A automatically added a second graticule with the window trace. The main trace was placed on the top graticule, and its highlighted portion shows what the window trace is displaying.

In Example 2, when you created a dual-graticule display, both traces shared the same time base. Here the two traces have different horizontal measures because they represent different views of time. This can be seen in the graticule labels and the trace descriptions presented in the alternate Trace Status major menu.

☐ Step 21: Touch the **WAVEFORM** button and then touch the **More ...** selector in the major menu.

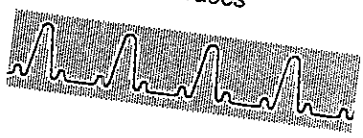
The original trace is on the Main time base, while the currently selected window trace is on a window time base.

☐ Step 22: Touch the horizontal icon (↔), and turn the bottom **Window Pos** knob left and right. The highlighted portion of the main trace moves and the window trace tracks it.

☐ Step 23: Turn the top **Window Size** knob left and right one click at a time. The size of the highlighted area changes and the window trace reflects that change.

You can add another window trace that is based on the original main trace, but you cannot take a window of a window. Since the window trace is the selected one there is no **Window** icon above the lower graticule.

☐ Step 24: Touch the main trace to select it, and then touch the **Window** icon on that graticule.

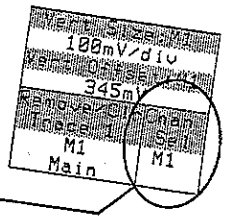


A second window trace is created, and shares the lower graticule with the original window trace. Two highlighted segments appear on the main trace. This new window is on its own window time base.

☐ Step 25: Turn the bottom **Window Pos** knob. The second window trace moves.

☐ Step 26: Turn the top **Window Size** knob. This knob changes the size of both windows.

The two window traces are placed on top of each other. You can separate them vertically. Normally, the **Chan Sel** selector of the Knob menu, on successive touching, shows all the channels that are represented in the trace. For window traces, this selector also includes a **Trace Sep** setting, which causes the knobs to move the selected window trace vertically. This moves only the selected trace.

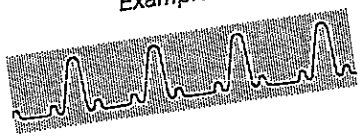


Chan Sel *Selector*

The **Chan Sel** *Selector in the Knob Menu*

☐ Step 27: Touch the vertical icon (↕), and the **Chan Sel** selector in the Knob menu until it displays **Trace Sep**.

☐ Step 28: Turn either knob and observe the selected window trace move up or down.



Horizontal Reference Point

Up to now, whenever you have changed the horizontal size of a trace, the left edge remained in place, and magnification occurred around it. You can change the anchor point of a trace to either the center or the right edge by using the **Horizontal Desc** pop-up menu.

☐ Step 29: Select the main trace (top graticule) by touching it. Touch the horizontal icon (↔), and use the bottom knob to position a critical portion of your trace at the center of the graticule. Turn the top knob left and right one click at a time, and observe that the critical part moves. End by re-establishing the original position with the critical portion of the trace centered.

☐ Step 30: Press the **WAVEFORM** button in the **MENUS** column, touch **Horizontal Desc** in the major menu and **Center** in the pop-up menu. Turn the top knob left one click at a time. Observe that the critical center part of the trace remains stationary.

Note that the **L** next to the horizontal icon changes to **C** to remind you that the reference point is the center of the screen.

Example 4: Using Signal Processing

This example shows how you can process your signals to get the most information from the available data.

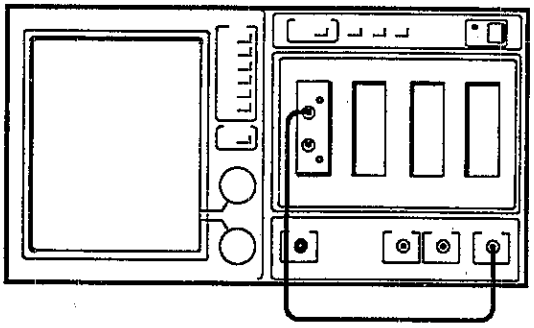
The amount of noise you see in this example will depend on the sampling head you have installed.

You will simulate a noisy signal by examining part of the calibrator signal at very fine horizontal (time per division) and vertical (volts per division) settings.

For this example you will need an 11801A with at least one dual-channel sampling head installed and one SMA cable.

☐ Step 1: Initialize the 11801A (press the **UTILITY** button in the **MENUS** column, touch **Initialize** in the major menu, and touch **Initialize** in the verification pop-up menu).

☐ Step 2: Connect the **CALIBRATOR** output to any sampling head input.



Connections for Example 4

☐ Step 3: Press the **SELECT CHANNEL** button nearest the sampling head input you have connected to the calibrator.

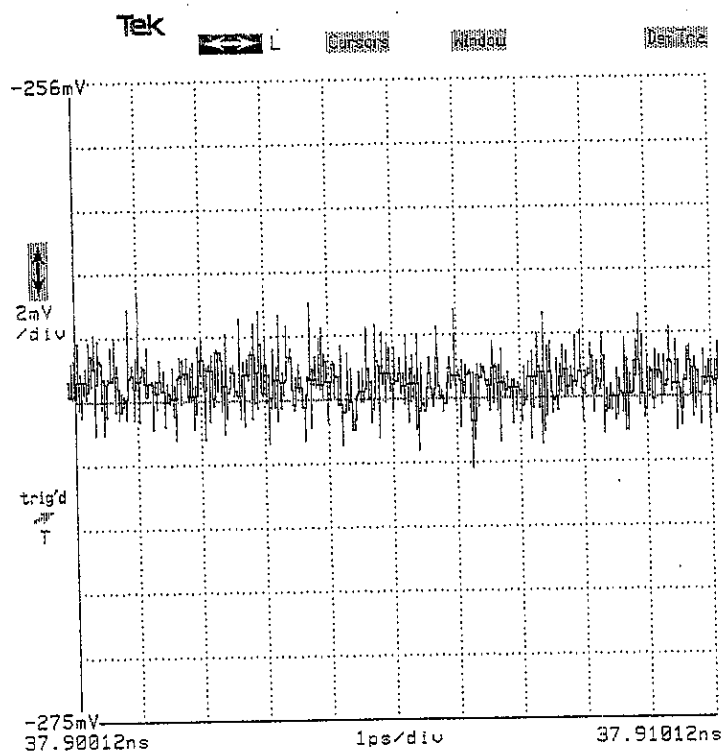
☐ Step 4: Press the **TRIGGER** button in the **MENUS** column, touch **Source** in the major menu and **Internal Clock** in the pop-up menu. Touch **Exit** to remove the pop-up menu.

☐ Step 5: Turn the top knob to the right until the horizontal scale is 1 ps/div.

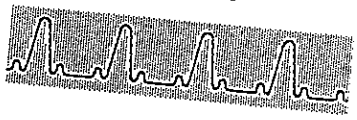
By turning off horizontal autoset, you can use the **AUTOSET** button to display a portion of the trace at this horizontal setting.

☐ Step 6: Press **UTILITY** and touch **Instrument Options**. Touch **Horizontal Autoset** until the selector shows Off and touch **Exit**.

☐ Step 7: Press the **AUTOSET** button. The display should appear as shown below.



A Horizontally and Vertically Expanded Portion of the Calibrator Signal



Averaging and Enveloping

An averaged trace is one where several trace records (successive trace acquisitions) are combined. Each displayed point of the resulting trace is an average of all the same points in the individual records. This can reduce the noise of the trace and increase vertical resolution.

Enveloping is similar in that several trace records are collected. Instead of a single-point average, the envelope displays the maximum and minimum excursion of the samples. This shows the accumulated variation of the signal.

The **DefTra** pop-up menu has **Avg(** and **Env(** selectors. Typically, an averaged trace expression:

Avg(M1)

would be entered with the selectors:

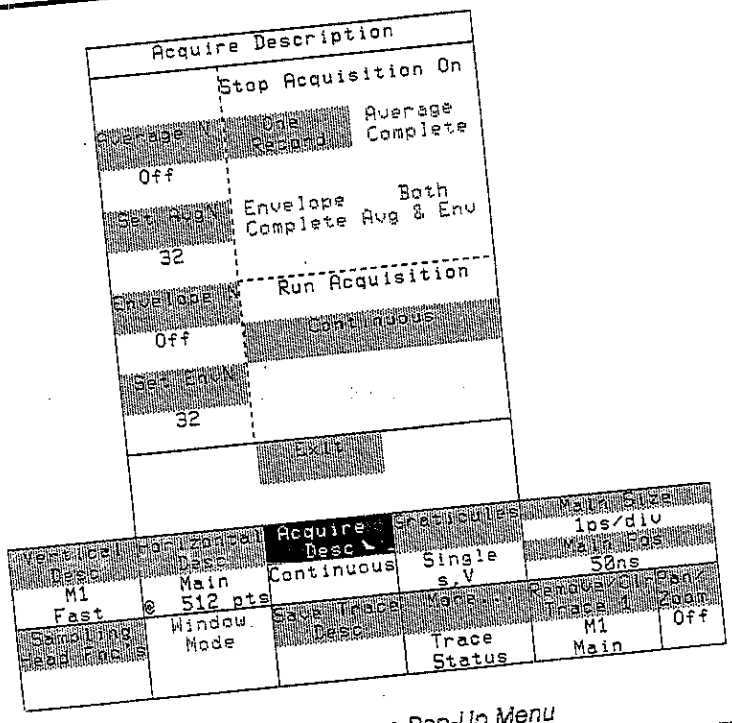
DefTra Avg(1)
Enter Desc

A short-cut is available to apply averaging or enveloping to an existing trace expression. The Waveform major menu's **Acquire Desc** pop-up menu provides **Average N** and **Envelope N** selectors to set these functions on and off.

☐ Step 8: Press the **WAVEFORM** major menu button in the **MENUS** column and touch **Acquire Desc** in the major menu.

☐ Step 9: Touch the **Average N** selector in the pop-up menu, then touch **Exit** to remove the pop-up menu.

The averaged trace appears less noisy. While the individual traces are being acquired, the current record number is displayed in the **Acquire Desc** selector. The trace expression, shown in the **Vertical Desc** selector, is **Avg(M1)**, showing that averaging has been added to your earlier expression.



The **Acquire Desc** *Pop-Up Menu*

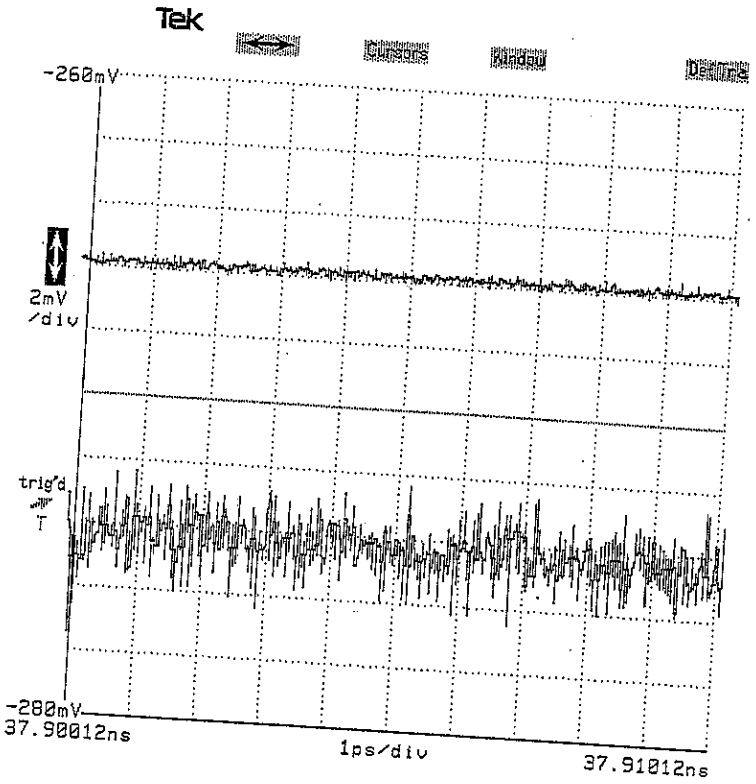
You can change the number of records in an average from the default of 32 that was set by the initialization.

☐ Step 10: Touch **Acquire Desc** in the major menu and **Set AvgN** in the pop-up menu. Adjust the top knob to change the average count.

Each time you click the knob, a new average begins. If you wish the 11801A to stop acquiring data after the required number of samples, you can use the **Average Complete** selector in the section **Stop Acquisition On**.

☐ Step 11: Touch **Acquire Desc** in the major menu and select **Average Complete** in the pop-up menu.

The 11801A stops acquiring data when the average is complete, leaving a stable display.



Averaged and Normal Traces

☐ Step 12: Touch **Acquire Desc** in the major menu and **Average N** in the pop-up menu, to turn off averaging. Notice that the trace expression in the **Vertical Desc** selector has removed the average function specification.

This is an example of averaging. Enveloping is done similarly, using **Envelope N**, **Set EnvN**, and **Envelope Complete** selectors.

Both averaging and enveloping can be done simultaneously. To do both, you must enter the trace expression from the **DefTra** or **Vertical Desc** pop-up menus. No shortcut is available from the **Acquire Desc** pop-up menu.

Variable Persistence

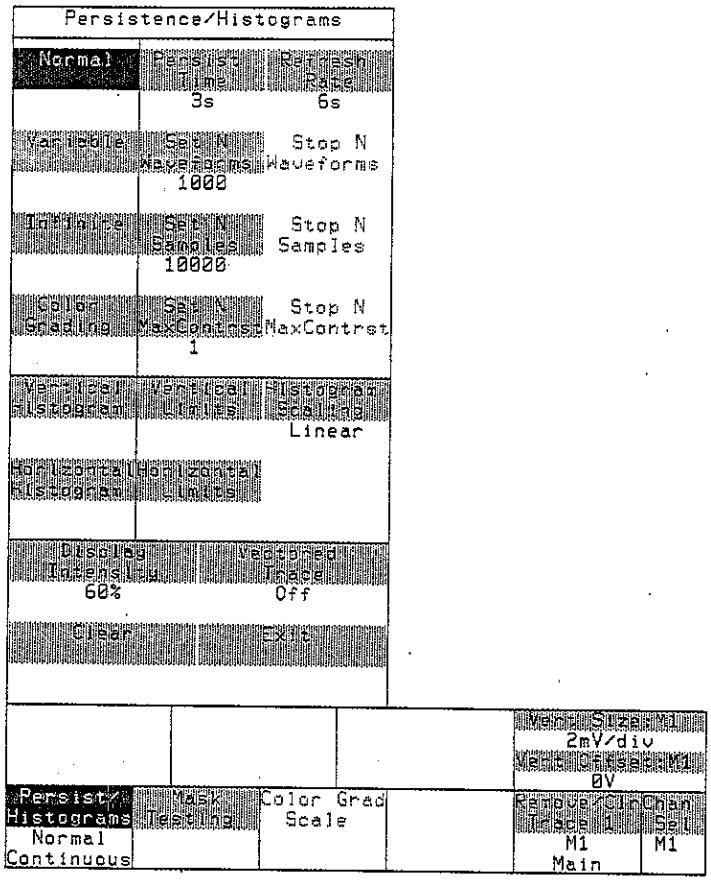
Another method of observing trace noise is using variable persistence, available through the Display Modes major menu. This leaves earlier trace data on the display for a specified period of time as new data are added, building a history of all displayed trace points.

☐ Step 13: Press the **DISPLAY MODES** button in the **MENUS** column to display the Display Modes major menu. Select **Persist/Histograms** in the major menu area.

☐ Step 14: Select **Variable** in the pop-up menu and select **Exit** to remove the pop-up menu.

The **Infinite** selector in the **Persist/Histograms** pop-up menu selects infinite persistence, a display mode in which trace data remain on the display as new values are added, building a history of all displayed trace points.

Color grading enables you to visually distinguish the relative density of trace data on the display. As trace data are accumulated, areas where more trace record points fall are displayed in a different color from areas where fewer points occur.



The **Persist/Histograms** *Pop-Up Menu*

☐ Step 15: Select **Persist/Histograms** in the major menu and select **Color Grading** in the pop-up menu. Select **Exit** to remove the pop-up menu. Observe the colored regions of the trace.

☐ Step 16: Select **Persist/Histograms** again and select **Normal** to return to the normal trace display. Select **Exit** to remove the pop-up menu.

Smoothing

Some sampling heads, including the SD-24, provide another way to reduce apparent noise. To access it, you use the **Sampling Head Fnc's** selector in the Waveform major menu.

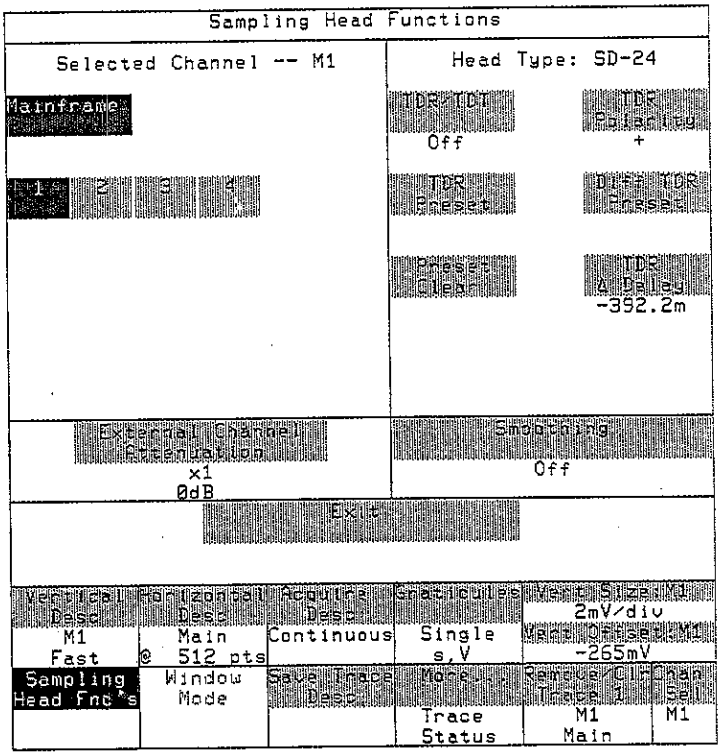
If you turn on smoothing for one sampling head channel, both channels are smoothed.

☐ Step 17: Press the **WAVEFORM** button in the **MENUS** column and touch **Sampling Head Fnc's** in the major menu. In the pop-up menu touch **1** (or whichever channel your trace is using) and **Smoothing**. Touch the **Exit** selector in the pop-up menu.

Observe the smoother trace.

☐ Step 18: Touch **Sampling Head Fnc's** in the major menu. In the pop-up menu touch **1** (or whichever channel your trace is using) and **Smoothing** to turn smoothing off. Touch the **Exit** selector in the pop-up menu.

Note that neither smoothing nor averaging can be applied to random data displays, such as eye patterns.



The **Sampling Head Fnc's** *Pop-Up Menu*

Record Length

You can specify the resolution of traces by setting the number of sample points in a trace. This is most important if you are using a remote interface to transfer trace data to a computer, but the effects are visible on the display. The **Horizontal Desc** selector always shows the point count of the selected trace.

☐ Step 19: Touch **Horizontal Desc** in the major menu. In the pop-up menu touch either **Main Record Length** or **Window Record Length** (both selectors assign the knobs identically).

If the channel loop gain is not correctly calibrated, changing record lengths can also change the trace appearance. See the 11801A User Reference on Enhanced Accuracy.

☐ Step 20: Turn the top **Main Record Len** knob one click at a time to the left and right, and observe the difference in the main trace.

The bottom knob similarly controls the window record lengths.

You should be aware of the following attributes of record lengths:

- All main time base traces share the same record length.
- All window traces share the same record length.
- Initialize sets both record lengths to 512.
- Variable persistence, infinite persistence, and color grading are available only for traces with a 512-point record length. Selecting one of these modes automatically sets the record length to 512.
- The 4096 record length has the same resolution as a 5120 record length, but appears as a shorter trace. Some FFT and other signal processing algorithms running on external computers require record lengths that are exponential multiples of 2. The 4096 record length is provided for these applications. The visual truncation is the result of a shorter record using the same resolution as the 5120 record length.

Measurements

This section presents three examples that illustrate the power and flexibility of the automated measurement capabilities of the 11801A. The previous section, Getting Started, showed how to operate the 11801A as a standard oscilloscope. This section will extend your knowledge to automated measurement features that are unique to the 11801A. The examples in this section will help you learn about:

- Taking automated measurements.
- Using and setting measurement annotations to control the measured portion of your trace.
- Setting the measurement default parameters.
- Selecting which of the three types of measurements, software, statistical, or hardware, best accomplishes your task.
- Storing a reference trace for comparison measurements.

The automated measurement system can save you time and help you use the 11801A efficiently.

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Example 5: Taking Automated Measurements

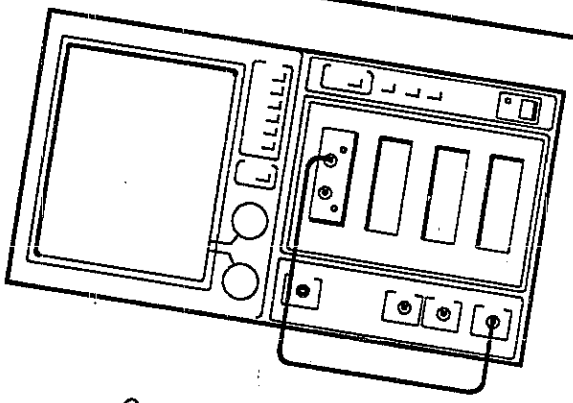
This example demonstrates how quickly you can display a dynamic measurement from a displayed trace.

For this example you will need an 11801A with at least one sampling head installed and one SMA connecting cable.

The first step in taking a trace measurement is to achieve a good display of the trace.

☐ Step 1: Initialize the 11801A (press the **UTILITY** button in the **MENUS** column, touch **Initialize** in the major menu, and touch **Initialize** in the verification pop-up menu).

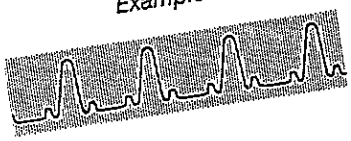
☐ Step 2: Connect the **CALIBRATOR** output to any sampling head input.



Connections for Example 5

☐ Step 3: Press the **SELECT CHANNEL** button on the sampling head channel you have connected to the calibrator signal.

☐ Step 4: Press the **TRIGGER** button and touch **Source** in the major menu. Select **Internal Clock** in the pop-up menu and touch **Exit** to remove the pop-up menu.



☐ Step 5: Press the **UTILITY** button and touch **Instrument Options** in the major menu. Select **Period Mode** in the pop-up menu and touch **Exit** to remove the pop-up menu.

☐ Step 6: Press the **AUTOSET** button.

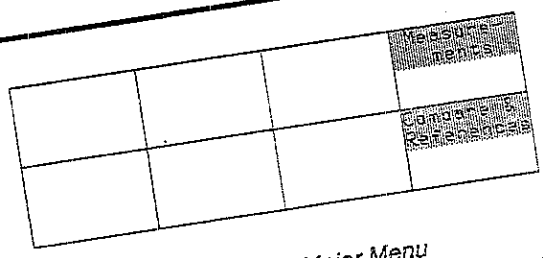
Get a stable signal display before using the automated measurement system.

You should have a stable display of the calibrator signal showing several cycles. It is important that all of the signal is on the display and that there are no places where the trace extends above or below the graticule area.

Specifying Measurements

The automated measurement system lets you specify a set of measurements for every trace on the display. The readouts of these measurements are continually updated to track changes in the signal. Up to twenty-four different measurements are available, as listed in the pop-up menu shown on the next page. You may specify up to six measurements to be taken simultaneously on the selected trace.

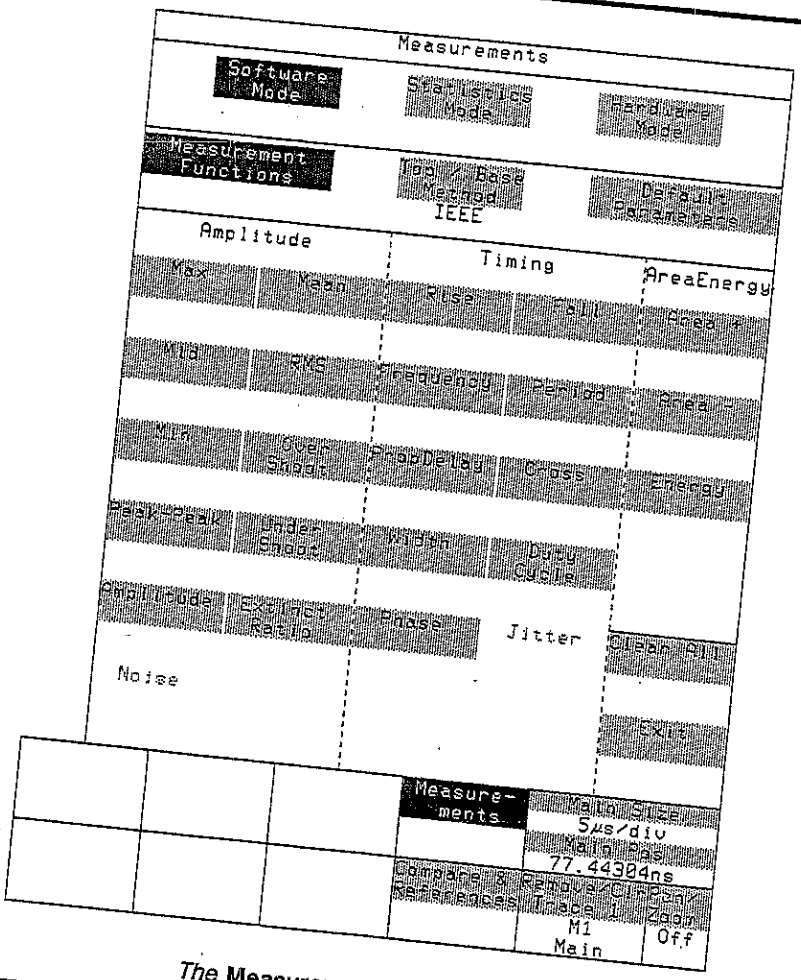
☐ Step 7: Press the **MEASURE** button.



The Measure Major Menu

The Measure major menu is displayed. Initially, this menu will appear mostly blank. Six of the selectors are reserved for your measurement readouts. The **Measurements** selector brings up a pop-up menu to let you choose which measurements you want.

☐ Step 8: Touch the **Measurements** selector.



The **Measurements** *Pop-Up Menu*

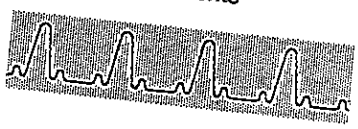
The **Amplitude**, **Timing**, and **AreaEnergy** sections of this pop-up menu show all the various measurements that you may specify. Touch the selectors in these areas to turn each measurement on and off. When a measurement is turned on, that selector is highlighted in the menu. Also, one of the selectors in the major menu area displays that measurement value.

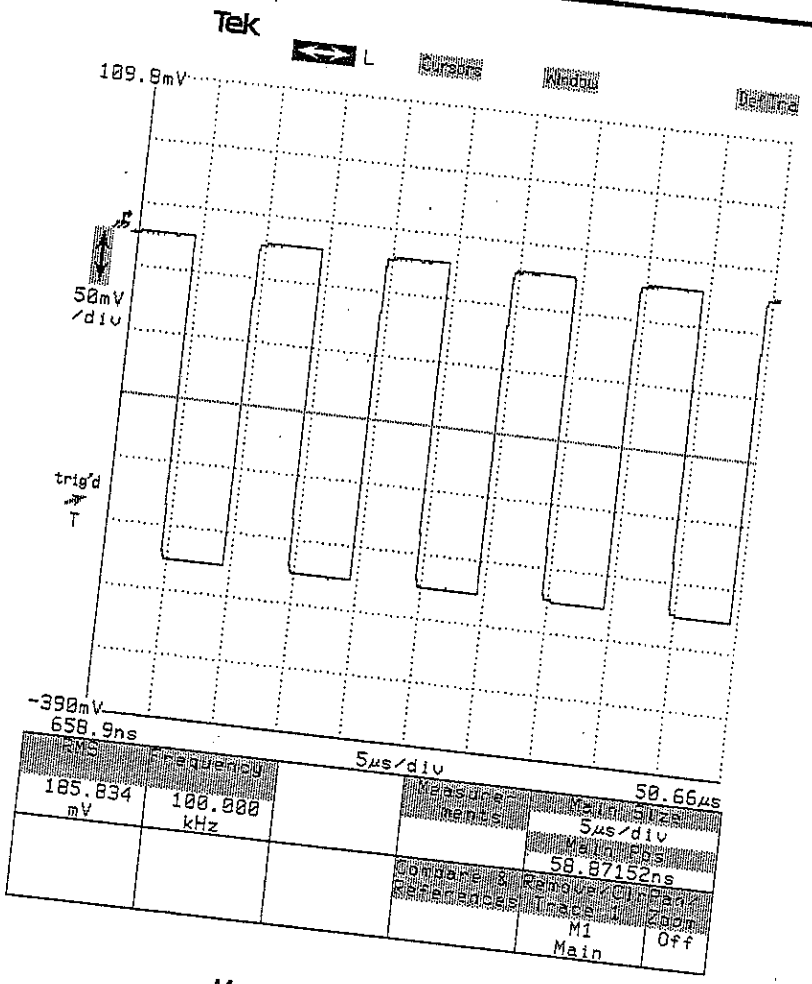
☐ Step 9: Touch the **RMS** and **Frequency** selectors.

This pop-up menu does not disappear as soon as you select a measurement, so that several measurements may be turned on at one time. The measurements are displayed, but you may want to view the trace while watching the measured values.

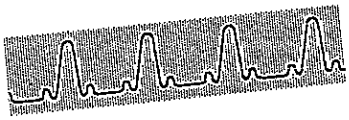
☐ Step 10: Touch the **Exit** selector at the bottom of the pop-up menu.

The readout areas of two of the selectors in the major menu area are no longer empty, but show the measured values you have specified. These values are updated continually.





Measurements of a Trace



Measurement Parameters and Annotations

For each measurement, more information is available and more control is provided. Touching the measurement selector in the major menu area does the following:

- Displays annotation lines on the graticule. These annotation lines graphically show the portions of the trace that the measurement readout value is based on.
- Highlights the portion of the trace that the measurement is based on.
- Displays a pop-up menu that documents the annotation lines, shows accumulated measurement statistics, and allows you to assign the knobs to various measurement parameters.

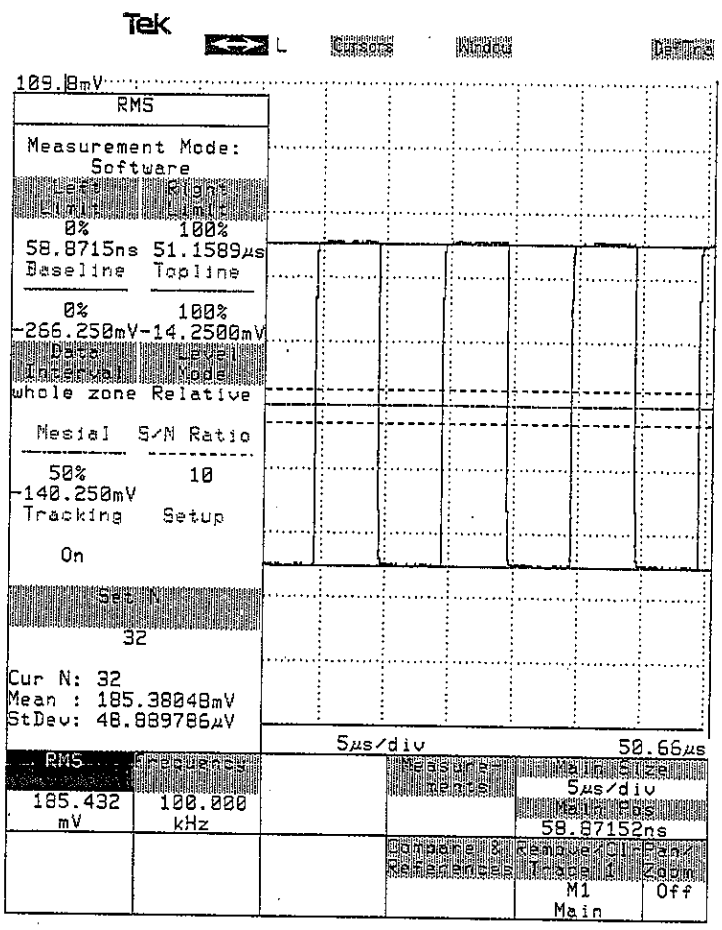
☐ Step 11: Touch the **RMS** selector in the major menu area.

Often you will want to observe the annotation lines without the pop-up menu hiding a portion of the trace. For this reason, annotation lines remain on the display even after a measurement pop-up menu has been removed.

☐ Step 12: Touch the **RMS** selector again in the major menu area.

The annotation lines remain and you can see all of the display. (If you wish to remove these annotation lines, push a different major menu button or select a different trace by touch.) For now, closely examine the **RMS** pop-up menu.

☐ Step 13: Touch the **RMS** selector a third time to redisplay the menu.



The **RMS** *Pop-Up Menu and Annotation Lines*

Changing a parameter affects *all* measurements, that use that parameter, on the selected trace.

At the bottom of the menu, non-selectable readouts show the Mean, Standard Deviation, and Current N (the number of samples the statistics are based on). A **Set N** selector lets you assign the knobs to control the N value. This N value is shared by all measurements on the selected trace, so if you change the N value of the **RMS** measurement, it will change the frequency measurement N value as well.

☐ Step 14: Touch the **Set N** selector and turn either knob, observing the change in N.

You can change measurement parameters without the pop-up menu in the way. An example is the measurement limits: when the pop-up menu is present, you can't see these vertical lines. The measurement limits define the portion of the trace that the measurement system is limited to examining.

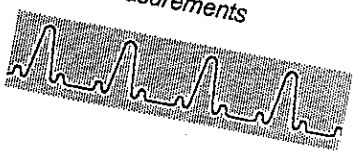
☐ Step 15: Touch either the **Left Limit** or **Right Limit** selector, to assign the two knobs to these parameters.

☐ Step 16: Touch the **RMS** selector in the major menu, to remove the pop-up menu.

The knob assignments remain after the pop-up menu is removed, so that you can set the limits without a menu covering part of the display.

☐ Step 17: Turn the top knob clockwise, so that the left limit bar moves into the area of the trace previously highlighted.

When you used the limit bar to exclude the portion of the trace where the measurement was being taken, the 11801A took the measurement at the next opportunity on the trace. This is shown by the highlighted portion of the trace moving to the right. This new left limit is effective for all measurements on this trace, including the frequency measurement.



Default Measurement Parameters

Left and right limits are examples of measurement parameters. Measurement parameters are settings that you change to control the measurement system. Most parameters are shared by all the measurements being taken on any one trace. This means that each trace has an associated set of measurement parameters.

If you are taking measurements on several traces and want them all to have the same parameters, you can set the default parameters *before* creating any of the traces. Each time a trace is created, its measurement parameters are copied from the default parameter set. In addition, you can set the parameters for any trace to the complete set of defaults at any time. You can access the default parameters through the **Measurements** pop-up menu using the **Default Parameters** selector.

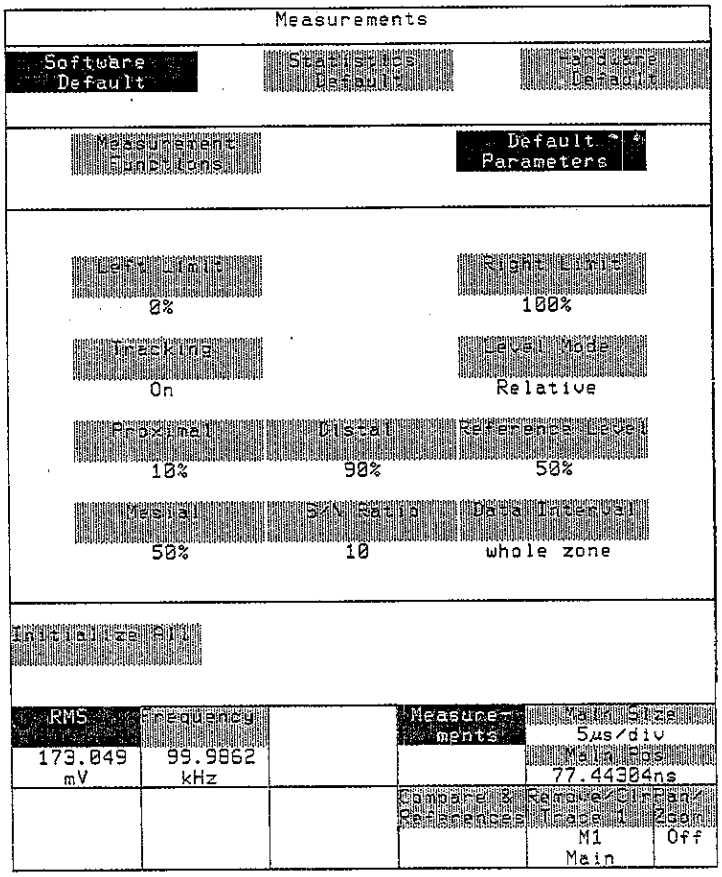
☐ Step 18: Touch the **Measurements** selector in the major menu, and then touch the **Default Parameters** selector in the pop-up menu.

The pop-up menu changes to show measurement defaults. Touching the **Measurement Functions** selector redisplays the original **Measurements** pop-up menu.

The new pop-up menu shows the various parameters that the measurements use. No one measurement uses all of these parameters, but each parameter is used for one or more measurements.

You can touch the various parameter selectors to assign the knobs to one or two of the parameters. After setting the parameters as desired, all traces created in the future will default to these measurement parameters.

Changing a default parameter does not affect any existing trace or measurement.



The **Default Parameters** *Pop-Up Menu*

☐ Step 19: Touch the **Left Limit** or **Right Limit** selector, and turn the bottom knob counter-clockwise to set the *default* right limit to 80%.

In addition, all the parameters of the selected trace can be set to default values by using the **Initialize All** selector.

Initialize All affects only the selected trace.

☐ Step 20: Touch the **Initialize All** selector, and then the **RMS** selector on the major menu.

The right limit of the measurement is now set to 80%. This change did not occur until you touched the **Initialize All** selector. Had you been displaying other traces, their parameters would have been unaffected by either the change to the defaults or by the **Initialize All**.

Measurement Modes

Up to now, the measurements you have been using have been software measurements. However, there are actually three measurement modes: software mode, hardware mode, and statistics mode. In software mode, measurements are taken from the digitized trace data record, the same data that forms the trace on the display. In hardware mode, measurements are taken from the analog signal output from the sampling head before it is digitized and assembled into a trace record. The 11801A uses special timer circuits to take hardware measurements. The advantage of hardware measurements is that they are performed faster than software measurements. In statistics mode, measurements are taken from color graded waveform data and are based on histograms computed at the crossing levels. You can use statistical measurements to measure "random" data such as eye diagrams.

You cannot take measurements in different modes on the same trace. If you create two identical traces, you can take hardware measurements on one and software measurements on the other. You can display only the measurements for the selected trace, however.

The following table compares the three types of measurements. It will help you determine the best measurement type for your application.

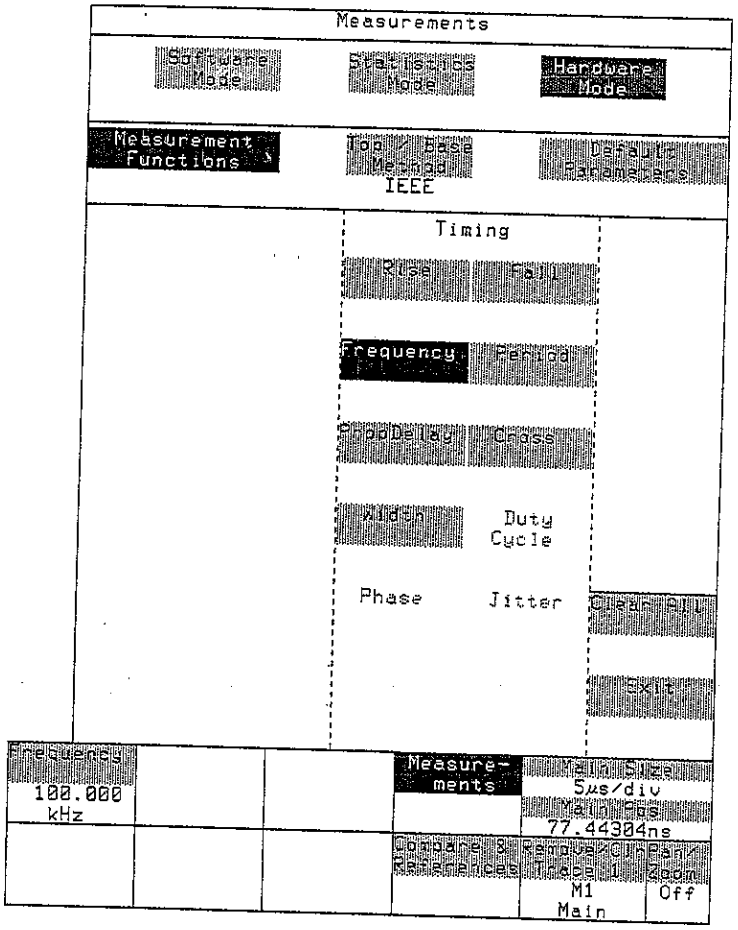
Example 5: Taking Automated Measurements

Measurement Mode Comparison

	Software	Hardware	Statistics
Functions	All measurements *except* Noise and Jitter available.	Limited to 7 timing measurements.	Full range of 24 measurements available.
Trace Complexity	All trace expressions supported	Only traces without arithmetic operators or functions are allowed. Averaging and enveloping are allowed, but the measurement is taken from unaveraged samples.	All trace expressions, that include an active trace, are supported.
Display Restrictions	Any display mode.	Any display mode.	Color graded mode only. One trace per graticule.
Resolution	Affected by displayed vertical size and trace functions (e.g., averaging) and smoothing.	Unaffected by display or functions. Sampling head smoothing will affect hardware measurements.	Affected by displayed vertical size and trace functions (e.g., averaging) and smoothing.
Speed	Slower	Faster	Updated when color graded database is updated (every 5 seconds).

Hardware measurements are specified using another alternate menu from the **Measurements** pop-up menu.

☐ Step 21: Touch the **Measurements** selector in the major menu, then touch **Hardware Mode** in the pop-up menu.



The **Hardware Measurements** *Pop-Up Menu*

You have now converted all your measurements on this trace to hardware measurements. Since hardware measurements cannot support amplitude or area energy measurements, these do not appear in the pop-up menu, and the **RMS** measurement has been removed from the major menu area.

The third measurement mode is Statistics Mode. Statistics measurements can be selected only when the color grading display mode is enabled. All measurements are selectable in Statistics Mode, including Noise and Jitter, which cannot be selected in software or hardware measurement mode.

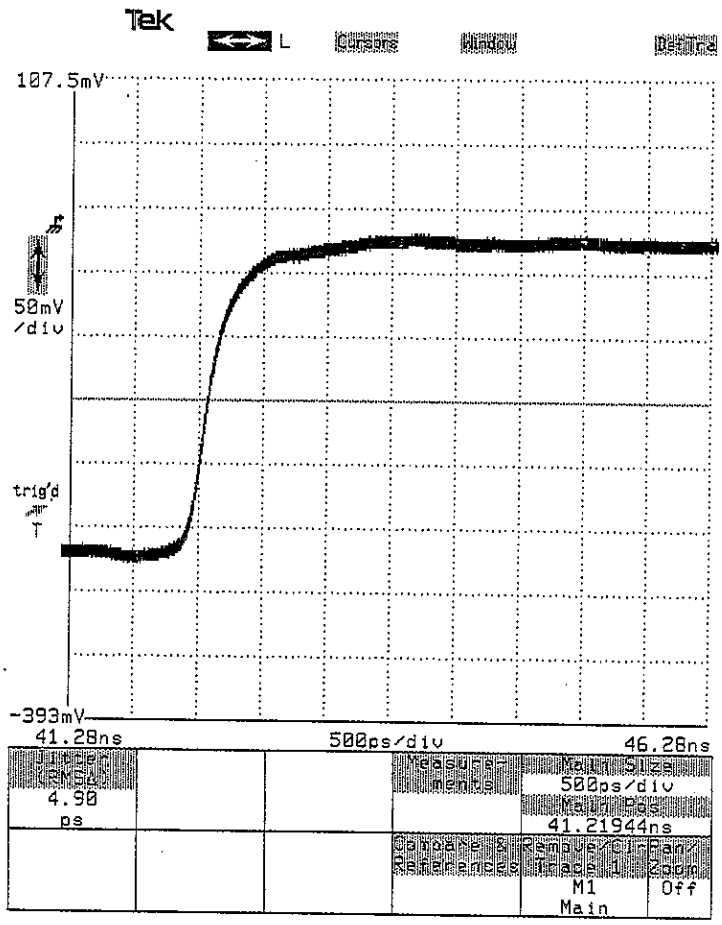
☐ Step 22: Press the **UTILITY** button to display the Utility1 major menu. Touch the **Instruments Options** selector in the major menu, then touch the **Edge Mode** selector in the pop-up menu, if it is not already selected. Touch **Exit** to remove the pop-up menu.

☐ Step 23: Press **AUTOSET**. You should now see the rising edge of the calibrator signal.

☐ Step 24: Press the **DISPLAY MODES** button. Touch the **Persist/Histograms** selector in the major menu, then touch the **Color Grading** selector in the pop-up menu. Touch **Exit** to remove the menu.

☐ Step 25: Press the **MEASURE** button. Touch the **Measurements** selector. To enable statistics mode measurements, touch **Statistics Mode** at the top of the pop-up menu. Touch **Jitter** and then touch **Exit** to remove the menu.

The data used for the statistics mode measurements are taken from the statistical database created when Color Grading is enabled. This capability enables you to make automatic pulse parametric measurements directly on random data such as eye diagrams.



A Jitter Measurement on the Calibrator Signal

Example 5: Taking Automated Measurements

Example 6: Taking Delay Measurements Using Cursors

This example shows another way to measure trace parameters, using cursors. When the measurement you want to make is not included in the list of automated measurements, you can use cursors.

You will use the cursors to take two common measurements, trace amplitude and delay between traces. The 11801A can do both of these as automated measurements, so you can compare the method of using automated measurements to using cursors.

For this example you will need an 11801A with at least one dual-channel sampling head installed and two SMA connecting cables of equal length.

☐ Step 1: Initialize the 11801A (press the **UTILITY** button in the **MENUS** column, touch **Initialize** in the major menu, and touch **Initialize** in the verification pop-up menu).

☐ Step 2: Connect the **CALIBRATOR** output to a sampling head input.

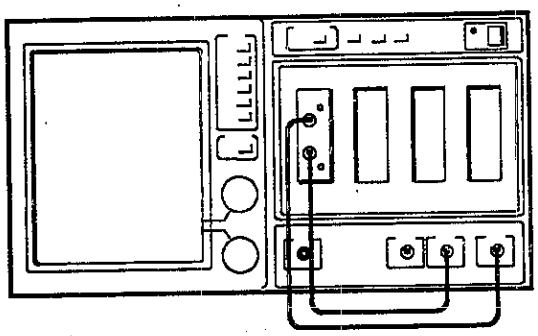
☐ Step 3: Connect the **INTERNAL CLOCK** output to any available sampling head input.

☐ Step 4: Press the **TRIGGER** button. Touch **Source** in the major menu area and select **Internal Clock**, then touch **Exit**.

☐ Step 5: Press the **SELECT CHANNEL** button on the sampling head input channel you have connected to the calibrator signal.

☐ Step 6: Turn the top knob to the left to set the horizontal scale to 10 ns/div.

You should see the calibrator signal on the display.



Connections for Example 6

The Cursors Major Menu

First you will use the cursors to determine the amplitude of the calibrator signal. This introduces the use of cursors on a single trace. You will then use cursors to measure the delay between two different traces.

Always display the traces *before* invoking the cursors.

The recommended way of using cursors is to display the trace(s) first, then invoke the cursors to take the measurement.

You invoke the cursors by touching the **Cursors** icon, located above the graticule.

This icon acts like most icons in that it assigns the knobs, in this case to control the cursor positions. However, the **Cursors** icon is unique in that it behaves much like a major menu button. It replaces the major menu with the special Cursors major menu, and highlights the Cursors icon instead of lighting any major menu button.

The Cursors major menu has selectors for **Cursor Type**, **Set Zero**, and **Exit**. The remainder of the major menu area displays the cursor positions and distance between cursors. You can select four types of cursors:

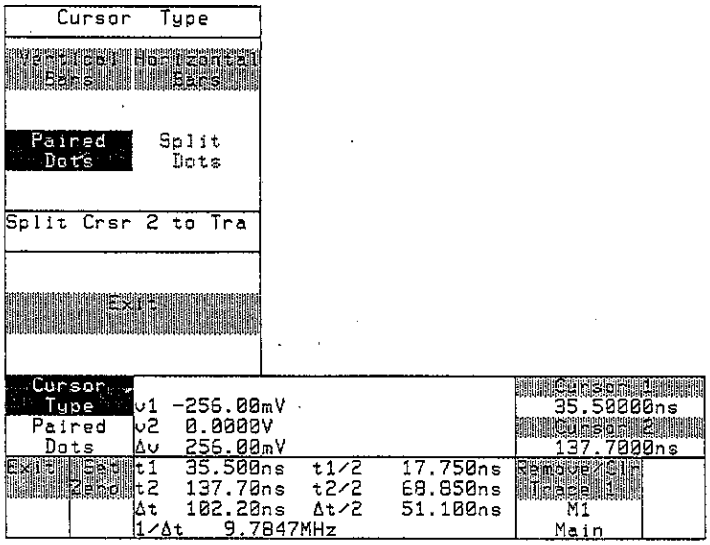
- **Vertical Bars**, which you move with the knobs to the desired horizontal position. The major menu shows the positions of the cursors and the distance between them in X units. Also, if the X units are seconds, the inverse of the distance between the cursors is shown. When the cursors are positioned at the beginning and end of a period, this represents frequency.

- **Horizontal Bars**, which you move with the knobs to the desired vertical position. The major menu shows the positions of the cursors and the distance between them in Y units.

- **Paired Dots**, which you move with the knobs to the desired horizontal position. The dots "float" vertically on the trace; you cannot control the vertical position. The major menu shows both vertical and horizontal positions of the cursors, in graticule units. Also, if the X units are seconds, the inverse of the distance between the cursors is shown.

- **Split Dots**, which operate like paired dots, but on two different traces of your choice. The same information is shown as for paired dots.

Example 6: Taking Delay Measurements Using Cursors



The **Cursors** *Major Menu and* **Cursor Type** *Pop-Up Menu*

The horizontal bar cursors are used to take amplitude measurements. You move them up and down with the knobs to the position you desire.

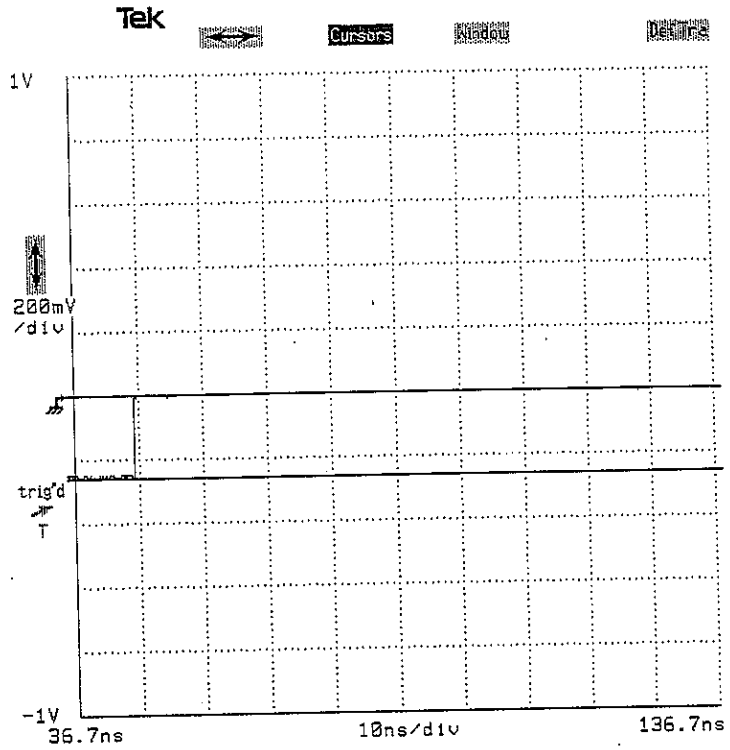
☐ Step 7: Touch the **Cursors** icon, and then the **Cursor Type** selector.

☐ Step 8: Touch the **Horizontal Bars** selector. Select **Exit** to remove the pop-up menu.

To precisely position the cursors, set the knobs to fine resolution by using the Keypad pop-up menu. Setting the resolution of one knob changes the resolution of both.

☐ Step 9: Use the upper and lower knobs to move the bars over the upper and lower levels of the trace.

The major menu area shows the voltage values of each cursor, and **ΔV** shows the distance between the cursors in volts. This is the amplitude of the calibrator signal.



Horizontal Bar Cursors Placed Over a Trace

The **Peak-Peak** automated measurement value will include any signal noise.

The same value can be determined using the automated measurement system. The sequence to do this is: press the **MEASURE** button, touch **Measurements** in the major menu area and then the **Peak-Peak** selector in the pop-up menu. The measurement value is visible in the **Peak-Peak** selector in the major menu area. **Exit** will allow you to observe the trace as the measurement readout is updated.

Using Split Dot Cursors

Dot cursors are small dots that "float" on the trace. You position them horizontally using the knobs, but their vertical height is determined by the trace on which they are are placed.

Split dot cursors operate the same way, but they are placed on two different traces of your choice. In this example, you will have one trace on each of two graticules, but this is not required to use split dot cursors. You will follow the convention of displaying the traces before invoking the cursors.

☐ Step 10: Establish a dual graticule display (press the **WAVEFORM** button, and touch the **Graticules** and **Create Second Graticule** selectors).

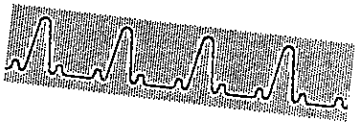
☐ Step 11: Press the **SELECT CHANNEL** button of the sampling head channel to which you have connected the **INTERNAL CLOCK** output.

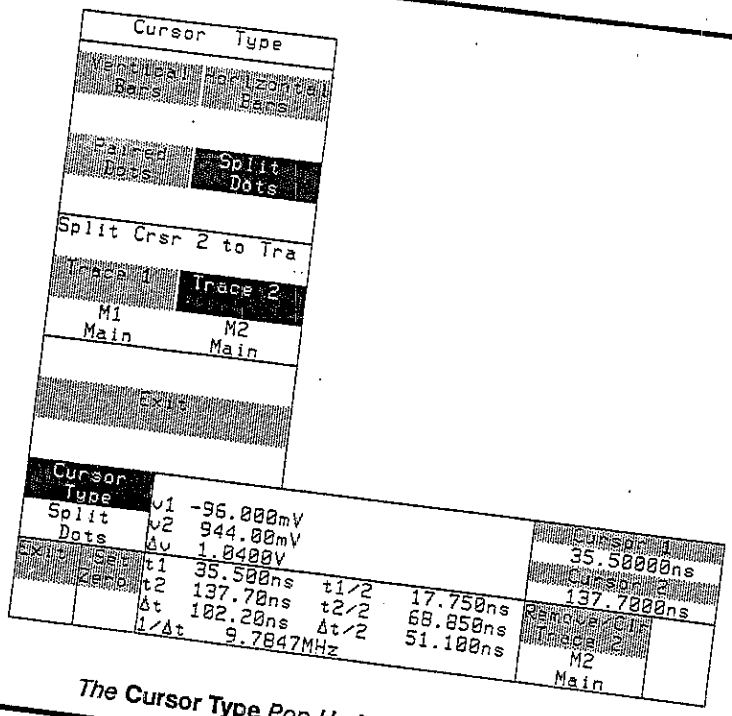
☐ Step 12: If both traces are on a single graticule, move one to the other graticule by touching either **Lower Graticule** or **Upper Graticule** and **Move Trace to Other Graticule.**

You should now see a trace on each graticule. You will use split dot cursors to measure the delay time between these traces.

☐ Step 13: Touch either trace on which you want to place a cursor. (In this case, since there are only two traces on the display, this step is already done.)

☐ Step 14: Touch the **Cursors** icon and the **Cursor Type** selector. Touch the **Split Dots** selector.





The **Cursor Type** *Pop-Up Menu in Split Dots Mode*

When you first select split dots cursors, both dots are on the selected trace. The **Cursor Type** pop-up menu remains on the display until you select the trace you want to move the other cursor to.

Each trace selector for the second cursor shows the trace description.

Beneath the selectors that allow cursor choice, a second set of selectors lists all of the traces currently on the display. The highlighted selector always shows which trace the second cursor is assigned to.

Initially, both dots are placed on the selected trace, so the highlighted selector shows the selected trace. Touching the only other trace selector in this case will assign the second cursor to that trace and remove the menu.

☐ Step 15: Touch the selector in the pop-up menu for the other trace on the display.

☐ Step 16: Move each cursor on its respective trace to a point halfway up the rising edge. Use the fine knob control for precise positioning. Some vertical noise is to be expected.

The major menu area shows the vertical and horizontal positions of both cursors. It also shows the distance between the cursors along both axes. The Δt readout shows the time between the leading edges, which is the delay time you want to measure.

The automated measurement system can take the same delay measurement. If you want to see how this is done, select the trace with the earliest transition, and then press the **MEASURE** button. Touch **Measurements**, **Hardware Mode**, **PropDelay**, and **Exit**.

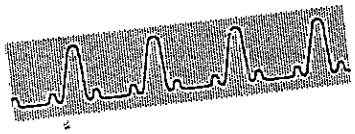
The measurement value will be displayed in the **PropDelay** selector in the major menu area, but will show zero because only one trace is being examined. To assign the second trace, touch **PropDelay** and, under the heading **Second Trace** (at the bottom of the pop-up menu), touch the **Trace n** selector of the other trace. Touch **Prop Delay** again to remove the pop-up menu.

Cursor Accuracy Considerations

Cursor measurements are limited to the resolution of the display. Tips to help you get the most accuracy from measurements are:

- Use the automated measurement system whenever you can, both for convenience and for accuracy.
- Use dot cursors to take a more precise measurement (when record length is greater than 512 points). Bar cursors are best for visual comparison and are positioned with display resolution (when record length is 512 points). Dot cursors follow the trace vertically as you position them horizontally, and provide readouts of actual trace data values.
- Always use the fine knob resolution to perform the final cursor positioning. Setting one cursor knob to fine will also set the other.
- When using cursors or software measurements, always make the area to be measured as large as possible, and cover as much of the graticule area as you can. This will give the finest resolution.

Example 6: Taking Delay Measurements Using Cursors



Example 7: Taking Comparison Measurements Using a Reference Trace

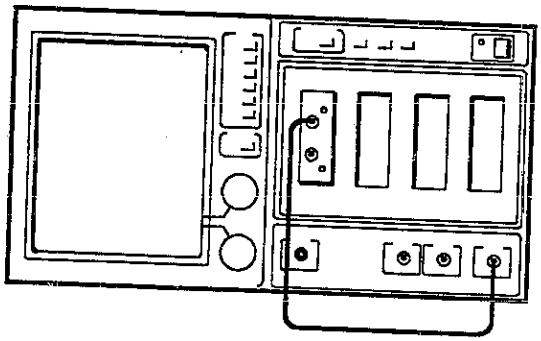
This example demonstrates the compare and reference features of the automated measurement system. This is particularly useful when you need to check a series of components or circuits to see if a particular measurement falls within an acceptable range.

For this example you will need an 11801A with at least one sampling head installed. Also, two SMA cables of different length will be used (2 ns and 5 ns cables are recommended).

☐ Step 1: Initialize the 11801A (press the **UTILITY** button in the **MENUS** column, touch **Initialize** in the major menu, and touch **Initialize** in the verification pop-up menu).

☐ Step 2: Connect the short cable from the **CALIBRATOR** output of the 11801A to a sampling head input.

☐ Step 3: Press the **TRIGGER** button, and touch **Source** and **Internal Clock**. Touch **Exit** to remove the pop-up menu.



Connections for Example 7

Example 7: Taking Comparison Measurements Using a Reference Trace

☐ Step 4: Press the **SELECT CHANNEL** button on the sampling head input that the calibrator signal is connected to.

☐ Step 5: Turn the top knob to the left to set the horizontal scale to 10 ns/div.

You will see the calibrator signal on the display.

You will measure the difference in propagation time down the two cables which are different lengths. The cross measurement, which shows the time delay from the trigger to the rising edge of a signal, will be the basis of your comparison.

☐ Step 6: Press the **MEASURE** button.

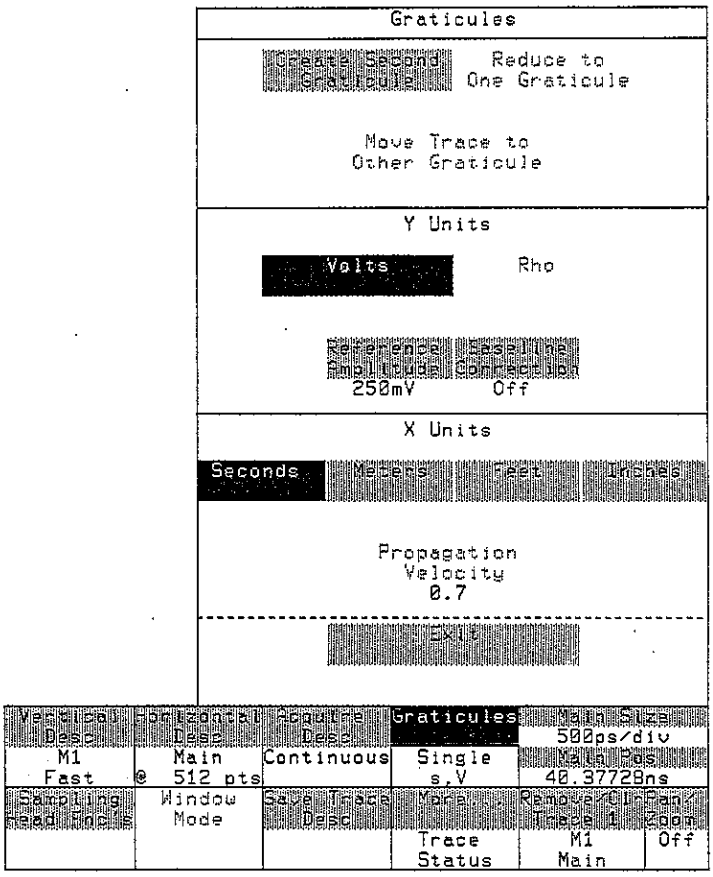
☐ Step 7: Touch **Measurements** and **Hardware Mode**.

☐ Step 8: Touch **Cross**, and touch **Exit** if you want to observe the trace.

Setting X Axis Units to Meters, Feet, or Inches

The measurement will be more useful to you if it is expressed in distance rather than time: how much longer is the second cable? The **Graticules** selector on the Waveform major menu lets you choose feet meters, or inches for the horizontal axis.

☐ Step 9: Press the **WAVEFORM** button and touch the **Graticules** selector.



The **Graticules** *Pop-Up Menu*

The pop-up menu shows an **X Units** section near the bottom. You can select seconds, meters, feet, or inches. In addition, the **Propagation Velocity** selector, can be used to assign the knobs to let you indicate the signal speed of your cable. The default **0.7** indicates that the horizontal axis labels, if feet or meters, will be based on a cable that passes signals at 0.7 times the speed of a cable having free air insulation.

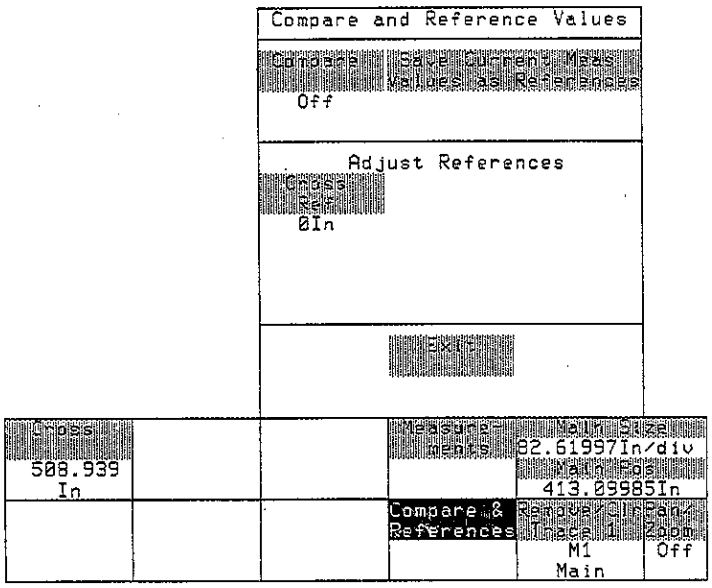
☐ Step 10: Touch **Inches, Feet,** or **Meters** in the pop-up menu. If you know that the propagation velocity of your cable differs from the default, touch the **Propagation Velocity** selector and adjust this parameter. If you don't know the velocity or are using Tektronix polyethylene dielectric SMA cables, accept the 0.7 default.

☐ Step 11: Press the **MEASURE** button to redisplay the Cross measurement.

The measurement readout is in the units of distance that you selected. Also, the horizontal axis is labeled in the units chosen.

Using the Reference Value

You will use this measurement value as a reference value. The **Compare & References** pop-up menu allows you to save this value, and cause all measurements to be displayed as a difference from this value.



The **Compare & References** *Pop-Up Menu*

☐ Step 12: Touch **Compare & References**, and then touch **Save Current Meas Values as References.**

You will see that the this reference value for the cross measurement is now very close to the cross measurement value in the major menu area (they may not match exactly because of noise or horizontal jitter).

The **Cross** selector in the major menu area displays the measurement parameters pop-up menu. The **Cross Ref** selector in the **Compare & References** pop-up menu assigns the knobs to adjust the reference value; this is useful when you want to establish your own standard reference value.

The **Compare** selector in the **Compare & References** pop-up menu changes the entire measurement system. This makes the measurement system display the measured deviation from the references, rather than the direct measurement.

☐ Step 13: Touch the **Compare** selector to set compare on, and touch the **Exit** selector to remove the pop-up menu.

The **Cross** measurement selector in the major menu area has changed to **ΔCross**, and the value being displayed is at or near zero. The zero value shows that this cable deviates very little from its own signal propagation characteristics.

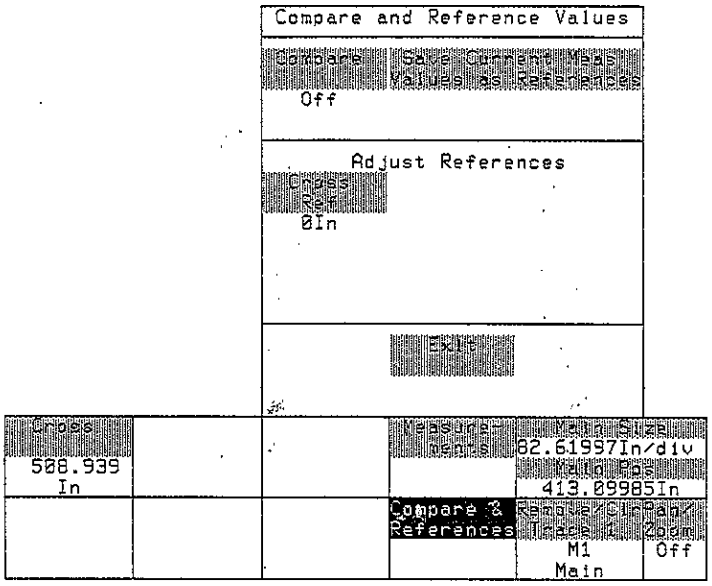
Once the 11801A has been set up with a comparison measurement, no further adjustment is necessary to make a series of deviation measurements. To compare the longer cable to the reference you have established:

☐ Step 14: Remove the short cable from the calibrator and sampling head, and replace it with the longer cable connected in the same way.

The **ΔCross** measurement readout shows the difference in length of the cables by showing how much longer it takes a signal to travel through the second cable. In a testing environment, this method of measuring can be used to test a collection of cables to a specific tolerance, without altering the setup on the 11801A.

Using the Reference Value

You will use this measurement value as a reference value. The **Compare & References** pop-up menu allows you to save this value, and cause all measurements to be displayed as a difference from this value.



The **Compare & References** *Pop-Up Menu*

☐ Step 12: Touch **Compare & References**, and then touch **Save Current Meas Values as References**.

You will see that the this reference value for the cross measurement is now very close to the cross measurement value in the major menu area (they may not match exactly because of noise or horizontal jitter).

Example 7: Taking Comparison Measurements Using a Reference Trace

The **Cross** selector in the major menu area displays the measurement parameters pop-up menu. The **Cross Ref** selector in the **Compare & References** pop-up menu assigns the knobs to adjust the reference value; this is useful when you want to establish your own standard reference value.

The **Compare** selector in the **Compare & References** pop-up menu changes the entire measurement system. This makes the measurement system display the measured deviation from the references, rather than the direct measurement.

☐ Step 13: Touch the **Compare** selector to set compare on, and touch the **Exit** selector to remove the pop-up menu.

The **Cross** measurement selector in the major menu area has changed to **ΔCross**, and the value being displayed is at or near zero. The zero value shows that this cable deviates very little from its own signal propagation characteristics.

Once the 11801A has been set up with a comparison measurement, no further adjustment is necessary to make a series of deviation measurements. To compare the longer cable to the reference you have established:

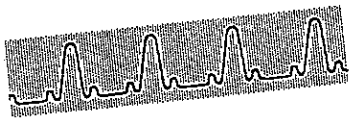
☐ Step 14: Remove the short cable from the calibrator and sampling head, and replace it with the longer cable connected in the same way.

The **ΔCross** measurement readout shows the difference in length of the cables by showing how much longer it takes a signal to travel through the second cable. In a testing environment, this method of measuring can be used to test a collection of cables to a specific tolerance, without altering the setup on the 11801A.

Advanced Topics

This section shows you how to get the most performance from your 11801A. It discuses techniques and features that are beyond the standard set of oscilloscope features. The examples in this section will help you learn about:

- Saving Trace Descriptions.
- Storing a reference trace for comparison measurements.
- Taking a histogram of the displayed trace data.
- Taking Time Domain Reflectometry (TDR) measurements.



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Example 8: Using Saved Trace Descriptions

This example demonstrates how saved trace descriptions can extend the capabilities of the 11801A. When you save a trace description, you save the parameters that control acquisition for a trace, but you do not save any data points. With saved trace descriptions, you can effectively control up to 40 traces at a time (450 traces with four SM-11 Multi-Channel Units attached). Saved trace descriptions can be used while they are not being displayed.

In Example 7 you compared a trace to a stored reference measurement value, and in Example 9 you compared a trace to a stored static trace. In this example, you will compare a trace on the display to a trace being acquired in the background. You could do this using two traces on the display, but in this example you will use a saved trace description and display only the trace that is to be measured.

For this example you will need an 11801A with at least one dual-channel sampling head installed. Also, a power divider and two SMA cables of different length will be used (2 ns and 5 ns cables are recommended). A signal splitting T adapter may be substituted for the power divider.

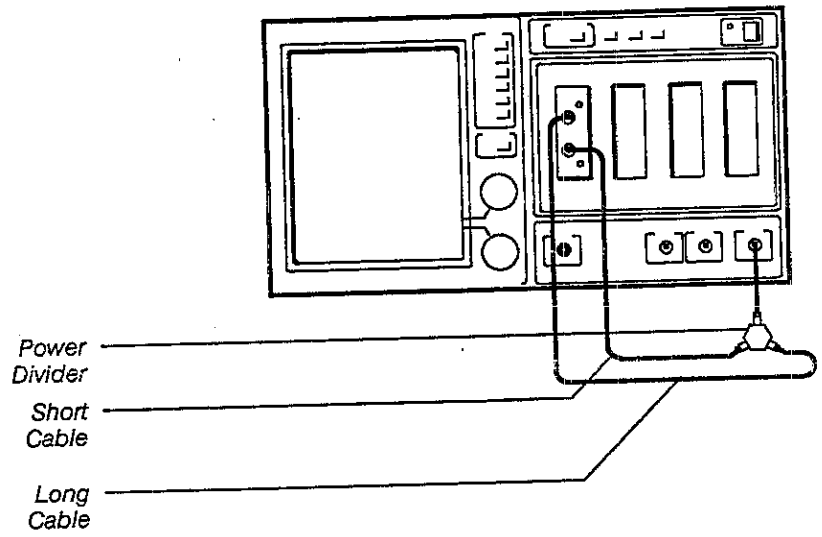
☐ Step 1: Initialize the 11801A (press the **UTILITY** button in the **MENUS** column, touch **Initialize** in the major menu, and touch **Initialize** in the verification pop-up menu).

☐ Step 2: Attach the power divider to the **CALIBRATOR** output of the 11801A.

☐ Step 3: Connect each cable from the power divider to a sampling head input connector.

The illustration on the next page shows these connections.

Example 8: Using Saved Trace Descriptions



Connections for Example 8

☐ Step 4: Press the **TRIGGER** button, touch **Source** and **Internal Clock**.

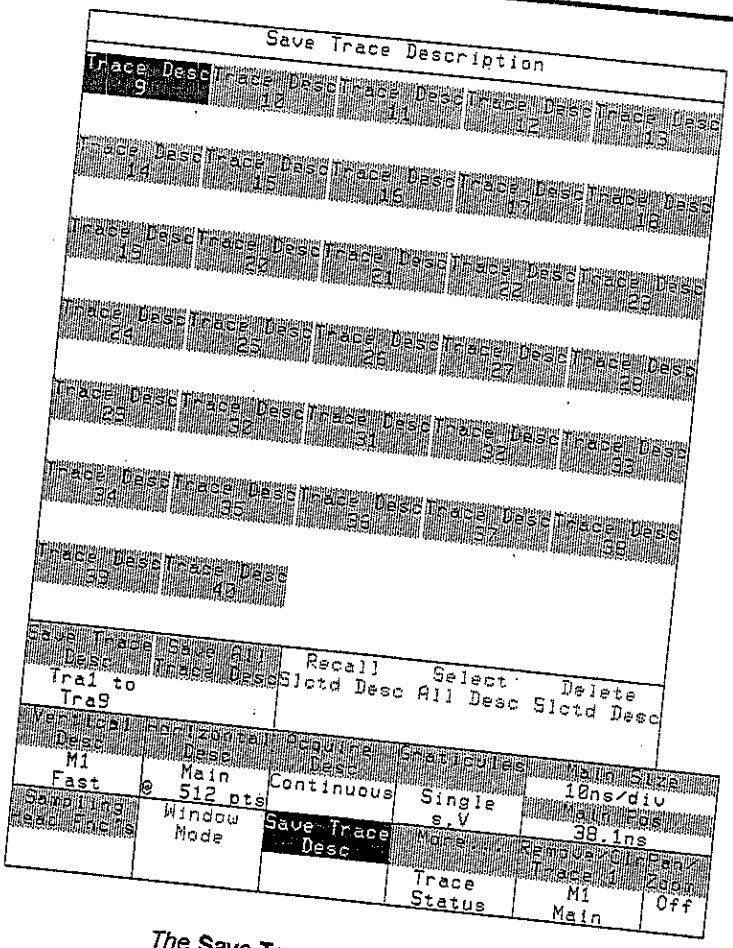
☐ Step 5: Press the **SELECT CHANNEL** button on the sampling head input channel to which you have connected the long cable.

☐ Step 6: Turn the top knob to set Main Size to 10 ns/div.

You should see the calibrator signal displayed.

You will now save this trace description using the Waveform major menu's **Save Trace Desc** selector.

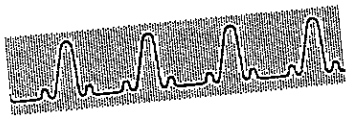
☐ Step 7: Press the **WAVEFORM** button, and touch the **Save Trace Desc** selector.



The **Save Trace Desc** *Pop-Up Menu*

Selectors **Trace Desc 9** through **Trace Desc 40** (or higher) are locations for saved trace descriptions. They start with 9 because the active visible traces are numbered 1 through 8. If a trace description is already saved in a location, the selector will indicate its channel and time base.

Example 8: Using Saved Trace Descriptions



The selectors at the bottom of the pop-up menu allow you to copy the description of the selected trace into a storage location, recall a saved trace description into the next available visible trace, or to delete a trace description. Touching the **Select All Desc** selector will highlight all the locations that are not empty.

☐ Step 8: If it is not already highlighted, touch **Trace Desc 9** (or any other number of your choice) to highlight it. Then touch **Save Trace Desc** *in the pop-up menu*. This selector will show **Tra1 to Tra9** (or whichever location you used).

Unlike stored traces, saved trace descriptions are not cleared by initializing the 11801A.

When you save the trace description, you are not saving data points as when you store a trace. Instead the 11801A saves all the parameters to create that trace when needed. Just as with a visible trace on the display, the data of a saved trace description will change with the input signal. The parameters saved are:

- Trace definition, including the input channel used and averaging.
- The window information, if it is a window trace.
- The measurements associated with the trace.

Saved trace descriptions do not save the size and position of traces on the main time base, or window size of traces on a window time base. When the saved trace description is recalled, these parameters are set to match the current time bases.

The limitations on saved trace description complexity are identical to hardware measurements.

Saved trace descriptions must be of simple one-channel traces, and cannot be of traces that use any arithmetic operator such as subtraction or multiplication. Averaging is the only trace function that can be applied to a saved trace description.

☐ Step 9: Delete the visible trace by touching **Remove/Clr Trace 1** and verifying that you want it removed in the query pop-up menu.

☐ Step 10: Press the **SELECT CHANNEL** button of the sampling head input channel to which you have connected the short cable.

The propagation delay measurement allows you to make a measurement to a second trace. *In hardware mode only*, that second trace may be a saved trace description.

☐ Step 11: Press the **MEASURE** button and touch **Measurements, Hardware Mode, Prop Delay,** and **Exit Menu.**

☐ Step 12: Touch **Prop Delay**, and at the bottom of the pop-up touch **Trace 9** (or whichever location you used).

You can read the propagation delay from **Prop Delay** selector in the major menu area. If you touch this selector to remove the pop-up menu, you will see that only one trace is on the display, and seven more can still be displayed.

Example 8: Using Saved Trace Descriptions

Example 9: Comparing Traces to Stored Traces

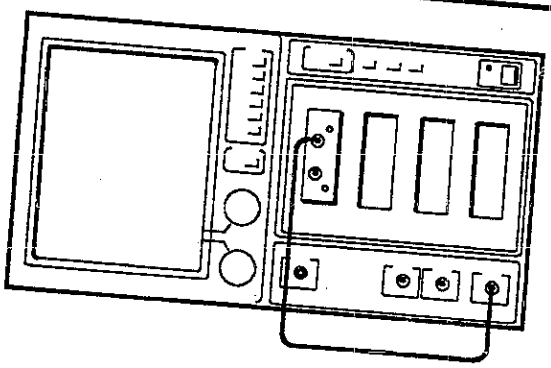
This example demonstrates how to store a trace that is a "snapshot" of a particular moment, and how to use the stored trace as a basis for comparing other traces. This is similar to Example 7, where you used a reference measurement as a basis of comparison. This time, the entire trace will be saved as a reference.

For this example you will need an 11801A with at least one sampling head installed and one SMA connecting cable.

☐ Step 1: Initialize the 11801A (press the **UTILITY** button in the **MENUS** column, touch **Initialize** in the major menu, and touch **Initialize** in the verification pop-up menu).

☐ Step 2: Connect the **CALIBRATOR** output to any sampling head input.

☐ Step 3: Press the **TRIGGER** button and select **Source** in the Trigger major menu. Select **Internal Clock** and touch **Exit** to remove the pop-up menu.



Connections for Example 9

☐ Step 4: Press the **SELECT CHANNEL** button on the sampling head input you have connected to the **CALIBRATOR** signal.

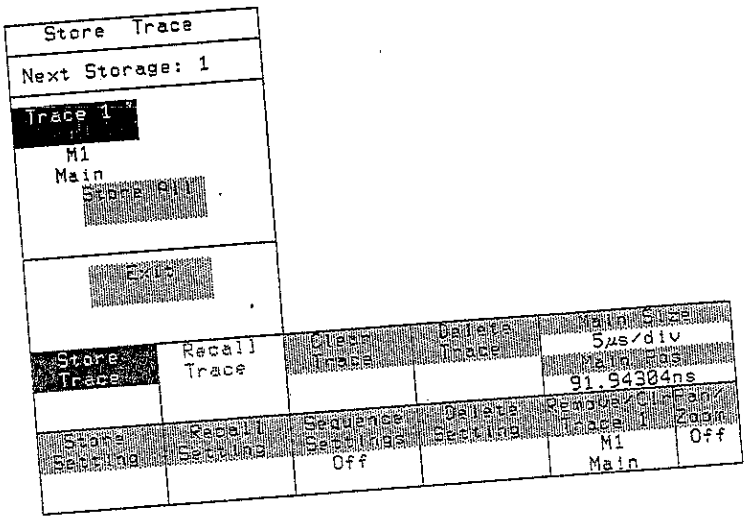
☐ Step 5: Press **UTILITY**, **Instrument Options**, and **Period Mode**.

☐ Step 6: Press the **AUTOSET** button.

You should have a stable display of the calibrator signal showing several cycles. Make sure that all of the signal is on the display, and that there are no places where the trace extends above or below the graticule area.

You will store this trace and then define a new trace that shows the difference between a signal and the stored trace.

Storing a trace means storing a copy of each data point that forms the trace on the display.



The Store/Recall Major Menu and **Store Trace** *Pop-Up Menu*

The **STORE/RECALL** button lets you store and recall traces and front-panel settings. In addition, you can clear traces (discard accumulated data and force re-acquisition) and delete traces.

☐ Step 7: Press the **STORE/RECALL** button, then touch **Store Trace** and select **Trace 1** in the **Store Trace** pop-up menu.

The 11801A has stored a trace in memory, named "STO 1". Once the trace is stored, there is no reason to leave its source on the display.

☐ Step 8: Touch **Remove/Clr Trace 1** and then touch **Remove Trace 1** in the pop-up menu.

☐ Step 9: This step is optional. If you wish to see the stored trace with which the comparison will be made, touch the **Recall Trace** selector and select **STO 1** in the pop-up menu.

☐ Step 10: Create a difference trace by touching the **DefTra** icon, then touch **1** (or whatever channel number you are using) under **Mainframe Channels, –, Stored Traces, Stored1,** and **Enter Desc.**

☐ Step 11: Touch the vertical icon (↕) and adjust the top knob to set the vertical size of the trace to 50 mV/div (the vertical size of the stored trace).

The difference trace should be close to a flat trace, because the signal you are comparing is identical to the source of the saved trace, except for noise.

This setup is useful in cases where you are tuning a circuit to a known standard of performance. First you save the desired signal trace from a circuit of known performance, then use the difference trace to observe other circuit samples. These circuits can then be dynamically tuned to the same performance.

To accurately quantify the signal variation from a straight line, you can use the **RMS** measurement:

☐ Step 12: Press the **MEASURE** button and touch **Measurements, RMS,** and **Exit.**

To tune a circuit, you could make adjustments to get the smallest RMS measurement instead of simply trying for the "flattest" trace.

Example 9: Comparing Traces to Stored Traces

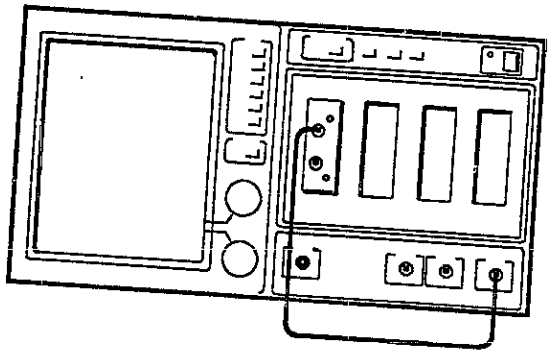
Example 10: Creating a Histogram Display

This example demonstrates how you can create a histogram of a displayed trace. As in Example 4, you will display the calibrator signal at very fine horizontal (time per division) and vertical (volts per division) settings to simulate a noisy signal.

For this example you will need an 11801A with at least one dual-channel sampling head installed and one SMA connecting cable.

☐ Step 1: Initialize the 11801A (press the **UTILITY** button in the **MENUS** column, touch **Initialize** in the major menu, and touch **Initialize** in the verification pop-up menu).

☐ Step 2: Connect the **CALIBRATOR** output to any sampling head input.



Connections for Example 10

☐ Step 3: Press the **TRIGGER** button, and touch **Source** and **Internal Clock**, then touch **Exit**.

☐ Step 4: Press the **SELECT CHANNEL** button on the sampling head input channel to which you have connected the calibrator.

☐ Step 5: Turn the top knob to the right until the horizontal scale is 1 ps/div.

☐ Step 6: Press **UTILITY** and touch **Instrument Options**. Touch **Horizontal Autoset** until the selector shows Off and touch **Exit**.

☐ Step 7: Press the **AUTOSET** button.

In Example 4, you used color grading to view the relative density of trace points in a display of this signal. A histogram will provide additional statistical information about the distribution of points in the trace.

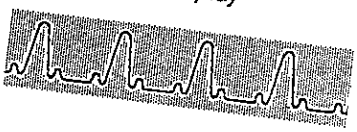
☐ Step 8: Press the **DISPLAY MODES** button and select **Persist/Histograms** in the major menu area.

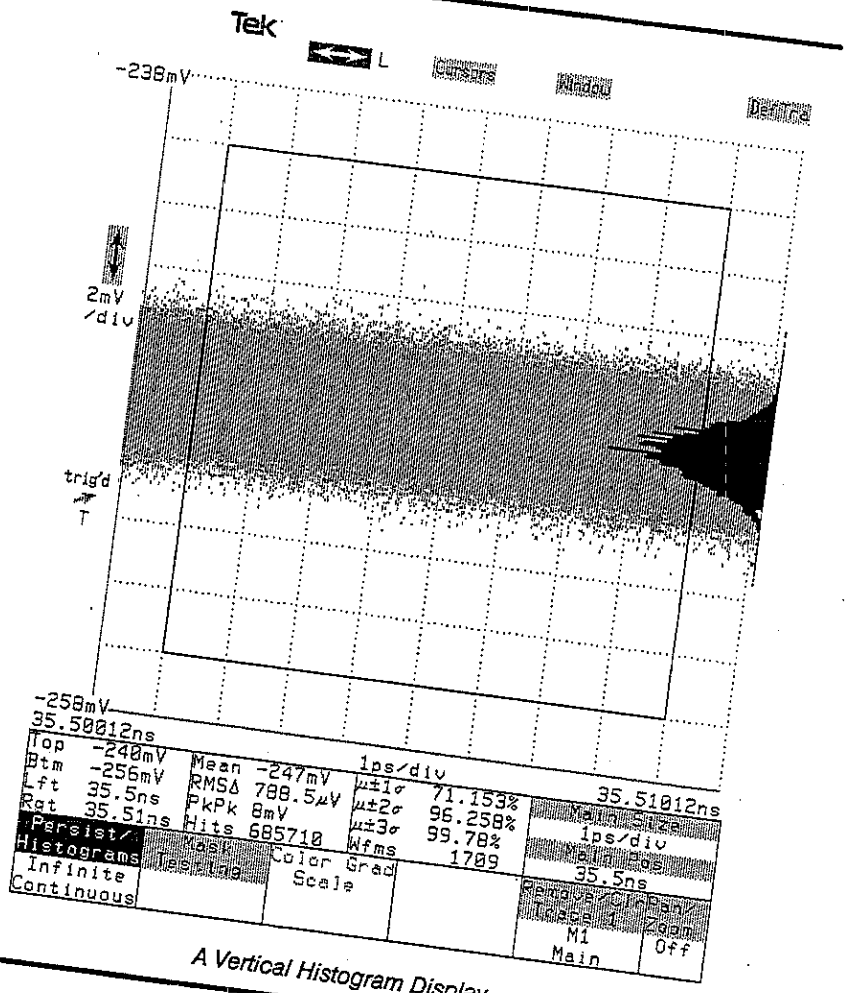
☐ Step 9: Select **Vertical Histogram** in the pop-up menu, and then select **Exit**.

When you selected **Vertical Histogram**, the display persistence automatically changed from **Normal** to **Infinite**. Histograms can be displayed on traces in the infinite persistence and color grading display modes, but not in normal or variable persistence modes.

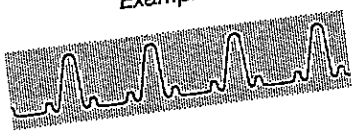
The histogram display appears in red along the right side of the graticule. A red box on the graticule outlines the limits of the histogram data; trace data that fall outside these limits are ignored.

The amount of noise you see in the displayed signal will depend on the sampling head you have installed. The illustration on the next page shows the calibrator signal as acquired using an SD-24 sampling head. If you are using a lower-noise sampling head, such as the SD-22, you will see less noise on the display.





A Vertical Histogram Display



The major menu area shows readouts for the histogram parameters and results:

- **Top, Btm, Lft,** and **Rgt** are the limits of the histogram data (displayed as a red box).
- **Mean** is the mean vertical value of the trace data within the histogram limits.
- **RMS**Δ is the root mean square deviation, or standard deviation, of trace data points from the **Mean** value.
- **PkPk** is the peak-to-peak measurement of the trace within the histogram limits.
- **Hits** is the number of trace data points that fall within the histogram limits.
- **Wfms** is the number of traces (waveforms) acquired for the histogram.
- $\mu\pm1\sigma$ is the percentage of points that are within one standard deviation (σ) of the mean (μ). $\mu\pm2\sigma$ and $\mu\pm3\sigma$ are the percentages of points that fall within two standard deviations and three standard deviations, respectively, of the mean.

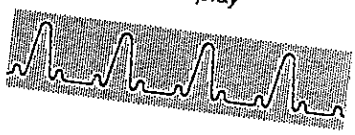
You can adjust the histogram limits to restrict the range of trace record points that the 11801A will recognize as valid data points.

☐ Step 10: Touch **Persist/Histograms** to redisplay the pop-up menu.

☐ Step 11: Select **Vertical Limits** in the pop-up menu.

The knobs are now assigned to **Top** and **Bottom.**

☐ Step 12: Use the knobs to adjust the top and bottom limits of the histogram, and observe the changes in the distribution displayed.



You can also control the number of samples the 11801A uses to develop the histogram. Using the **Persist/Histograms** pop-up menu, you can set a number of waveforms (traces) or a number of samples (individual trace record points, or "hits") to acquire for the histogram before stopping acquisition.

☐ Step 13: Touch the **Persist/Histograms** selector to redisplay the pop-up menu.

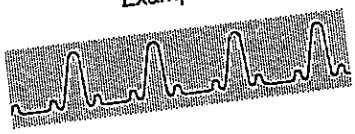
☐ Step 14: Touch **Set N Samples** to assign the knobs to control the number of samples for the histogram.

☐ Step 15: Turn either knob to set the **Sample N** value.

☐ Step 16: Select **Stop N Samples** in the **Persist/Histograms** pop-up menu.

Trace acquisition stops when the number of **Hits** listed in the major menu area is equal to the number of samples you set.

Example 10: Creating a Histogram Display



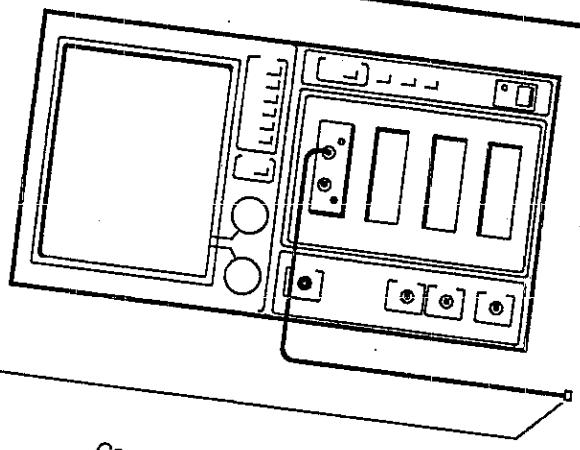
Example 11: Taking TDR Measurements

This example demonstrates the TDR (Time Domain Reflectometry) feature of the SD-24 sampling heads when they are used in combination with the 11801A. TDR is a method of examining and measuring a network or transmission line by sending a pulse into the network and monitoring the reflections.

For this example you will need an 11801A with at least one SD-24 sampling head installed. Also, you will need one SMA cable, preferably of 5 ns length.

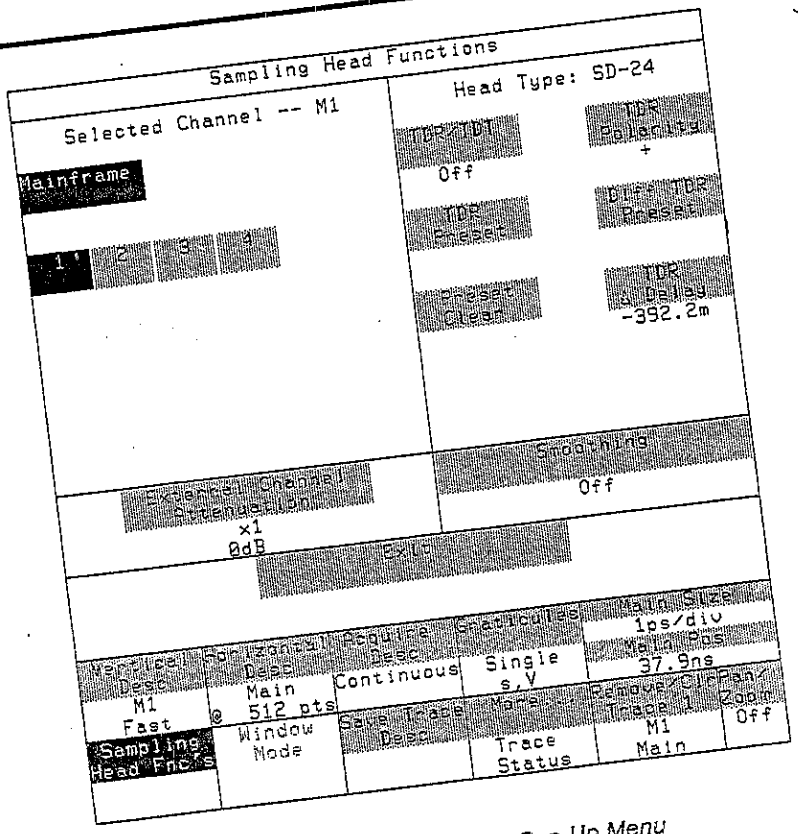
☐ Step 1: Initialize the 11801A (press the **UTILITY** button in the **MENUS** column, touch **Initialize** in the major menu, and touch **Initialize** in the verification pop-up menu).

☐ Step 2: Attach one end of the cable to any SD-24 sampling head input. Leave the other end unattached.



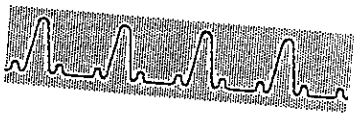
Connections for Example 11

☐ Step 3: Press the **WAVEFORM** button, and touch the **Sampling Head Fnc's** selector.



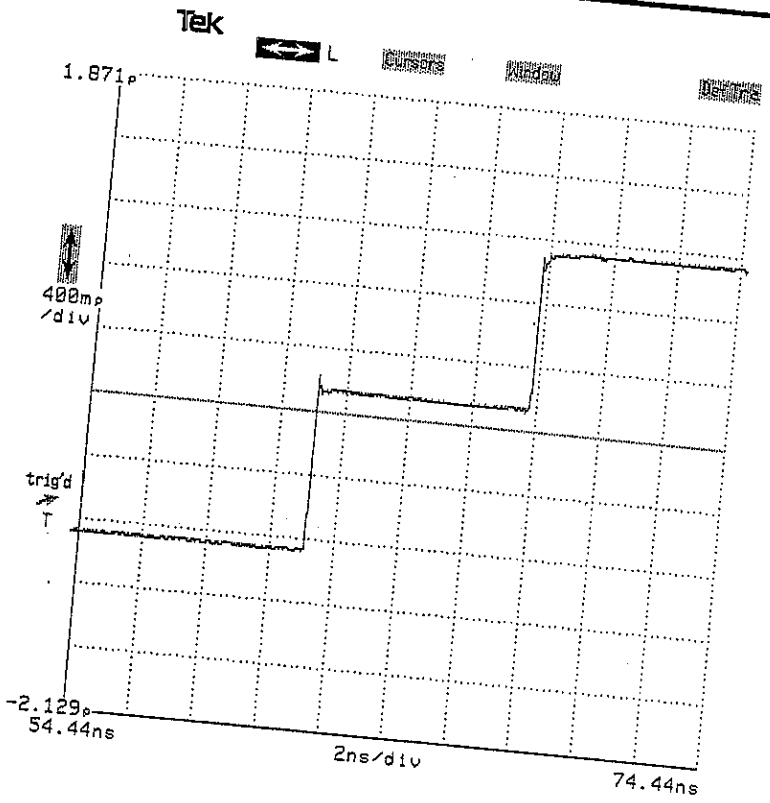
The **Sampling Head Fnc's** *Pop-Up Menu*

☐ Step 4: Touch **1** (or whichever channel you are using) and then **TDR Preset** to define a trace and turn on TDR.



The sampling head will turn on a red light next to the channel input connector, indicating that TDR is activated for that channel. TDR can be used on each channel independently.

☐ Step 5: Adjust the display sizes and positions to show a trace similar to that shown below. The vertical (↕) and horizontal (↔) icons will let you make fine adjustments.



TDR Pulse and Reflection

The first rise of this trace is the TDR pulse leaving the sampling head; the second rise is the reflection of the pulse returning from the end of the cable.

Changing Graticule Units for TDR

Under normal operation, the graticule units of measurement are volts for the vertical axis and seconds for the horizontal axis. These are not the units of measurement commonly used in TDR.

When you selected **TDR Preset**, the 11801A automatically changed the units of the vertical axis to units of rho (ρ). You can change the measurement units for both graticule axes by using the **Graticules** selector in the Waveform major menu.

☐ Step 6: Touch **Graticules** in the major menu and **Feet, Meters,** or **Inches** in the pop-up menu. If you know that the propagation velocity of your cable differs from the default, touch the **Propagation Velocity** selector and adjust this parameter. If you don't know the velocity or are using Tektronix SMA cables, accept the 0.7 default. This unitless number represents the fraction of the speed of light that signals pass through your network or transmission line.

The horizontal axis is now calibrated in your chosen units of measurement.

Cursor readouts, and measurements when appropriate, are expressed in the same units as the graticule axes.

Observe the **Y Units** section of the **Graticules** pop-up menu. The vertical axis units are set to rho, so **Rho** is selected. In addition, the **Reference Amplitude** selector shows a reference amplitude of **250mV**. This is the amplitude of the pulse that the SD-24 sampling head sends through the cable.

Readouts are displayed in units of impedance (Ω), as well as in units of rho, in the Cursors major menu.

Measuring Distance with TDR

One of the common uses of TDR is measuring distance. The 11801A makes it easy to measure the length of a cable or circuit board run by using the Cursors major menu. Distance is determined by the measuring the time required for a pulse to travel down a transmission line (for example, a cable or circuit board run) and for its reflection to return. The measured distance is dependent on the propagation velocity of the transmission line.

☐ Step 7: Touch the **Cursors** icon to display the Cursors major menu.

☐ Step 8: Touch **Cursor Type**, touch **Vertical Bars** in the pop-up menu and then touch **Exit**.

☐ Step 9: Use the knobs to position Cursor 1 at the first rising edge and position Cursor 2 at the second rising edge.

You are now measuring the distance between the rising edge of the pulse leaving the head and the rising edge of the reflection. If you select Feet for the Y Units in the Graticules pop-up menu, you can read the length of the cable, in feet, at the $\Delta f/2$ readout. The Δf readout shows you the total distance traveled by the pulse and its reflection. Divide that value in half, $\Delta f/2$, and you have the length of the cable.

Example 11: Taking TDR Measurements

Glossary

Acquisition
The process of repeatedly sampling the signals coming through input channels, and accumulating the samples into traces.

Active Graticule
The graticule in a dual-graticule display that shows the selected trace.

Annotation
Lines that show the current measurement parameter settings.

Autoset
A means of letting the 11801A set itself to provide a stable and meaningful display of a given trace.

Averaging
Displaying a trace that is the combined result of several acquisitions, thereby reducing apparent noise.

Axis Label
There are three notations on each axis. The first and last notation on each axis show the numeric value of the graticule edge (*not* the edge of the displayed points, which are slightly outside the graticule). The center notation is the scale factor expressed in units per division.

Channel
A place to connect a signal or attach a network or transmission line to sampling heads. Also, the smallest component of a trace expression.

Channel Number
The number assigned to a specific signal input connector. The top channel of the leftmost sampling head compartment of the 11801A mainframe is always mainframe channel 1, regardless of any repositioning or omission of sampling heads.

Color Graded
A display mode in which the 11801A displays regions of a trace in different colors according to the densities of displayed points (based on multiple acquisitions of the trace) in that region.

Complex Trace
A trace with a trace expression beyond a single channel specification. Any trace using a numeric value, a function, a reference to a stored trace or saved trace description, or an arithmetic operator is a complex trace. However, using the average function does not make a trace complex.

Control Knob
see Knob

Cursor
Any of four styles of paired markers that you position with the knobs. The 11801A displays the positions of the cursors and the distance between them, in axis units.

Default Measurement Parameter
A value from the default set of measurement parameters. The operator can change the default values. Whenever a trace is created, the measurement parameters are copied from the default set.

Dragging
The act of changing your touch panel selection by moving your finger without removing it from the screen. The selection that is activated is the last one that you were touching before you withdrew your finger.

Dual Graticule
A display with two graticules. Each one is half the height of the single graticule.

Entry Line
A text line that shows your input as you enter selections in a pop-up menu.

Enveloping
Displaying a trace that shows the extremes of variation of several acquisitions.

GPIB (General Purpose Interface Bus)
An interface (IEEE standard 488.1) that can be used for remote computer control of, and data capture from, the 11801A.

Graticule
The grid where traces are displayed.

Hardware Measurement
An automated measurement that is captured by special circuitry that monitors signals directly, as opposed to software measurements that are derived from acquired trace samples.

Highlighted Trace
The selected trace in a single-graticule or dual-graticule display.

Histogram
A graphical representation of the distribution of acquired trace record points on the display.

Horizontal Reference Point
The point about which the trace is expanded or contracted when horizontal size adjustments are made. The horizontal reference point remains anchored as the rest of the trace grows or shrinks around it.

Icon
A marker on the edge of the graticule that performs a specific function when touched.

Initialize
Setting the 11801A to a completely known, default condition.

Infinite Persistence Mode
A mode of operation where the 11801A displays newly acquired trace data points and keeps the previously acquired data points on the screen.

Internal Clock
A trigger source that is synchronized with the Calibrator signal.

Keypad Menu
A pop-up menu that controls knob resolution and lets you enter specific numeric values for any control to which a knob is assigned.

Knob
One of the two large rotary controls to the right of the 11801A screen.

Knob Assignment
The value that a knob will adjust at a given time.

Knob Menu
The on-screen menu that always displays the current knob assignment. The knob menu also lets you display the Keypad menu.

Knob Parameter
see Knob Assignment

Major Menu
The menu that is displayed at the bottom of the screen alongside the Knob menu. One of the several major menus is always displayed.

Major Menu Button
A labeled button above the knobs that determines which major menu is displayed.

Measurement
An automated numeric readout that the 11801A provides directly from the displayed trace in real time, without operator intervention.

Measurement Parameter
One of several controls that the 11801A operator can exercise over the automated measurement process.

Measurement Statistics
The accumulation of a history of individual measurement readouts, showing the mean and standard deviation of a selected number of samples.

Outline Box
A visual feedback mechanism of the touch panel. Your potential selection is always indicated by a box while you have your finger touching the screen.

Pop-up Menu
A temporary menu that provides an interactive dialog for a specific purpose. A sub-menu of a major menu.

Power Divider
A connector that lets you branch a signal from a cable into two other cables. Impedances are matched in a power splitter to preserve transmission line characteristics in all attached cables.

Principal Power Switch
The master power switch located on the rear panel of the 11801A.

Record Length
The number of samples (data points) that make up a trace.

RS-232-C
An interface that allows remote computer control of, and data capture from, the 11801A.

Sampling Head
A high-performance amplifier that captures the incoming signal of a channel and reports the sampled data to the 11801A mainframe.

Saved Trace Description
A specification of a trace that is acquired but not visible on the display.

Selected Trace
The highlighted (brightest) trace of a multi-trace display. The selected trace is the trace that is acted on by the knobs and menu selectors.

Selector
An area of a menu that performs some action when you touch it.

Setting
The state of the system at some given time.

Software Measurement
An automated measurement that is derived from acquired trace samples, as opposed to hardware measurements that are captured by special circuitry that monitors the signals directly.

Smoothing
Processing applied by the sampling head prior to the digitization of a trace, to reduce apparent noise. With smoothing, the sampling head samples the signal 8 times instead of once, and the average of the samples is then used by hardware measurements and the digitizing circuitry.

Statistical Measurement
An automated measurement that is derived from color graded waveform data and is based on histograms computed at the crossing levels. A statistical measurement can be selected only in color graded display mode.

Stored Trace
A collection of sampled points that constitute a single trace acquisition that is saved in memory.

T Adapter
A connector that lets you branch a signal from a cable into two other cables. Simple connections are made and impedances are not matched in a T adapter.

Time Base
The time-dependent specifications that control the acquisition of a trace. The time base determines when and how long to acquire and digitize signal data points.

Time-Domain Reflectometry (TDR)
A method of characterising a transmission line or network by sending a signal from one end and monitoring the electrical reflections.

Trace
The visible representation of an input signal or combination of signals. Identical to waveform.

Trace Expression
The definition of what the trace displays. It can include one or more channels combined arithmetically and modified by functions.

Trace Number
A number assigned by the 11801A to identify a trace. Display traces are numbered 1 through 8. A new trace is always given the lowest available number.

Trigger
An electrical event that initiates acquisition of a trace as specified by the time base.

Variable Persistence Mode
A mode of operation where the 11801A displays newly acquired trace data points and keeps the previously acquired data points on the screen for a specified duration.

Vertical Description
see Trace Expression

Waveform
The visible representation of an input signal or combination of signals. Identical to trace.

Window
A trace that represents a horizontally expanded portion of another trace.

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