Instruction Manual

Tektronix

TDS 310, TDS 320, & TDS 350
Two Channel Oscilloscopes

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TEK INTER-OFFICE COMMUNICATION

TO John Martin 94-540 DATE June 25, 1991

FROM Frank Gray, 50-PAT

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Francis I. Gray
Group Patent Counsel

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Front Panel

TDS 300 Series oscilloscopes are simple to use. To reduce the clutter of knobs and buttons on the front panel (see Figure 3-1), many instrument control functions are menu driven. Use menus to access instrument functions that you typically set once before making measurements. Use knobs or buttons to control instrument functions that you most often adjust during measurements.

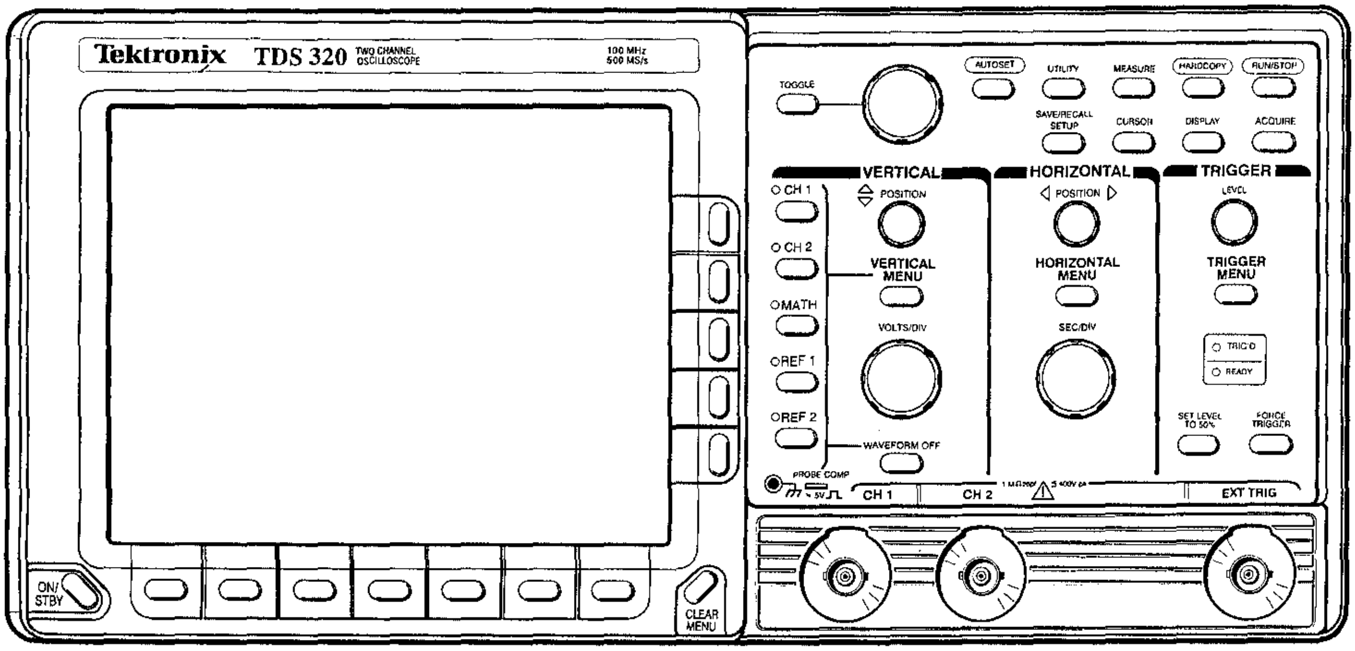
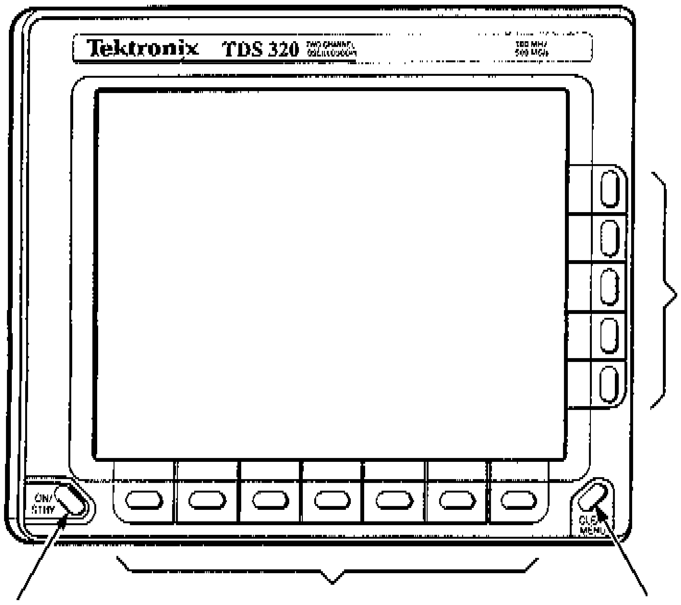


Figure 3-1: The TDS 320 Oscilloscope Front Panel

The menus are easy to use. For example, to make a change to the vertical operating system, press the **VERTICAL MENU** button to display the menu choices.

This section illustrates each control and connector and contains brief descriptions of its use or function.

Display and Power Controls



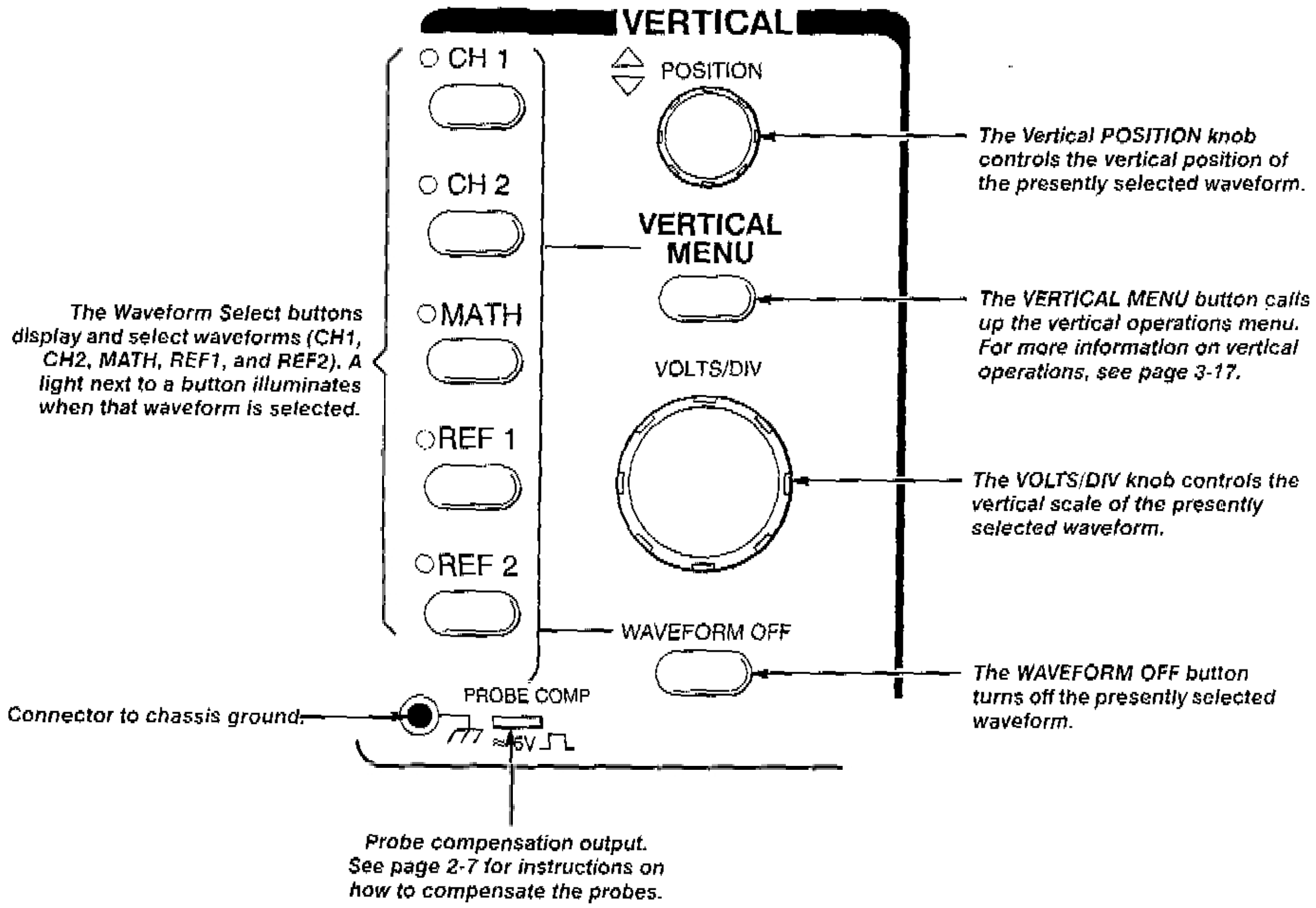
The Side Menu buttons provide access to side menu selections. See page 2-3 for more information on the user interface.

The ON/STBY button toggles instrument power.

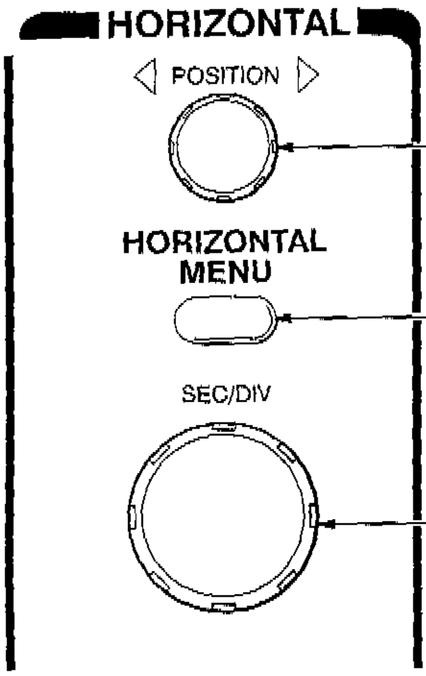
The Main Menu buttons provide access to main menu selections. See page 2-3 for more information on the user interface.

The CLEAR MENU button clears all menus from the screen.

Vertical Controls



Horizontal Controls

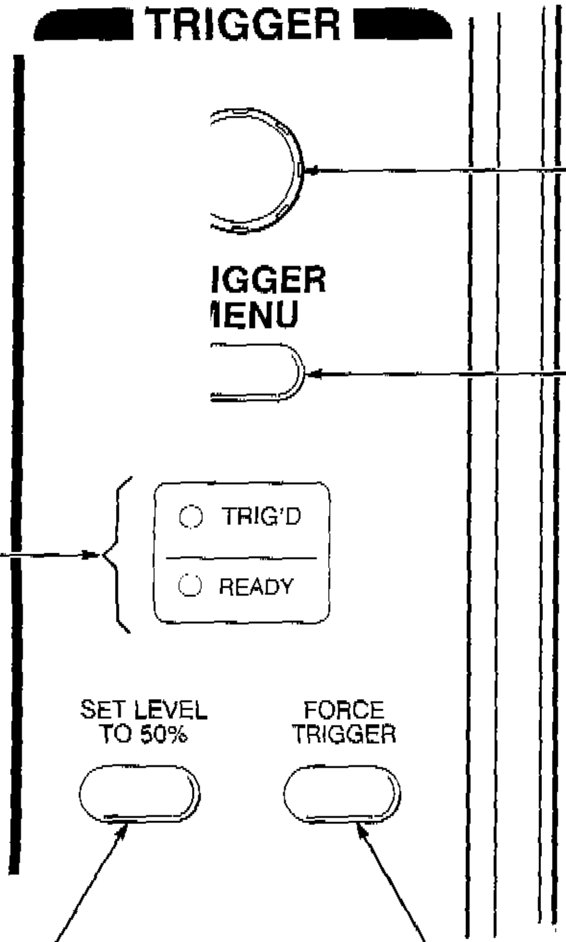


The Horizontal POSITION knob controls the horizontal position of all waveforms.

The HORIZONTAL MENU button calls up the horizontal operations menu. For more information on horizontal operations see page 3-20.

The SEC/DIV knob controls the horizontal scale of the active waveforms.

Trigger Controls



The Trigger LEVEL knob controls the trigger.

The TRIGGER MENU button calls up the trigger menu. See page 3-25 for more information on triggering.

The Trigger Status Lights indicate the status of the triggering system. The TRIG'D light illuminates when the instrument recognizes a valid trigger.

The READY light illuminates when the instrument can accept a valid trigger and is waiting for that event to occur.

The SET LEVEL TO 50% button sets the trigger level at the half-way point between the peaks of the trigger signal.

The FORCE TRIGGER button forces the oscilloscope to start acquiring a waveform regardless of whether a trigger event occurs. This button has no effect if the acquisition system is stopped.

Miscellaneous Controls

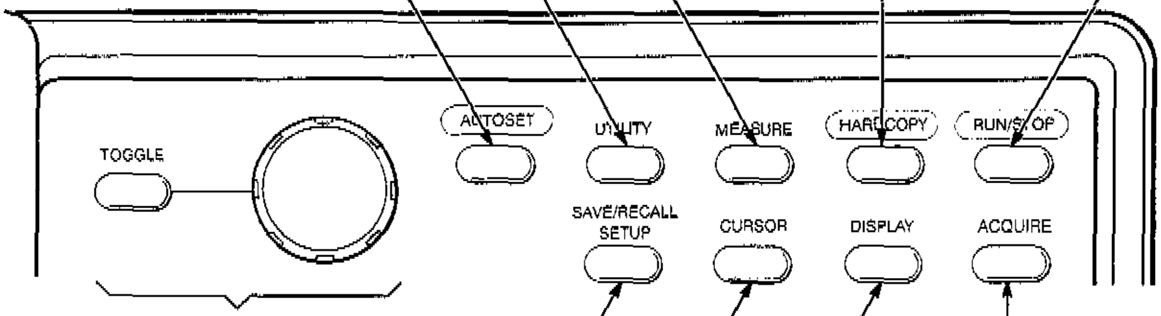
The MEASURE button calls up the automated measurements menu. See page 3-29 for more information on automated measurements.

The UTILITY button calls up the utility menu. See page 3-45 for more information on utilities.

The AUTOSET button automatically sets up the instrument to produce a usable display of the input signals. For more on the autoset function, see page 2-11.

The HARDCOPY button starts print operations. See page 3-41 for more information on making hard copies.

The RUN/STOP button starts and stops acquisition.



The General Purpose Knob controls many side menu functions, including the cursors. The TOGGLE button switches control from cursor to cursor.

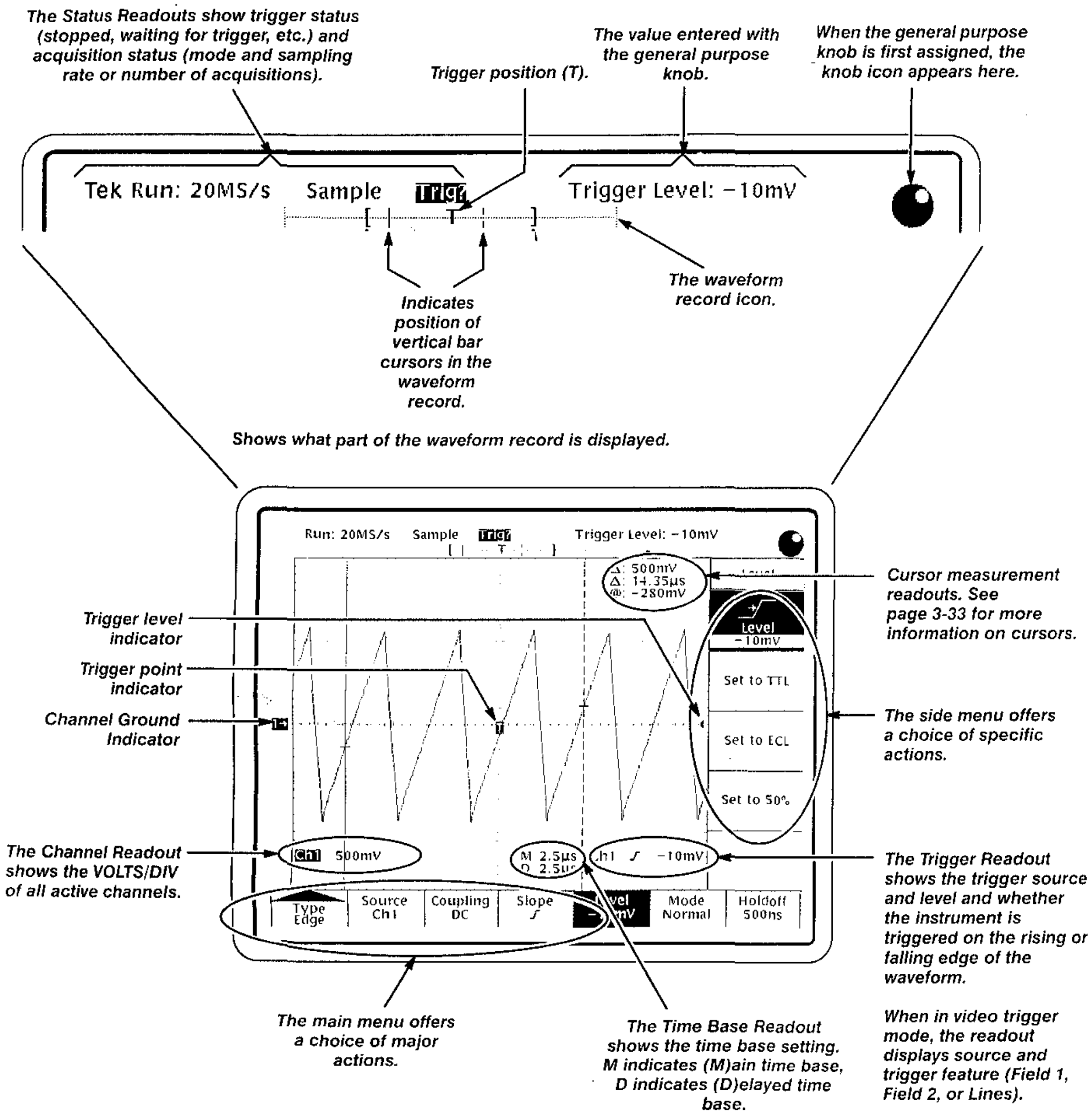
The ACQUIRE button calls up the acquisition menu. See page 3-37 for more information on controlling acquisition.

The SAVE/RECALL SETUP button calls up the save/recall setup menu. See page 3-43 for more information on saving and recalling setups.

The CURSOR button calls up the cursor menu. See page 3-33 for information on making measurements with cursors.

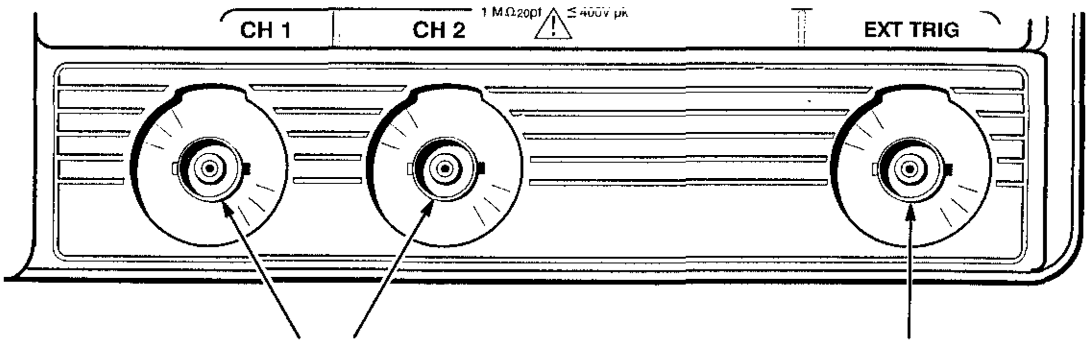
The DISPLAY button calls up the display menu. See page 3-39 for information on controlling the display.

Display Map



The Status Readouts show trigger status (stopped, waiting for trigger, etc.) and acquisition status (mode and sampling rate or number of acquisitions).
Trigger position (T).
The value entered with the general purpose knob.
When the general purpose knob is first assigned, the knob icon appears here.
Tek Run: 20MS/s
Sample
Trig?
Trigger Level: −10mV
Indicates position of vertical bar cursors in the waveform record.
The waveform record icon.
Shows what part of the waveform record is displayed.
Trigger level indicator
Trigger point indicator
Channel Ground Indicator
The Channel Readout shows the VOLTS/DIV of all active channels.
Cursor measurement readouts. See page 3-33 for more information on cursors.
The side menu offers a choice of specific actions.
The Trigger Readout shows the trigger source and level and whether the instrument is triggered on the rising or falling edge of the waveform.
When in video trigger mode, the readout displays source and trigger feature (Field 1, Field 2, or Lines).
The main menu offers a choice of major actions.
The Time Base Readout shows the time base setting. M indicates (M)ain time base, D indicates (D)elayed time base.
Set to TTL
Set to ECL
Set to 50%
Type Edge
Source Ch1
Coupling DC
Slope
Mode Normal
Holdoff 500ns

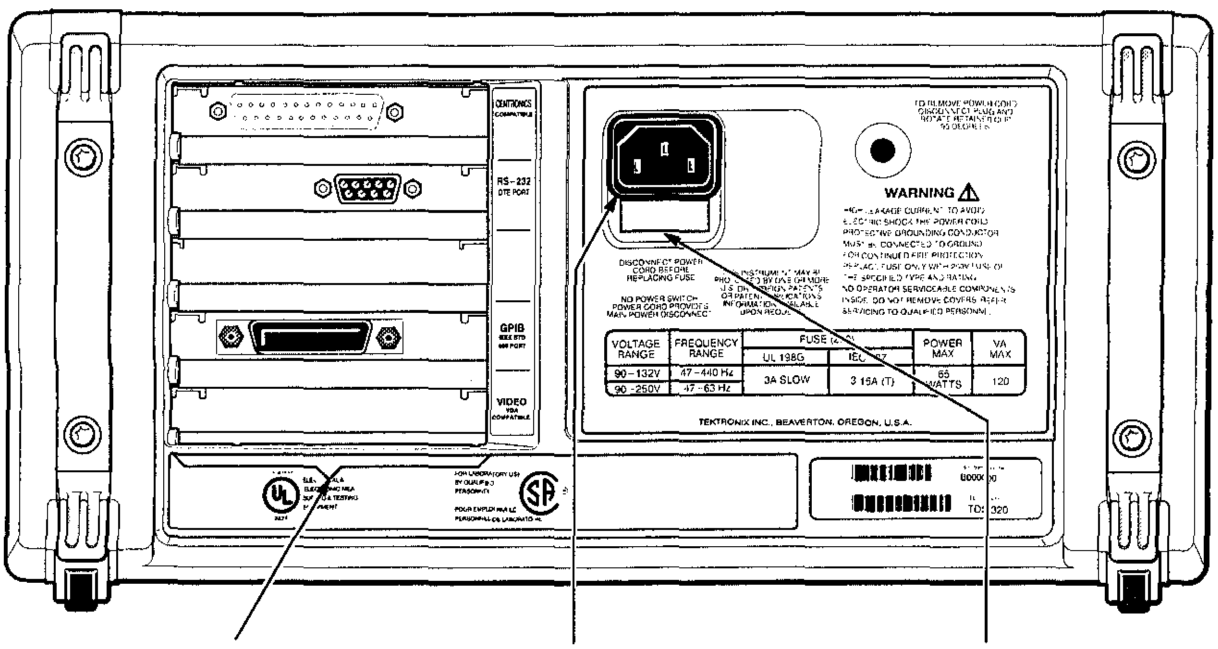
Inputs



The channel BNC inputs (CH1 and CH2) accept electrical signals for display.

The EXT TRIG input accepts external trigger signals. See page 3-26 for more information on external triggering.

Rear Panel



The Option 14 Panel (Option 14 instruments only) allows access to three communications interfaces: a Centronics parallel port, an RS-232 interface, and a GPIB interface.

You can use the Centronics, RS-232, and GPIB interfaces to transmit hardcopy data; see page 3-41 for hardcopy procedures.

You can use the GPIB and RS-232 interfaces to operate and program the oscilloscope from a GPIB controller; see the TDS 310, 320, & 350 Programmer Manual for more information. information.

The power connector accepts line voltage to power the instrument. See page 1-3 for a list of power cord and connector options.

The fuse drawer holds the line fuse. See page 8-9 for fuse replacement procedures.

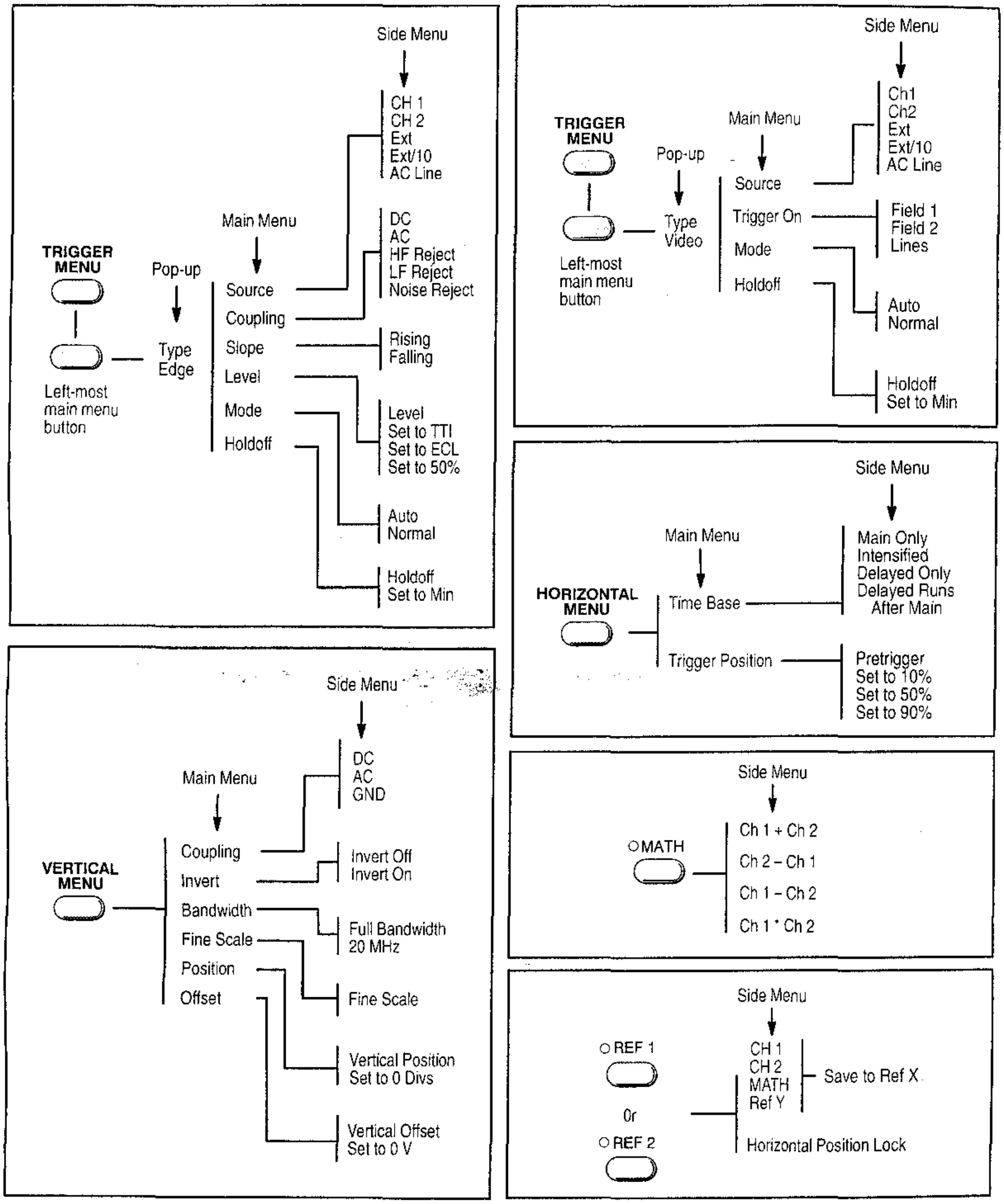


Figure 3-2: Primary Functions Menu Map

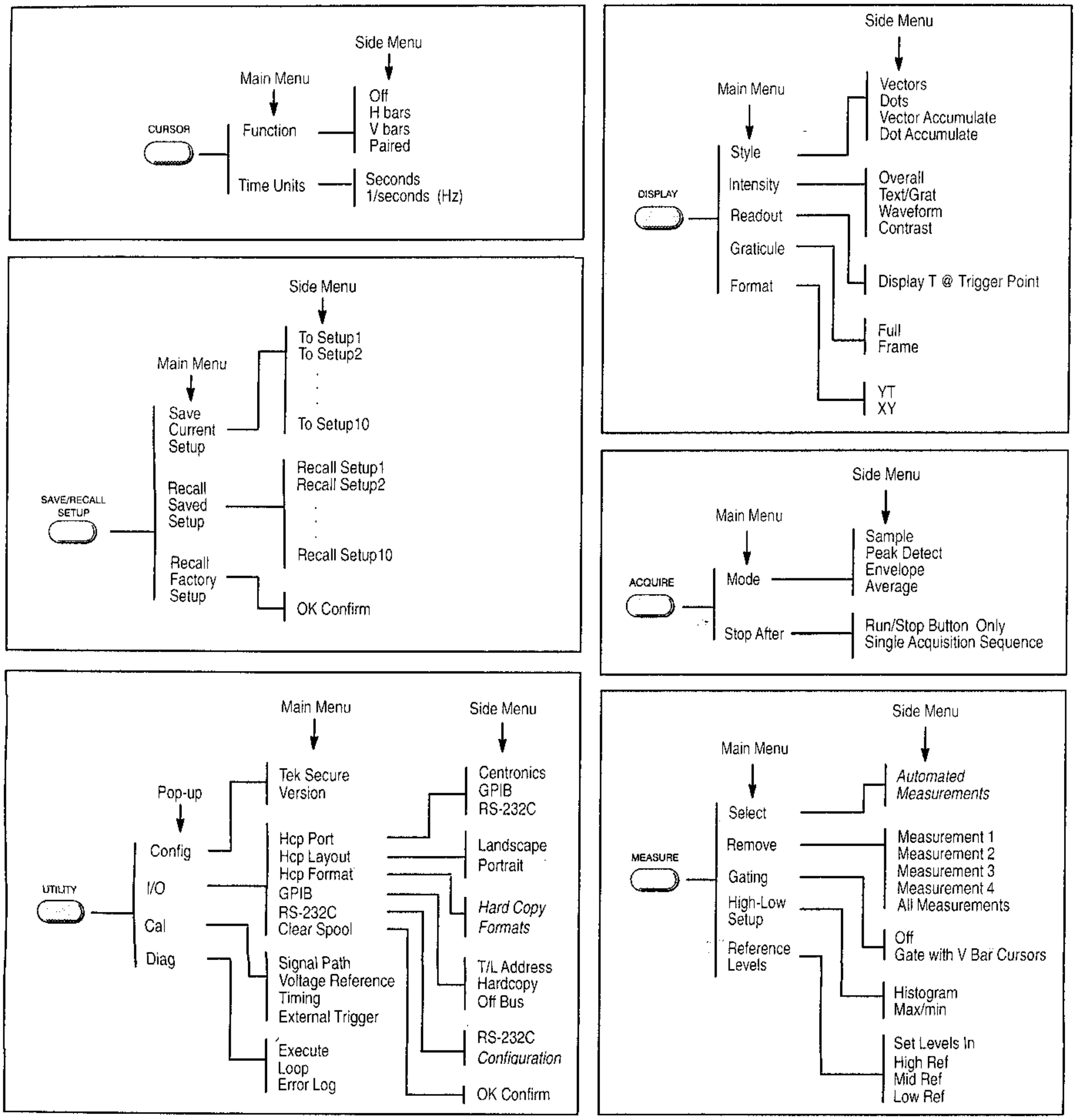


Figure 3-3: Secondary Functions Menu Map

Manipulating Waveforms

There are four basic ways to manipulate waveforms with TDS 300 Series oscilloscopes.

- You can change their display parameters with the vertical and horizontal systems
- You can add, subtract, and multiply them with the waveform math feature
- You can save them to and recall them from reference waveform memories

Vertical Operations

To access the vertical system features, press the **VERTICAL MENU** button, shown in Figure 3-4.

NOTE

The ***VERTICAL MENU*** *button calls up the vertical menu only if a channel waveform (CH 1 or CH 2) is selected. If a math or reference waveform is selected, the* ***VERTICAL MENU*** *button calls up the math or reference waveform menu.*

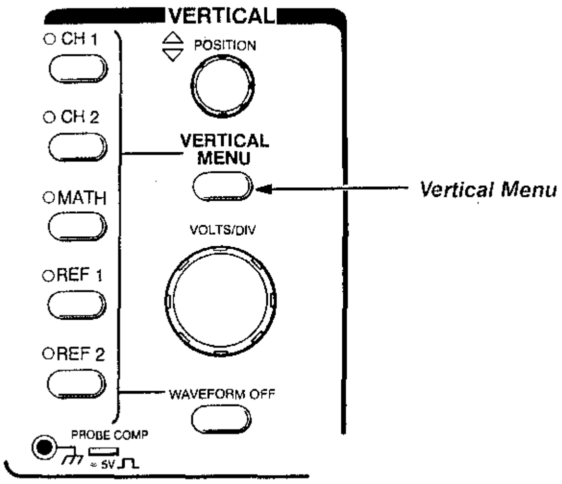


Figure 3-4: The VERTICAL MENU Button

Figure 3-5 shows the vertical menu.

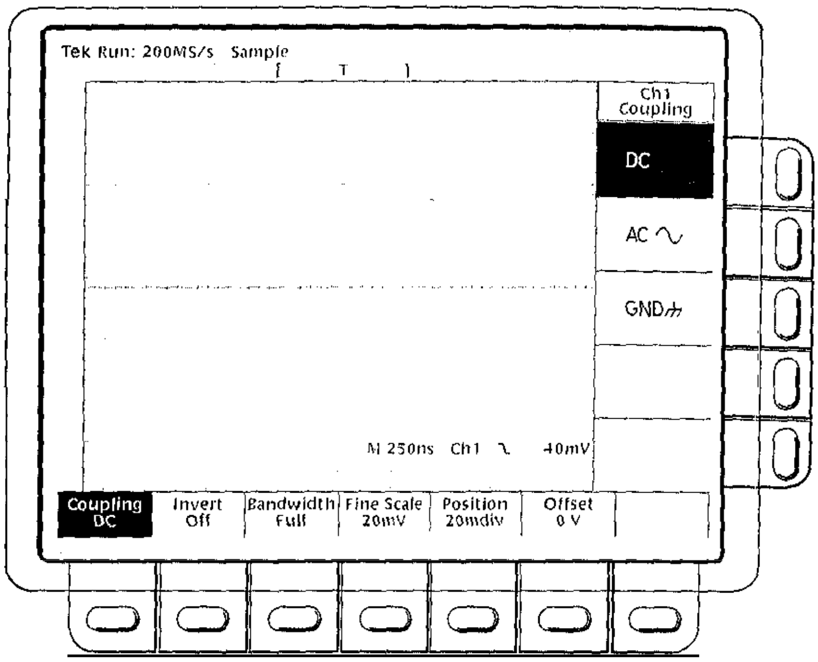


Figure 3-5: The Vertical Menu

Use the vertical menu to perform these tasks.

Select Input Coupling — Press the main menu button **Coupling**. Use the side menu to select **DC**, **AC**, or ground (**GND**) coupling.

Invert a Waveform — Press the main menu button **Invert**. Use the side menu to turn invert off and on. When you turn invert on, the selected waveform "flips" around the zero volt axis. Figure 3-6 shows an inverted pulse signal.

NOTE

*Invert "flips" the waveform, but it does not alter the trigger level accordingly. To obtain a stable trigger after inverting a waveform, press **SET LEVEL TO 50%**.*

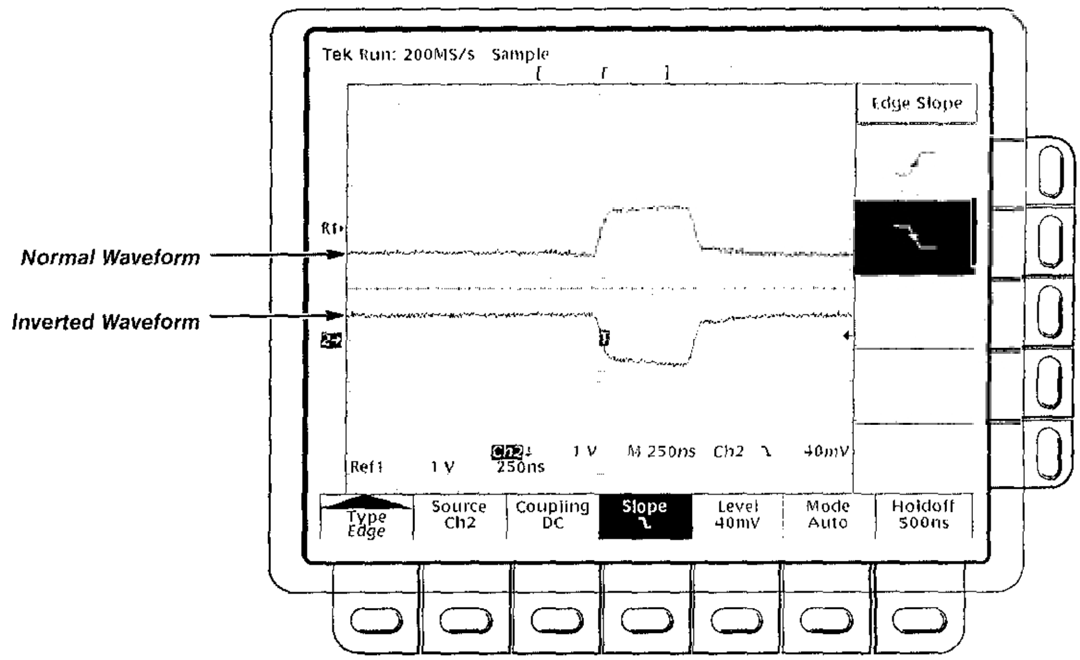


Figure 3-6: Inverting a Waveform

Select Bandwidth — Press the main menu button **Bandwidth**. Use the side menu to switch between 20 MHz and full bandwidth.

Make Fine V/div Adjustments — Press the main menu button **Fine Scale** to activate the **General Purpose Knob**. Then use the knob to make precise adjustments to the vertical scale setting.

Adjust Vertical Position — Press the main menu button **Position** to activate the **General Purpose Knob**. Then, use the knob to adjust vertical position or use the side menu to set the vertical position to 0 divisions. Vertical position is limited to a range of ±5 divisions.

NOTE

*This selection performs the same function as the vertical **POSITION** knob.*

Adjust Vertical Offset — Press the main menu button **Offset** to activate the **General Purpose Knob**. Then use the knob to adjust offset or use the side menu to set the offset to 0 V. Offset performs the same basic function as the vertical **POSITION** knob, but it has a wider range. Use offset to view a waveform that has a large DC bias.

Horizontal Operations

To access horizontal system features, press the **HORIZONTAL MENU** button, shown in Figure 3-7. Figure 3-8 shows the horizontal menu.

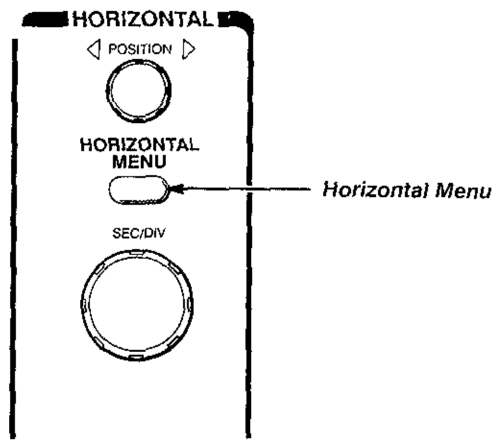


Figure 3-7: The HORIZONTAL MENU Button

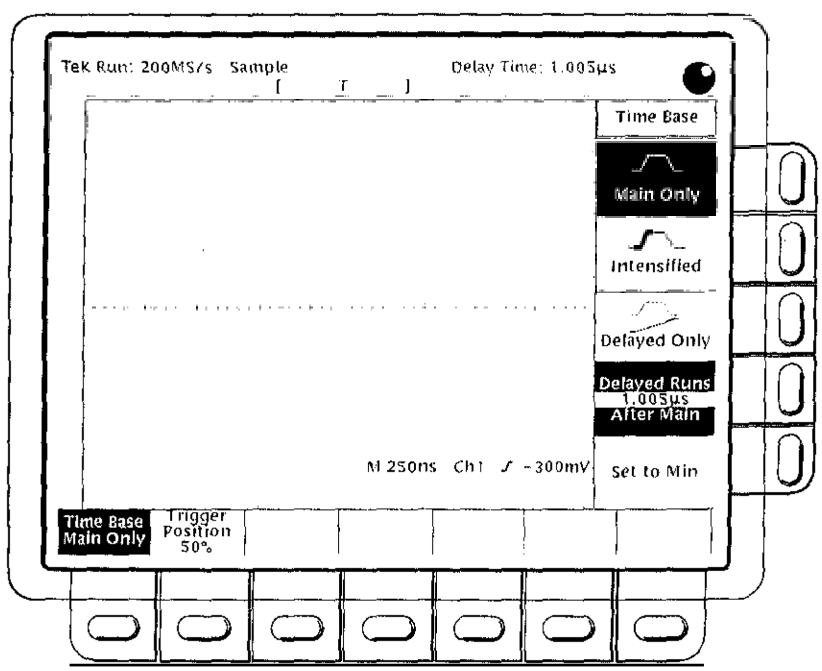


Figure 3-8: The Horizontal Menu

Use the horizontal menu to perform these tasks.

Select the Time Base — Press the main menu button **Time Base**. Use the side menu to select from these options.

- Press **Main Only** to show only the main time base.
- Press **Intensified** to show both the main and delayed time bases. The oscilloscope intensifies a portion of the waveform; this intensified zone indicates the location of the delayed time base with respect to the main. Use the **SEC/DIV** knob to change the length of the zone and the **General Purpose Knob** to change its position.
- Press **Delayed Only** to show only the delayed time base.
- Use the **General Purpose Knob** to adjust the delay time (the interval between the main and delayed time bases). You adjust the delay time in coarse increments when Main Only or Intensified are selected and in fine increments when Delayed Only is selected. The side menu selection **Delayed Runs After Main** shows the delay time.
- Press **SET to Min** to set the delay time to its minimum value.

Adjust Horizontal Trigger Position — Press the main menu button **Trigger Position**. Use the **General Purpose Knob** to adjust horizontal trigger position, or use side menu selections to set the trigger position to 10%, 50%, or 90% of the waveform record.

Displaying Math Waveforms

TDS 300 Series oscilloscopes can add or multiply the two channel waveforms or subtract one from the other and display the result as a math waveform. To activate the math waveform, press the **MATH** button, shown in Figure 3-9.

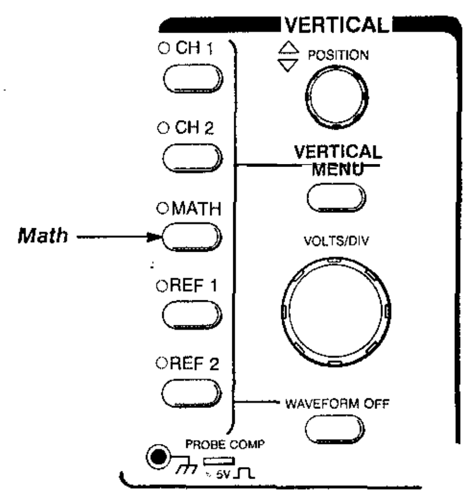


Figure 3-9: The MATH Button

Then select a formula from the side menu (**Ch1 + Ch2**, **Ch1 − Ch2**, **Ch2 − Ch1**, or **CH1 * Ch2**). Figure 3-10 shows a square wave on Channel 2 added to a sine wave on Channel 1.

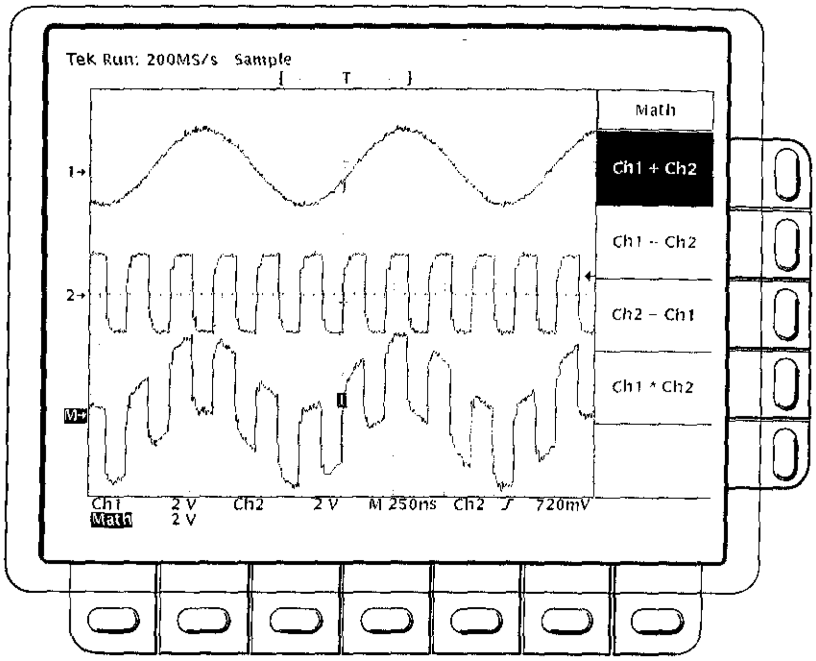


Figure 3-10: A Math Waveform

Saving and Recalling Waveforms

TDS 300 Series oscilloscopes have two reference waveforms. You can use the reference waveforms to store "live" waveforms (channel and math waveforms). You can also shift a stored waveform from one reference waveform to the other.

Reference waveforms respond just like live waveforms to changes in vertical position and scale, but they do not respond to horizontal scale adjustments. There is no way to horizontally expand a reference waveform.

To save a live waveform to a reference waveform, press one of the reference waveform buttons (**REF 1** or **REF 2**) shown in Figure 3-11.

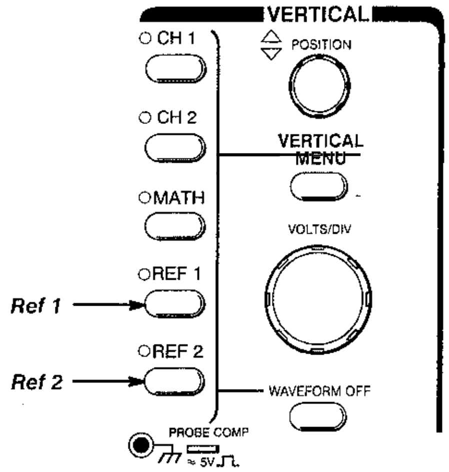


Figure 3-11: The Reference Waveform Buttons

If the selected reference waveform already holds a waveform, it appears on the screen. A side menu also appears; select one of these options from the side menu (see Figure 3-12).

- Press **Save CH1 to Ref(x)** to save the channel 1 waveform to the selected reference waveform.
- Press **Save CH2 to Ref(x)** to save the channel 2 waveform to the selected reference waveform.
- Press **Save MATH to Ref(x)** to save the math waveform to the selected reference waveform.
- Press **Save Ref(y) to Ref(x)** to save the unselected reference waveform to the selected reference waveform. (For example, Ref2 to Ref1 or Ref1 to Ref2.)
- Press **Horizontal Position** to toggle between the Lock and Independent modes. In Lock mode, the horizontal position of the selected reference waveform is locked to the live waveforms. In Independent mode, the selected reference waveform is independently positionable.

NOTE

If you save a waveform to a "full" reference waveform, its previous contents will be overwritten.

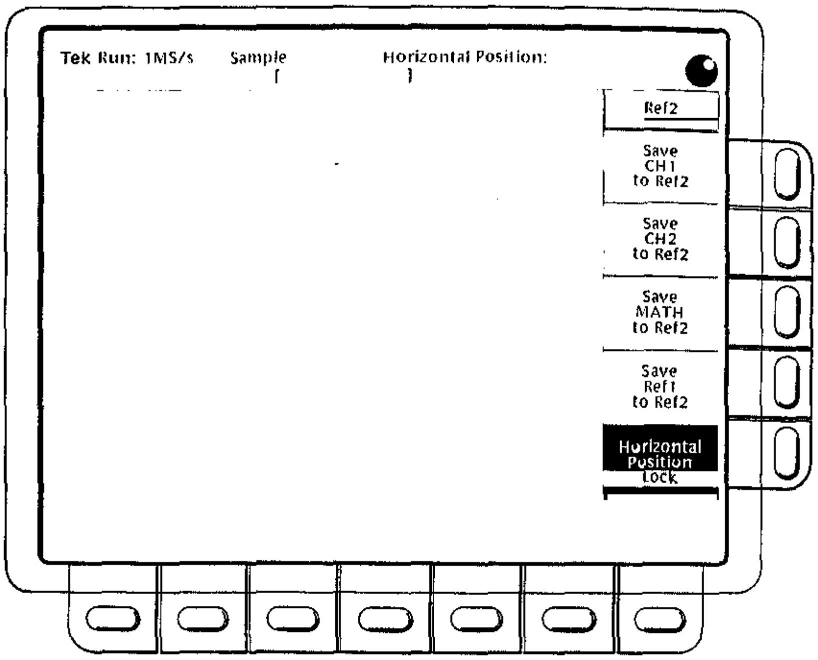


Figure 3-12: A Reference Waveform Menu

The reference waveforms maintain their contents indefinitely, regardless of the power state or setup of the instrument. To remove a selected reference waveform from the display, press **WAVEFORM OFF**. To recall a reference waveform simply press its front panel button (**REF 1** or **REF 2**).

Triggering

TDS 300 Series oscilloscopes have two triggers: a standard edge trigger and a video trigger. To access trigger settings and features, press the **TRIGGER MENU** button, shown in Figure 3-13.

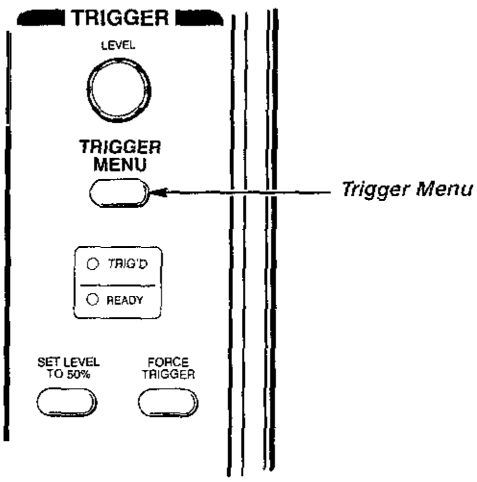


Figure 3-13: The TRIGGER MENU Button

This button calls up one of two menus: the edge trigger menu or the video trigger menu. Press the leftmost main menu button to switch between the two trigger menus.

Edge Triggering

The edge trigger triggers on the rising or falling edge of the input signal. You can access edge trigger settings through the edge trigger menu, shown in Figure 3-14. Be sure the leftmost main menu selection indicates **Type Edge**.

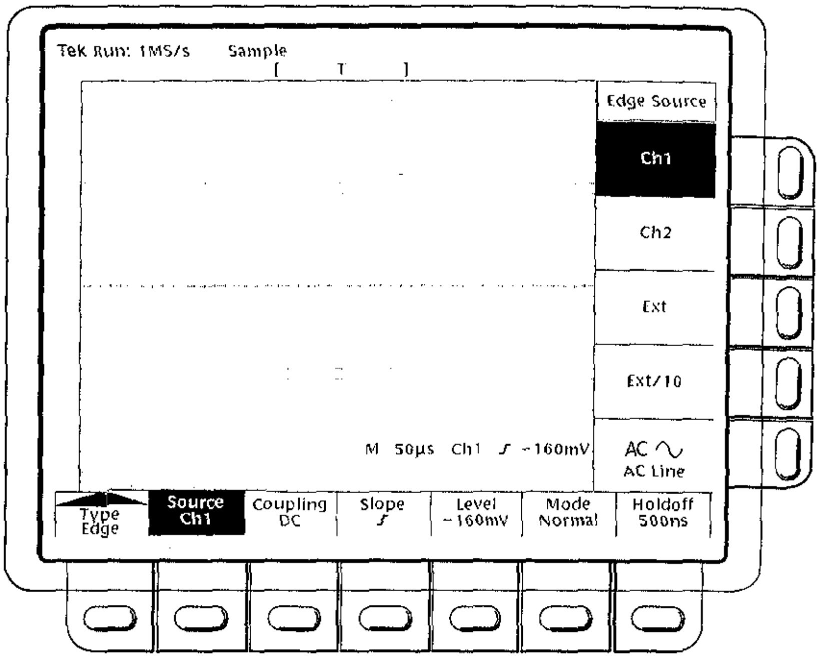


Figure 3-14: The Edge Trigger Menu

Use the edge trigger menu to perform these tasks.

Select the Trigger Source — Press the main menu button **Source.** Use the side menu to select from these options.

- Press **Ch1** or **Ch2** to set the trigger source to one of the input channels.
- Press **Ext** or **Ext/10** to set the trigger source to the **EXT TRIG** input on the front panel. **Ext/10** attenuates the external input signal by a factor of ten. Note that while the instrument can trigger on external trigger signals, it cannot display them.
- Press **AC** to set the trigger source to the oscilloscope line voltage signal.

Select Trigger Coupling — Press the main menu button **Coupling.** Use the side menu to select from these options.

- Press **DC** to select DC coupling.
- Press **AC** to select AC coupling.
- Press **HF Reject** to select high frequency reject mode. High frequency rejection removes the high frequency portion of the triggering signal. This allows only the low frequency components to pass on to the triggering system. High frequency reject mode attenuates signals above 30 kHz.
- Press **LF Reject** to select low frequency reject mode. Low frequency rejection is the opposite of high frequency rejection. Low frequency reject mode attenuates signals below 80 kHz.

- Press **Noise Reject** to select noise reject mode. Noise rejection provides DC low sensitivity, but it requires additional signal amplitude for stable triggering.

Change Trigger Slope — Press the main menu button **Slope**. Use the top two side menu buttons to switch between positive-going and negative-going slope.

Adjust Trigger Level — Press the main menu button **Level**. Use the side menu to select from these options.

- Use the **General Purpose Knob** to adjust trigger level. (Note that this selection performs the same function as the trigger **LEVEL** knob on the front panel.)
- Press **Set to TTL** to automatically set the trigger level to the TTL switching threshold.
- Press **Set to ECL** to automatically set the trigger level to the ECL switching threshold.
- Press **Set to 50%** to set the trigger level to the midpoint of the trigger source signal. (Note that this selection performs the same function as the **SET LEVEL TO 50%** button on the front panel.)

Select Trigger Mode — Press the main menu button **Mode**. Use the side menu to select either **Auto** or **Normal** mode.

In normal trigger mode, the oscilloscope waits for a valid trigger from the trigger signal source. In auto trigger mode, the oscilloscope produces an internal trigger in the absence of other trigger events.

At horizontal scale settings of 100 ms per division and slower, auto trigger mode switches to an untriggered roll display. When the display is in "roll" mode the envelope and average acquisition modes does not work properly, and the display does not show a trigger "T" on the waveform.

Adjust Holdoff — Press the main menu button **Holdoff** to activate the **General Purpose Knob**. Use the knob to adjust holdoff; the TDS 300 Series have a holdoff range of 500 ns to 10 s. Press the side menu button **Set to Min** to quickly set the holdoff to 500 ns.

Taking Measurements

TDS 300 Series oscilloscopes have two features that make them easy for you to obtain quantitative data from a displayed waveform: automated measurements and cursors.

Automated Measurements

The oscilloscope can perform 21 different automated measurements on a waveform (four measurements at any one time). To access these measurements, press the **MEASURE** button, shown in Figure 3-16.

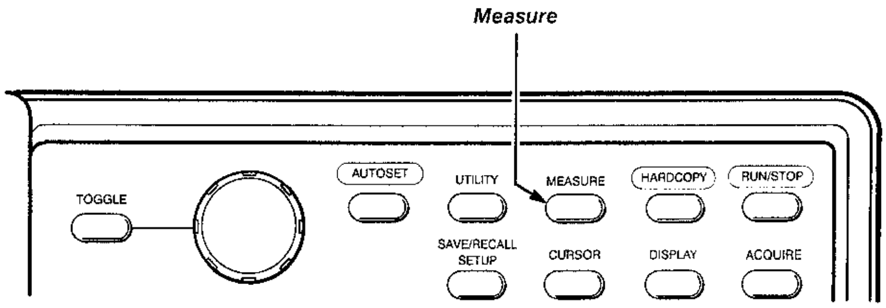


Figure 3-16: The MEASURE Button

The **MEASURE** button activates the measure menu, shown in Figure 3-17.

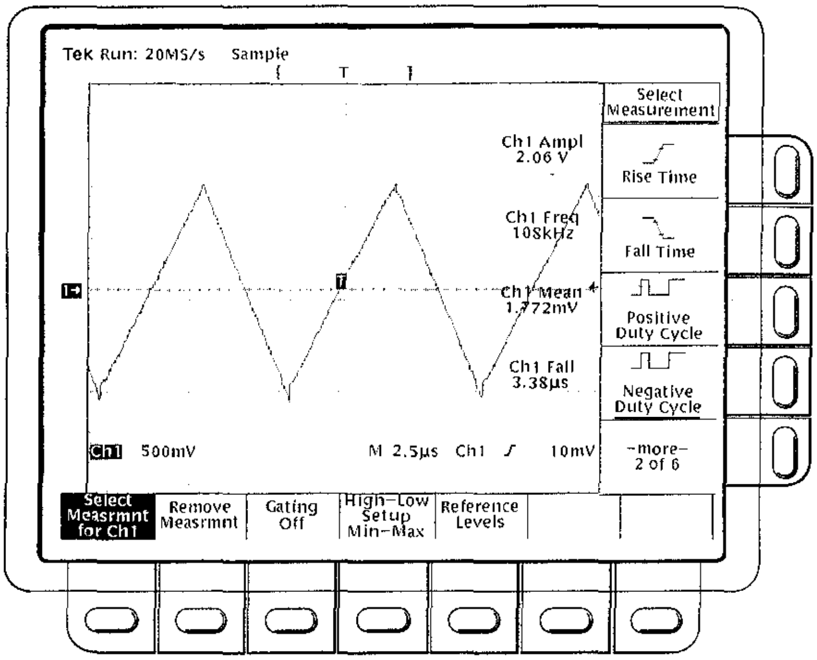


Figure 3-17: The Measure Menu and Active Measurements

Use the measure menu to perform the following tasks.

Activate a Measurement — Use this procedure to activate a measurement for the selected waveform.

1. Press the main menu button **Select Measrmnt for....**
2. If necessary, press the lowermost side menu button (labeled **–more– x out of 6**) to page through the available measurements until the measurement you want to take appears in the side menu.
3. Then press one of the top four side menu buttons to activate a particular measurement.

The measured values appear to the left of the side menu, as shown in Figure 3-17. For definitions of the available measurements, see Table 3-1.

NOTE

*Measurements only remain active while the channel is active. If you activate several measurements for a channel and then press the **WAVEFORM OFF** button, the measurements disappear just like the waveform.*

Table 3-1: Measurement Definitions

Name	Definition
Period	Timing measurement. Time it takes for the first complete signal cycle to happen in the waveform or gated region. The reciprocal of frequency. Measured in seconds.
Frequency	Timing measurement for the first cycle in the waveform or gated region. The reciprocal of the period. Measured in Hertz (Hz) where 1 Hz = 1 cycle per second.
Positive Width	Timing measurement of the first pulse in the waveform or gated region. The distance (time) between MidRef (default 50%) amplitude points of a positive pulse.
Negative Width	Timing measurement of the first pulse in the waveform or gated region. The distance (time) between MidRef (default 50%) amplitude points of a negative pulse.
Rise time	Timing measurement. Time taken for the leading edge of the first pulse in the waveform or gated region to rise from a Low Ref value (default = 10%) to a High Ref value (default = 90%) of its final value.
Fall Time	Timing measurement. Time taken for the falling edge of the first pulse in the waveform or gated region to fall from a High Ref value (default = 90%) to a Low Ref value (default =10%) of its final value.
Positive Duty Cycle	Timing measurement of the first cycle in the waveform or gated region. The ratio of the positive pulse width to the signal period expressed as a percentage. $$PositiveDutyCycle = \frac{PositiveWidth}{Period} \times 100\%$$
Negative Duty Cycle	Timing measurement of the first cycle in the waveform or gated region. The ratio of the negative pulse width to the signal period expressed as a percentage. $$NegativeDutyCycle = \frac{NegativeWidth}{Period} \times 100\%$$
Burst Width	Timing measurement. The duration of a burst. Measured over the entire waveform or gated region.
Positive Overshoot	Voltage measurement over the entire waveform or gated region. $$PositiveOvershoot = \frac{Max - High}{Amplitude} \times 100\%$$
Negative Overshoot	Voltage measurement. Measured over the entire waveform or gated region. $$NegativeOvershoot = \frac{Low - Min}{Amplitude} \times 100\%$$
High	The value used as 100% whenever High Ref, Mid Ref, and Low Ref values are needed (as in fall time and rise time measurements). Measured over the entire waveform or gated region.

Table 3-1: Measurement Definitions (Cont.)

Name	Definition
Low	The value used as 0% whenever High Ref, Mid Ref, and Low Ref values are needed as in fall time and rise time measurements. Measured over the entire waveform or gated region.
Maximum	Voltage measurement. The maximum amplitude. Typically the most positive peak voltage. Measured over the entire waveform or gated region.
Minimum	Voltage measurement. The minimum amplitude. Typically the most negative peak voltage. Measured over the entire waveform or gated region.
Peak to Peak	Voltage measurement. The absolute difference between the maximum and minimum amplitude in the entire waveform or gated region.
Amplitude	Voltage measurement. The high value less the low value measured over the entire waveform or gated region. $Amplitude = High - Low$
Mean	Voltage measurement. The arithmetic mean over the entire waveform or gated region.
Cycle Mean	Voltage measurement. The arithmetic mean over the first cycle in the waveform, or the first cycle in the gated region.
Cycle RMS	Voltage measurement. The true Root Mean Square voltage over the first cycle in the waveform, or the first cycle in the gated region.
RMS	Voltage measurement. The true Root Mean Square voltage over the entire waveform or gated region.

Remove a Measurement — Press the main menu button **Remove Measrmnt**. Use the top four side menu buttons to remove specific measurements or use the lowest side menu button to remove all measurements.

Use Gating — By default, TDS 300 Series oscilloscopes take automated measurements on the entire waveform record. If you want a measurement of only a portion of the waveform, you can use gating to mark the boundaries of that portion. Use this procedure to "gate" a signal.

1. Press the main menu button **Select Measrmnt for...**.
2. If necessary, press the lowermost side menu button (labeled **–more– x out of 6**) to page through the available measurements until the measurement you want to take appears in the side menu.
3. Then press one of the top four side menu buttons to activate a particular measurement.
4. Press the main menu button **Gating**.
5. Press the side menu button **Gate with V Bar Cursors**.
6. Use the **General Purpose Knob** to set one cursor to the left edge of your gate.

7. Press **TOGGLE**.
8. Use the **General Purpose Knob** to set the other cursor to the right edge of the gate. All automated measurements now take data only from the portion of the waveform that is within the gate.
9. Press **Gate Off** to turn gating off.

NOTE

***Gate Off** deactivates the gating function, but it does not deactivate the vertical cursors. Deactivate the cursors from the cursor menu as described in the next section.*

Switch High-Low Setup — Press the main menu button **High–Low Setup** to change the way the measurement system determines the high and low levels of waveforms. Use the side menu to select from these options.

- Press **Histogram** to set the levels statistically. The oscilloscope attempts to find the highest density of points above and below the midpoint, ignoring spikes. This method works well for measuring square waves and pulse waveforms.
- Press **Min–Max** to set the levels to the lowest amplitude (most negative) and highest amplitude (most positive) samples.

Set Reference Levels — Press the main menu button **Reference Levels** to set the high, middle, and low reference levels. The oscilloscope uses these levels for rise time, fall time, width, and overshoot measurements. Use the side menu to select from these options.

- Press **Set Levels in** to toggle the units of the reference levels. Switch between volts and percent.
- Press **High Ref, Mid Ref,** or **Low Ref** to select a particular reference level. Use the **General Purpose Knob** to alter the selected reference level. The defaults are 90%, 50%, and 10%, respectively.

Taking Measurements with Cursors

You can also take quantitative measurements of a waveform with the cursor system. To take measurements with cursors, follow this procedure.

1. Press the front panel button **CURSOR**, shown in Figure 3-18. The **CURSOR** button calls up the cursor menu, shown in Figure 3-19.

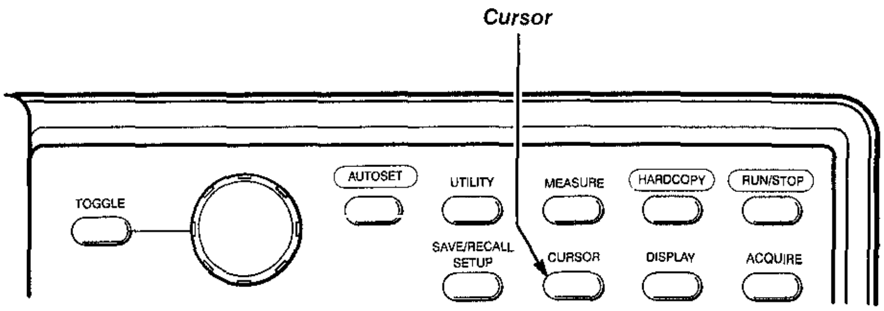


Figure 3-18: The CURSOR Button

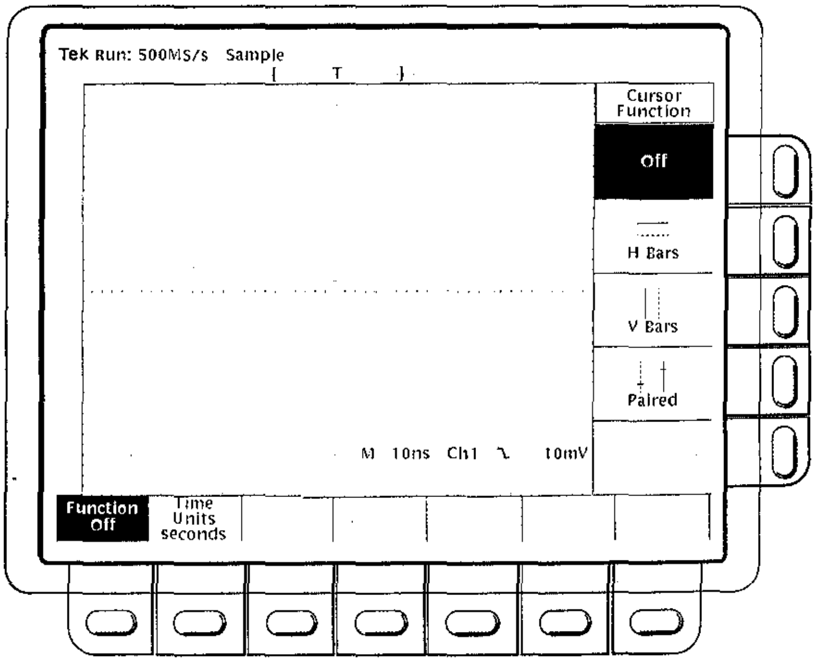


Figure 3-19: The Cursor Menu

2. If you want to take a time measurement in Hertz instead of seconds, press the main menu button **Time Units** and use the side menu to switch between the two.

3. If the main menu selection **Function** is not highlighted, press its main menu button.

4. Use the side menu to select the type of measurement you want to take. Select **H Bars** to take a voltage measurement, select **V Bars** to take a time measurement, or select **Paired** to take simultaneous voltage and time measurements.

5. Use the **General Purpose Knob** to move one cursor to a desired measurement point. For example, if you wanted to measure both the peak-to-peak voltage and period of a sine wave, you would start by moving one paired cursor to a “trough” (see Figure 3-20).

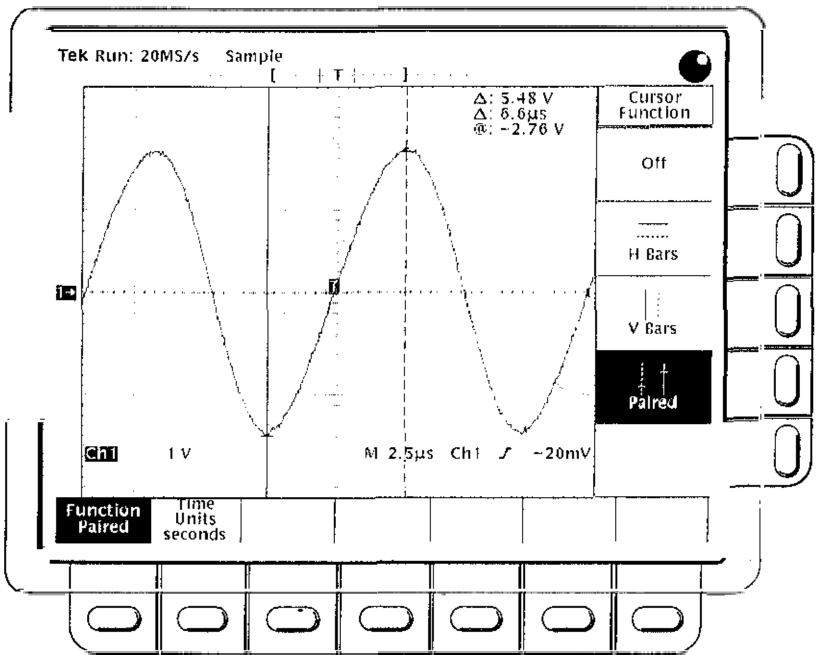


Figure 3-20: Paired Cursor Measurements of a Sine Wave

6. Press **TOGGLE**.
7. Use the **General Purpose Knob** to move the second cursor to another desired measurement point. To continue the example, you would move the second cursor to the previous “peak.”
8. Read the measured value(s) at the upper right corner of the display next to the Δ sign(s). Figure 3-20 shows a sine wave with a 5.48 V_{p-p} and a 13.2 μs period (6.6 μs X 2).

Warranted Characteristics

Warranted characteristics are described in terms of quantifiable performance limits that are warranted. This subsection lists only warranted characteristics.

NOTE

In these tables, those warranted characteristics that are checked in the Performance Tests, *starting on page 6-11, appear in* ***boldface type*** *under the column* Name.

Performance Conditions

The electrical characteristics found in these tables of warranted characteristics apply when the oscilloscope has been adjusted at an ambient temperature between +20° C and +30° C, has had a warm-up period of at least 20 minutes, and is operating at an ambient temperature between −10° C and +55° C (unless otherwise noted).

Table 4-1: Warranted Characteristics — Signal Acquisition System

Name	Description	
Accuracy, DC Voltage Measurement, Average Acquisition Mode	**Measurement Type**	**DC Accuracy**
	Average of ≥16 waveforms	±(2.0% × |(reading − Net Offset)| + Offset Accuracy + 0.1 div)
	Delta volts between any two averages of ≥16 waveforms acquired under the same setup and ambient conditions	±(2.0% × |reading| + 0.15 div + 0.3 mV)
Accuracy, DC Gain, Sample or Average Acquisition Modes	±2%	
Pulse Response, Peak Detect and Envelope Mode	**Sec/Div Setting**	**Minimum Pulse Width**
	5 s/div − 25 µs/div	10 ns
	10 µs/div − 10 ns/div (TDS 310) 10 µs/div − 5 ns/div (TDS 320) 10 µs/div − 2.5 ns/div (TDS 350)	The greater of 10 ns or .02 × sec/div setting

Table 4-1: Warranted Characteristics — Signal Acquisition System (Cont.)

Name	Description	
Accuracy, Offset	**Volts/Div Setting**	**Offset Accuracy**
	2 mV/div – 99.5 mV/div	±(0.4% × |Net Offset[1]| + 3 mV + 0.1 div × V/div setting)
	100 mV/div – 995 mV/div	±(0.4% × |Net Offset[1]| + 30 mV + 0.1 div × V/div setting)
	1 V/div – 10 V/div	±(0.4% × |Net Offset[1]| + 300 mV + 0.1 div × V/div setting)
Analog Bandwidth, DC Coupled	DC – ≥50 MHz (TDS 310) DC – ≥100 MHz (TDS 320) DC – ≥200 MHz (TDS 350); DC – ≥180 MHz for 2 mV/div	
Cross Talk (Channel Isolation)	≥100:1 at 50 MHz with equal Volts/Div settings on each channel	
Input Impedance, DC-Coupled	1 MΩ ±1% in parallel with 20 pF ±2.0 pF	
Input Voltage, Maximum	±400 V (DC + peak AC); derate at 20 dB/decade above 100 kHz to 13 V peak AC at 3 MHz and above	
Lower Frequency Limit, AC Coupled[2]	≤10 Hz	

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

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

Table 4-2: Warranted Characteristics — Time Base System

Name	Description
Accuracy, Long Term Sample Rate and Delay Time	±100 ppm over any ≥1 ms interval
Accuracy, Delta Time Measurements[1, 2]	For single-shot acquisitions using sample acquisition mode and a bandwidth limit setting of FULL: ±(1 WI + 100 ppm × |Reading| + 0.6 ns) For repetitive acquisitions using average acquisition mode with ≥16 averages and a bandwidth limit setting of FULL: ±(1 WI + 100 ppm × |Reading| + 0.4 ns)

[1]For input signals ≥5 divisions in amplitude and a slew rate of ≥2.0 divisions/ns at the delta time measurement points. Signal must be acquired at a volts/division setting ≥5 mV/division.
[2]The WI (waveform interval) is the time between the samples in the waveform record. Also, see the footnotes for *Sample Rate Range* and *Equivalent Time or Interpolated Waveform Rates* in Table 4-11 on page 4-12.

Table 4-3: Warranted Characteristics — Triggering System

Name	Description	
Accuracy, Trigger Level, DC Coupled	**Trigger Source**	**Sensitivity**
	CH1 or CH2	$\pm(3\%$ of $\vert\text{Setting} - \text{Net Offset}^{1}\vert + 0.2$ div $\times$ volts/div setting + Offset Accuracy$)$
	External	$\pm(6\%$ of $\vert\text{Setting}\vert + 20$ mV$)$
	External/10	$\pm(6\%$ of $\vert\text{Setting}\vert$ 200 mV$)$
Sensitivity, Edge-Type Trigger, DC Coupled	**Trigger Source**	**Sensitivity**
	CH1 or CH2	TDS 310: 0.35 division from DC to 20 MHz, increasing to 1 div at 50 MHz
		TDS 320: 0.35 division from DC to 50 MHz, increasing to 1 div at 100 MHz
		TDS 350: 0.35 division from DC to 50 MHz, increasing to 1 div at 200 MHz
	External	TDS 310: 50 mV from DC to 20 MHz, increasing to 150 mV at 50 MHz
		TDS 320: 50 mV from DC to 50 MHz, increasing to 150 mV at 100 MHz
		TDS 350: 50 mV from DC to 50 MHz, increasing to 150 mV at 200 MHz
	External/10	TDS 310: 500 mV from DC to 20 MHz, increasing to 1.5 V at 50 MHz
		TDS 320: 500 mV from DC to 50 MHz, increasing to 1.5 V at 100 MHz
		TDS 350: 500 mV from DC to 50 MHz, increasing to 1.5 V at 200 MHz
Input Impedance, External Trigger	1 MΩ ±2% in parallel with 20 pF ±2 pF	
Maximum Input Voltage, External Trigger	±400 V (DC + peak AC); derate at 20 dB/decade above 100 kHz to 13 V peak AC at 3 MHz and above	

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

Table 4-4: Power Requirements

Name	Description
Source Voltage and Frequency	90 to 132 VAC_{RMS}, continuous range, for 47 Hz through 440 Hz 132 to 250 VAC_{RMS}, continuous range, for 47 Hz through 63 Hz
Power Consumption	≤65 Watts (120 VA)

Table 4-5: Warranted Characteristics — Environmental, Safety, and Reliability

Name	Description
Atmospherics	Temperature: −10° C to +55° C, operating; −51° C to +71° C, non-operating Relative humidity: to 95%, at or below +40° C; to 75%, +41° C to +55° C Altitude: To 15,000 ft (4570 m), operating; to 40,000 ft (12190 m), non-operating
Dynamics	Random vibration: 0.31 g_{RMS}, from 5 to 500 Hz, 10 minutes each axis, operating; 2.46 g_{RMS}, from 5 to 500 Hz, 10 minutes each axis, non-operating
Emissions[1]	Meets or exceeds the requirements of the following standards: EN 50081−1 European Community Requirements EN 55022 radiated emissions EN 55022 Class B conducted emissions EN 60555−2 power harmonics VFG 0243 FCC Rules and Regulations, 47 CFR, Part 15, Subpart B, Class A
Susceptibility[2]	TDS 310 and TDS 320: ≤±0.2 division waveform displacement, or ≤0.4 division increase in p-p noise. TDS 350: ≤±0.2 division waveform displacement, or ≤0.4 division increase in p-p noise below 200 MHz. ≤±0.3 division waveform displacement, or ≤±0.6 division increase in p-p noise from 200 MHz to 500 MHz. The instruments are subjected to the EMI specified in the following standards: EN 50082−1 European Community Requirements IEC 801−3 radiated susceptibility IEC 801−4 fast transients IEC 801−5 AC surge

[1]To maintain emission requirements when connecting to the I/O interface of this oscilloscope, use only a high-quality, double-shielded (braid and foil) cable. The cable shield must have low impedance connections to both connector housings. Acceptable cables are listed in Table 1-4 on page 1-6.

[2]Susceptibility test run with both channel inputs terminated with grounding caps, both channels set to 2 mV/Div, DC Coupling, the trigger source set to Line, the Acquisition Mode set to Peak Detect, and the time base set to 25 μs/Div.

Typical Characteristics

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

Table 4-6: Typical Characteristics — Signal Acquisition System

Name	Description			
Accuracy, DC Gain, Envelope Acquisition Mode	±3% for sec/div settings from 5 Sec/Div to 25 µsec/div; ±2% for sec/div settings from 10 µs/div to 10 ns/div (TDS 310); ±2% for sec/div settings from 10 µs/div to 5 ns/div (TDS 320); ±2% for sec/div settings from 10 µs/div to 2.5 ns/div (TDS 350)			
Accuracy, DC Voltage Measurement, Sample Acquisition Mode	**Measurement Type**		**DC Accuracy**	
	Any Sample		±(2.0% × (|reading − Net Offset[1]|) + Offset Accuracy + 0.13 div + 0.6 mV)	
	Delta Volts between any two samples[2] acquired under the same setup and ambient conditions		±(2.0% × |reading| + 0.26 div + 1.2 mV)	
Frequency Limit, Upper, 20 MHz Bandwidth Limited	20 MHz			
Step Response Settling Error	**Volts/Div Setting**	**Step Amplitude**	**Settling Error (%)[3]**	
			100 ns	**20 ms**
	2 mV/div – 99.5 mV/div	≤2 V	≤1.0	≤0.1
	100 mV/div – 995 mV/div	≤20 V	≤1.5	≤0.2
	1 V/div – 10 V/div	≤200 V	≤2.5	≤0.2
Common Mode Rejection Ratio (CMRR)	100:1 at 60 Hz, reducing to 20:1 at 50 MHz, with equal Volts/Div and Coupling settings on each channel.			

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

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

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

[4]*Reference is a 9-div p-p sine wave input sampled at 200 MS/s for the TDS 310, 500 MS/s for the TDS 320, and 1 GS/s for the TDS 350.*

Table 4-7: Typical Characteristics — Triggering System

Name	Description	
Error, Trigger Position, Edge Triggering	**Acquire Mode**	**Trigger-Position Error[1,2]**
	Sample, Average	±(1 WI + 2 ns)
	Peak Detect, Envelope	±(2 WI + 2 ns)
Sensitivity, Video-Type Trigger	**Source**	**Typical Sensitivity**
	CH1 or CH2 External External/10	0.6 division of video sync signal 75 mV of video sync signal 750 mV of video sync signal
Lowest Frequency for Successful Operation of "Set Level to 50%" Function	50 Hz	
Sensitivity, Edge Type Trigger, Not DC Coupled[3]	**Trigger Coupling**	**Typical Signal Level for Stable Triggering**
	AC	Same as DC-coupled limits[4] for frequencies above 60 Hz. Attenuates signals below 60 Hz.
	Noise Reject	Three and one half times the DC-coupled limits.[4]
	High Frequency Reject	One and one half times times the DC-coupled limits[4] from DC to 30 kHz. Attenuates signals above 30 kHz.
	Low Frequency Reject	One and one half times the DC-coupled limits[4] for frequencies above 80 kHz. Attenuates signals below 80 kHz.

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

[2]The waveform interval (WI) is the time between the samples in the waveform record. Also, see the footnote for the characteristics *Sample Rate Range* and *Equivalent Time or Interpolated Waveform Rates* in Table 4-11 on page 4-12.

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

[4]See the characteristic *Sensitivity, Edge-Type Trigger, DC Coupled* in Table 4-3, which begins on page 4-5.

Table 4-8: Typical Characteristics — Probe Compensator Output

Name	Description	
Output Voltage and Frequency, Probe Compensator	**Characteristic**	
	Voltage	5.0 V (low-high) into a 1 MΩ load
	Frequency	1 kHz

Nominal Traits

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

Table 4-10: Nominal Traits — Signal Acquisition System

Name	Description	
Bandwidth Selections	20 MHz and FULL	
Digitizers, Number of	Two, identical, digitized simultaneously	
Digitized Bits, Number of	8 bits[1]	
Input Channels, Number of	Two, identical, called CH 1 and CH 2	
Input Coupling	DC, AC, or GND	
Ranges, Offset, All Channels	**Volts/Div Setting**	**Offset Range**
	2 mV/div – 99.5 mV/div	±1 V
	100 mV/div – 995 mV/div	±10 V
	1 V/div – 10 V/div	±100 V
Range, Position	±5 divisions	
Range, Sensitivity[2]	2 mV/div to 10 V/div	
Rise Time	TDS 310: 7 ns TDS 320: 3.5 ns TDS 350: 1.75 ns	
TekProbe Interface	Level one probe coding	

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

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

Table 4-11: Nominal Traits — Time Base System

Name	Description
Range, Sample-Rate[1,2]	TDS 310: 10 Samples/s to 200 MSamples/s in a 1–2–5 sequence TDS 320: 10 Samples/s to 500 MSamples/s in a 1–2–5 sequence TDS 350: 10 Samples/s to 1 GSamples/s in a 1–2–5 sequence
Range, Seconds/Division	TDS 310: 10 ns/div to 5 s/div in a 1–2.5–5 sequence TDS 320: 5 ns/div to 5 s/div in a 1–2.5–5 sequence TDS 350: 2.5 ns/div to 5 s/div in a 1–2.5–5 sequence
Range, Time Base Delay Time	16.5 ns to 50 seconds
Record Length	1,000 samples

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

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

Table 4-12: Nominal Traits — Triggering System

Name	Description	
Range, Hold Off	500 ns minimum to 10 seconds maximum	
Ranges, Trigger Level	**Source**	**Range**
	Any Channel	±12 divisions from center of screen
	External	±1.5 Volts
	External /10	±15 Volts
	Line	±300 Volts
Formats and Field Rates, Video Trigger	Triggers from sync-negative composite video, 525 to 625 lines, 50 Hz to 60 Hz, interlaced systems – such as NTSC, PAL, or SECAM	
TekProbe Interface, External Trigger	Level one probe coding	

Table 4-13: Nominal Traits — Display System

Name	Description
CRT Type	7-inch (17.95 cm) diagonal, magnetic deflection; horizontal raster-scan; P31 green phosphor
Video Display Resolution	640 pixels horizontally by 480 pixels vertically Display area is 5.04 inch (12.92 cm) horizontally by 3.78 inch (9.69 cm) vertically

Table 4-13: Nominal Traits — Display System (Cont.)

Name	Description
Waveform Display Graticule	A single graticule 401 × 501 pixels (8 × 10 divisions, with divisions that are approximately 1 cm by 1 cm)
Intensity Levels	Dim and Bright, with adjustable Overall Intensity and Contrast

Table 4-14: Nominal Traits — Interfaces

Name	Description
GPIB	Part of Option 14 I/O interface or TDS3F14 I/O interface field upgrade kit; complies with IEEE Std 488–1987
RS-232	Part of Option 14 I/O interface or TDS3F14 I/O interface field upgrade kit; a 9-pin male DTE RS-232 interface that complies with EIA/TIA 574–90
Centronics	Part of Option 14 I/O interface or TDS3F14 I/O interface field upgrade kit; a 25-pin, IBM PC-type, parallel printer interface that complies electrically with Centronics C332–44, Rev A

Table 4-15: Nominal Traits — Power Distribution System

Name	Description
Fuse Rating	5 mm × 20 mm, (UL 198 G): 3 A Slow, 250 V, (IEC 127): 3.15 A (T), 250 V

Table 4-16: Nominal Traits — Safety Characteristics

Name	Description
Safety Certification	Listed UL 1244; Category Certified CAN/CSA–C22.2 No. 231 Series-M89

Table 4-17: Nominal Traits — Mechanical Characteristics

Name	Description
Weight	
Standard Instrument	6.8 kg (15 lbs) stand-alone instrument; 8.4 kg (18.5 lbs) with front cover, accessories, and accessories pouch installed; 12.7 kg (28 lbs) when packaged for domestic shipment

Performance Verification

These procedures verify the TDS 310, TDS 320, and TDS 350 two channel oscilloscopes. Depending on what you want to accomplish, you may only need to perform a few of these procedures.

- To rapidly confirm that this oscilloscope functions, just do the procedures under *Self Tests*, which begin on page 6-5.

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

- To further check functionality, do the procedures under *Functional Tests* that begin on page 6-7.

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

- If you need a more extensive confirmation of performance, do the *Performance Tests*, beginning on page 6-11, after doing the *Functional* and *Self Tests* just referenced.

  Advantages: These procedures add direct checking of warranted specifications. They require more time and suitable test equipment. (See *Equipment Required* on page 6-3.)

Conventions

Throughout these procedures the following conventions apply:

- Each test procedure uses the following general format:

  Title of Test

  Equipment Required

  Time Required

  Prerequisites

  Procedure

- Refer to Figure 6-1: "Main menu" refers to the menu that labels the seven menu buttons under the display. "Side menu" refers to the menu that labels the five buttons to the right of the display. "Pop-up menu" refers to a menu that pops up when a main menu button is pressed.

- Where instructed to use a front-panel button or knob, select from a main or side menu, or verify a readout or status message, the name of the button or knob appears in boldface type.
- Instructions for menu selection follow this format: **FRONT PANEL BUTTON → Pop-Up (if necessary) → Main Menu Button → Side Menu Button**. For example, "Push **TRIGGER MENU → Type: Video → Trigger On → Any Line**."

This symbol denotes information you must read to do the procedure properly.

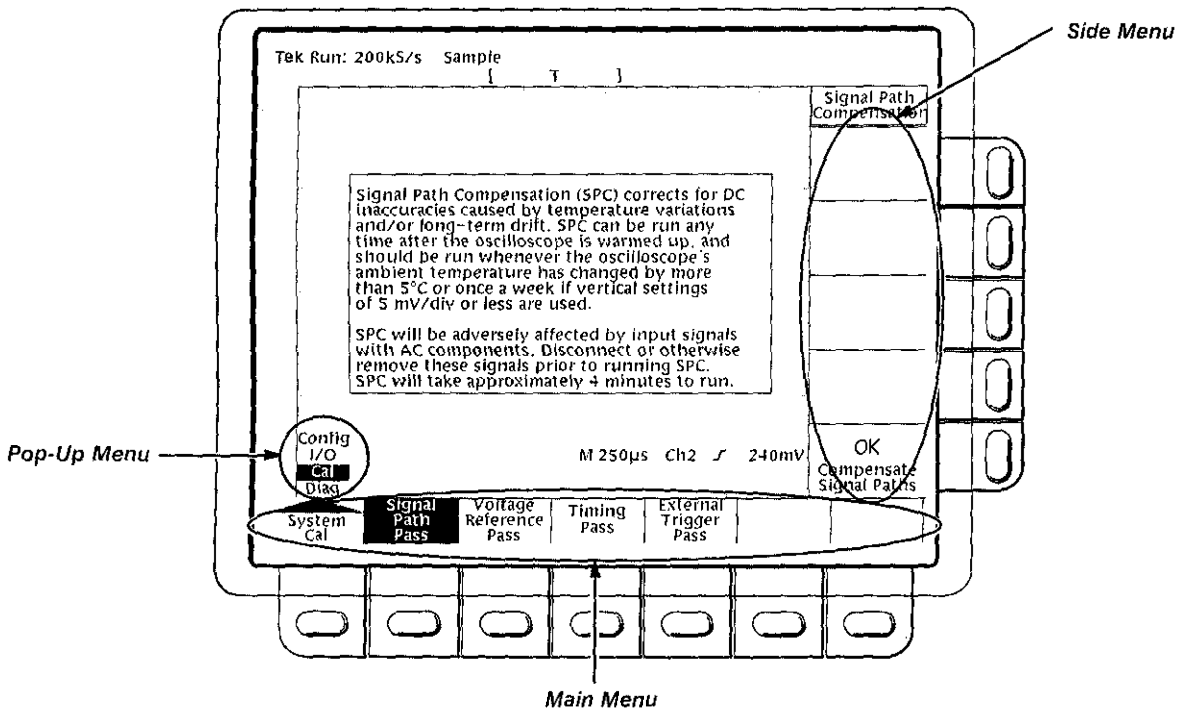


Figure 6-1: Menu Locations

Test Equipment

These procedures use external, traceable signal sources to directly check instrument performance. If your test equipment does not meet the minimum requirements listed in Table 6-1, your test results will be invalid.

Table 6-1: Test Equipment

Item Number and Description		Minimum Requirements	Example	Purpose
1	Termination 50 Ω (two required)	Impedance 50 Ω; connectors: female BNC input, male BNC output	Tektronix part number 011-0049-01	Checking delay between channels
2	Cable, Precision Coaxial (two required)	50 Ω, 91 cm (36 in), male to male BNC connectors	Tektronix part number 012-0482-00	Signal interconnection
3	Connector, Dual-Banana	Female-BNC to dual-banana	Tektronix part number 103-009-00	Several accuracy tests
4	Connector, BNC "T"	Male-BNC to dual-female-BNC	Tektronix part number 103-0030-00	Checking trigger sensitivity
5	Coupler, Dual-Input	Female-BNC to dual-male-BNC	Tektronix part number 067-0525-02	Checking delay between channels
6	Generator, DC Calibration	Variable amplitude to ±110 V; accuracy to 0.1%	Data Precision 8200	Checking DC offset, gain, and measurement accuracy
7	Generator, Leveled Sine Wave, Medium-Frequency	200 kHz to 250 MHz; variable amplitude from 5 mV to 4 V_{p-p} into 50 Ω	TEKTRONIX SG 503 Leveled Sine Wave Generator	Checking trigger sensitivity at low frequencies
8	Generator, Time Mark	Variable marker frequency from 10 ms to 10 ns; accuracy within 2 ppm	TEKTRONIX TG 501A Time Mark Generator	Checking sample rate and delay-time accuracy
9	Probe, 10X, included with this instrument	A P6109B (TDS 310 and TDS 320) or P6111B (TDS 350) probe	Tektronix number P6109B (TDS 310 and TDS 320) or P6111B (TDS 350)	Signal interconnection

Test Record

Photocopy the next page and use it to record the performance test results for your instrument.

TDS 310, TDS 320, and TDS 350 Test Record

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

Performance Test		Minimum	Incoming	Outgoing	Maximum
DC Voltage Measurement Accuracy					
CH1 VOLTS/DIV	1 V	+97.1 V	______	______	+98.9 V
	200 mV	+8.28 V	______	______	+8.52 V
	50 mV[1]	−581 mV	______	______	−619 mV
	50 mV[2]	−881 mV	______	______	−919 mV
	Δ at 50 mV	+286 mV	______	______	+314 mV
	10 mV	+54.6 mV	______	______	+65.4 mV
	5 mV	−982 mV	______	______	−998 mV
CH2 VOLTS/DIV	1 V	+97.1 V	______	______	+98.9 V
	200 mV	+8.28 V	______	______	+8.52 V
	50 mV[1]	−581 mV	______	______	−619 mV
	50 mV[2]	−881 mV	______	______	−919 mV
	Δ at 50 mV	+286 mV	______	______	+314 mV
	10 mV	+54.6 mV	______	______	+65.4 mV
	5 mV	−982 mV	______	______	−998 mV
Analog Bandwidth					
CH1		42.5 mV	______	______	N/A
CH2		42.5 mV	______	______	N/A
Long Term Sample Rate and Delay Time Accuracy					
		−2.0 Div	______	______	+2.0 Div
Edge Trigger Sensitivity, DC Coupled					
Main Trigger		stable trigger	______	______	N/A
Main Trigger − Falling		stable trigger	______	______	N/A

[1] Generator set at −0.6 V.

[2] Generator set at −0.9 V.

Self Test

This procedure uses internal routines to verify that the oscilloscope functions and passes its internal self tests and signal path compensations. It also confirms that the oscilloscope was adjusted properly at the time it was last adjusted. No test equipment or hookups are required.

Equipment Required: None.

Time Required: Approximately 5 minutes.

Prerequisites: Power up the oscilloscope and allow a 20 minute warm-up before doing this procedure.

Procedure:

1. Press **UTILITY** → **System: Diag** → **Execute** → **OK Confirm Run Test**. The internal diagnostics verify proper oscilloscope function. This verification takes about 30 seconds. While it progresses, a variety of test patterns flash on screen. When finished, status messages appear on the screen.
2. Check that the screen reports no failures. If it reports a failure, the instrument has failed the self test. Proceed immediately to the troubleshooting procedure on page 8-30.
3. Press **CLEAR MENU.**
4. Press **UTILITY** → **System: Cal.**
5. Check that the word ***Pass*** appears in the main menu under the **Voltage Reference**, **Timing**, and **Ext Trig** menu labels. (See Figure 6-2.) If any of the labels read ***Fail***, the instrument has failed the self test. Proceed immediately to the system calibration procedure on page 7-2.

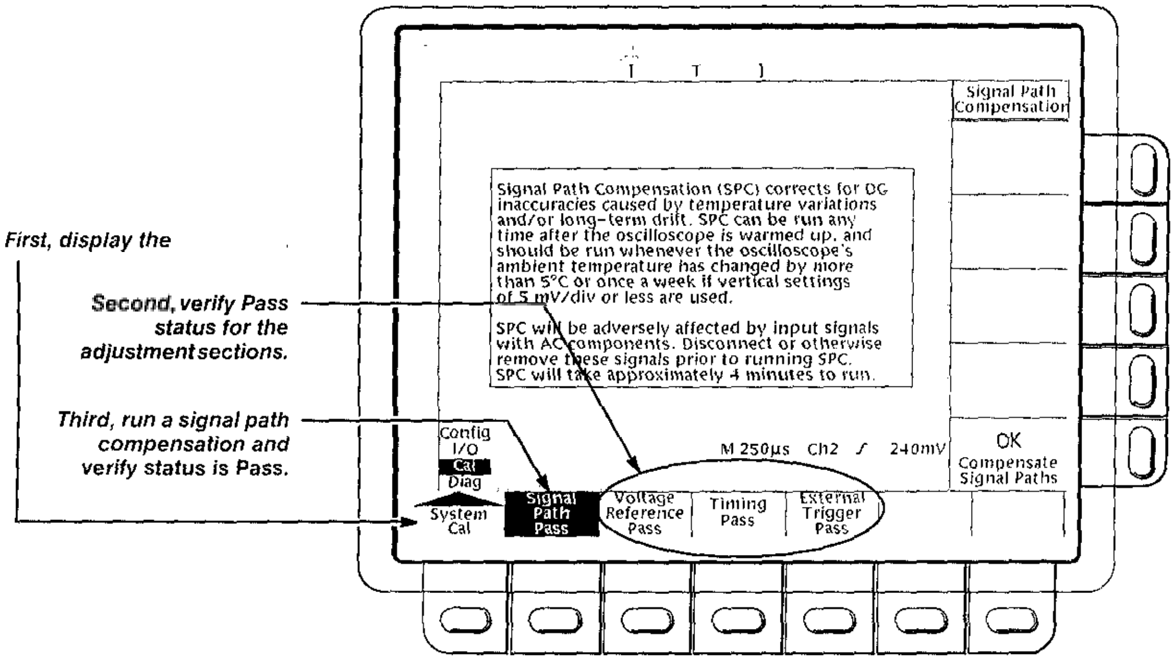


Figure 6-2: Verifying Adjustments and Signal Path Compensation

6. Press **Signal Path** → **OK Compensate Signal Paths**. When compensation completes, the status message updates to *Pass* or *Fail* in the main menu

7. Check that the word **Pass** appears under **Signal Path** in the main menu. (See Figure 6-2.) If ***Pass*** does not appear, the instrument has failed the performance verification; return it to Tektronix for servicing.

Functional Test

The purpose of this procedure is to confirm that the oscilloscope functions properly.

This procedure verifies functions; that is, it verifies that oscilloscope features *operate*. It does *not* verify that they operate within limits.

Therefore, when the instructions that follow call for you to verify that a signal appears on-screen "that is about five divisions in amplitude" or "has a period of about six horizontal divisions," etc., do *NOT* interpret the quantities given as limits. Operation within limits is checked in *Performance Tests*, which begin on page 6-11.

DO NOT make changes to the front-panel settings that are not called out in the procedure. If you make changes to these settings other than those called out in the procedure, you may obtain invalid results. In this case, just redo the procedure from step 1.

NOTE

If the oscilloscope fails any of these checks it has failed the performance verification. To diagnose the causes of a failure, proceed to the troubleshooting procedures on page 8-27.

Equipment Required: One P6109B (TDS 310 and TDS 320) or P6111B (TDS 350) probe (Item 9).

Time Required: Approximately 5 minutes.

Prerequisites: None.

Procedure:

1. Install the probe on **CH 1.** Connect the probe tip to **PROBE COMP** on the front panel; leave the probe ground unconnected. (See Figure 6-3.)

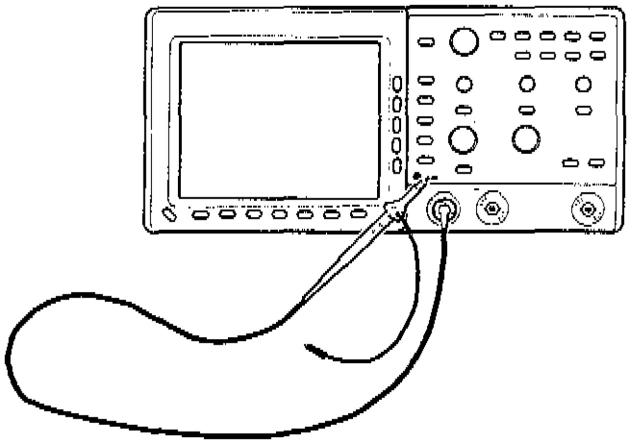


Figure 6-3: Hookup for Functional Test

2. Press **SAVE/RECALL SETUP → Recall Factory Setup → OK Confirm Factory Init.**
3. Press **AUTOSET**.
4. Set the **VOLTS/DIV** to 1 V. Use the vertical **POSITION** knob to center the waveform vertically on screen.
5. Set the **SEC/DIV** to 250 μs.
6. Check that a square-wave probe-compensation signal of about five divisions in amplitude is on screen. (See Figure 6-1 on page 6-2 to locate the readout.)
7. Check that one period of the square wave probe-compensation signal is about four horizontal divisions on screen.
8. Check that the horizontal **POSITION** knob positions the signal left and right on screen when rotated.
9. Press **TRIGGER MENU → Mode → Normal.**
10. Check that the trigger level readout for the main trigger system changes with the trigger **LEVEL** knob.
11. Check that the trigger-level knob can trigger and untrigger the square-wave signal as you rotate it. (Leave the signal *un*triggered.)
12. Check that pressing **SET LEVEL TO 50%** triggers the signal that you just left untriggered.
13. Press **ACQUIRE → Mode → Sample.**
14. Check that the instrument displays an actively acquiring waveform on-screen. (Note that there is noise present on the peaks of the square wave.)
15. Press the side menu button **Peak Detect**. Check that the instrument displays an actively acquiring waveform on screen with the noise "peak detected."

16. Press the side menu button **Envelope**. Check that the instrument displays an actively acquiring waveform on screen with the noise displayed.
17. Press the side menu button **Average**. Check that the instrument displays an actively acquiring waveform on screen with the noise reduced.
18. Press **WAVEFORM OFF** to remove Channel 1 from the display.
19. Press **CH 2** and move the probe to the **CH 2** input.
20. Repeat steps 3 through 17 for Channel 2.
21. Disconnect the probe from the channel input and the **PROBE COMP** terminal.

Performance Tests

The procedures are in three groupings: *Signal Acquisition System Checks*, *Time Base System Checks*, and *Triggering System Checks*. They check all the characteristics that appear in **boldface** type under *Warranted Characteristics* on page 4-3.

Prerequisites

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

- The cabinet must be installed.
- You must have performed and passed the procedures under *Self Tests*, on page 6-5 and those under *Functional Tests*, on page 6-7.
- The digitizing oscilloscope must have been operating for a warm-up period of at least 20 minutes, and must be operating at an ambient temperature between −10° C and +55° C.

Signal Acquisition System Checks

These procedures check signal acquisition system characteristics that are listed as checked under *Warranted Characteristics* in the *Specifications* section.

Check DC Voltage Measurement Accuracy

WARNING

Performance of this procedure requires input voltages up to 98 VDC. Contact with live circuits could cause injury or death. Be sure to set the DC calibration generator to 0 volts before connecting, disconnecting, and/or moving the test hookup during the performance of this procedure.

Equipment Required: One dual-banana connector (Item 3), one DC calibration generator (Item 6), and one precision coaxial cable (Item 2).

Time Required: Approximately 35 minutes.

Prerequisites: The oscilloscope must meet the prerequisites listed on page 6-11.

Procedure:

1. Set the output of a DC calibration generator to 0 volts.

2. Connect the output of a DC calibration generator through a dual-banana connector followed by a 50 Ω precision coaxial cable to **CH 1**, as shown in Figure 6-4.

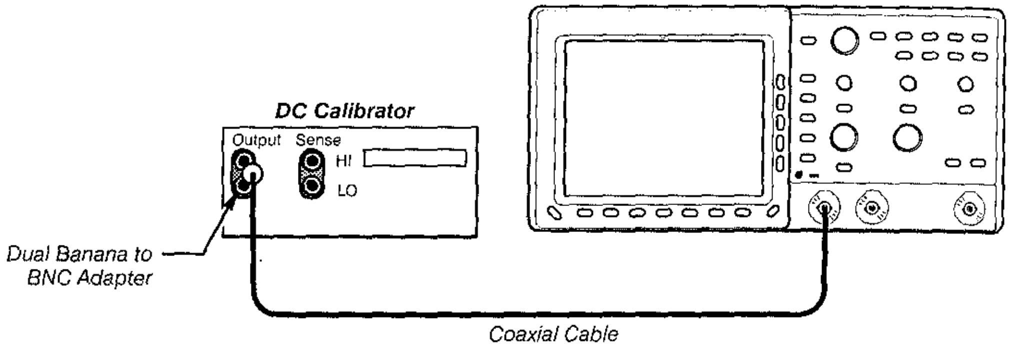


Figure 6-4: Hookup for DC Voltage Measurement Accuracy Check

3. Press **SAVE/RECALL SETUP** → **Recall Factory Setup** → **OK Confirm Factory Init**.
4. Press **ACQUIRE** → **Mode** → **Average 16**.
5. Press **MEASURE** → **Select Measurement**.
6. Press the side menu button **more** until the menu label **Mean** appears in the side menu. Press the side menu button **Mean**.
7. Set the **VOLTS/DIV** to one of the settings listed in Table 6-2 that you have not yet checked. (Start with the first setting listed.)
8. Press **VERTICAL MENU** → **Position**.

Table 6-2: DC Accuracy

Scale Setting	Position Setting (Divs)	Offset Setting	Generator Setting	Accuracy Limits
1 V	+5	+100 V	+98 V	+97.1 V to +98.9 V
200 mV	+5	+10 V	+8.4 V	+8.28 V to +8.52 V
50 mV	−5	−1 V	−0.6 V	−581 mV to −619 mV
50 mV	−5	−1 V	−0.9 V	−881 mV to −919 mV
Δ at 50 mV				+286 mV to +314 mV
10 mV	−5	0 V	+60 mV	+54.6 mV to +65.4 mV
5 mV	0	−1 V	−990 mV	−982 mV to −998 mV

9. Turn the **General Purpose Knob** to set the vertical position to the setting listed in Table 6-2. The baseline level moves off screen.
10. Press the main menu button **Offset**.
11. Use the **General Purpose Knob** to set vertical offset to the setting listed in Table 6-2 for the present vertical scale setting. The baseline level remains off screen.
12. Set the generator to the level and polarity indicated in Table 6-2 for the vertical scale, position, and offset settings you have made. The DC test level should appear on screen. (If it does not return, the DC accuracy check has failed for the present vertical scale setting of the current channel.)
13. Check that the readout for the measurement **Mean** readout on screen is within the limits listed for the present vertical scale and position/offset/generator settings.
14. Repeat steps 7 through 13 until you have checked all the vertical scale settings listed in Table 6-2. Record the measurements for each of the 50 mV settings.
15. Subtract the second 50 mV measurement from the first and compare the result to the "Δ at 50 mV" limits in Table 6-2.
16. Press **WAVEFORM OFF**; then, press **CH** 2.
17. Set the generator output to 0 V.
18. Move the test hookup to the **CH 2** input.
19. Repeat steps 5 through 15 for channel 2.
20. Set the generator output to 0 V.
21. Disconnect the cable at the **CH 2** input connector.

DC Gain Accuracy

DC gain accuracy is verified by successful completion of the self tests and the DC voltage measurement accuracy (in the previous procedure).

Offset Accuracy

Offset accuracy is verified by successful completion of the Self Tests and the DC voltage measurement accuracy (in the previous procedure).

Check Analog Bandwidth

Equipment Required: One medium-frequency leveled sine wave generator (Item 7), one 50 Ω precision cable (Item 2), and one 50 Ω termination (Item 1).

Time Required: Approximately 20 minutes.

Prerequisites: *See page 6-11.*

Procedure:

1. Connect, through a 50 Ω precision cable and a 50 Ω termination, the sine wave output of a medium-frequency leveled sine wave generator to **CH 1** (see Figure 6-5). Set the output of the generator to a reference frequency of 50 kHz.

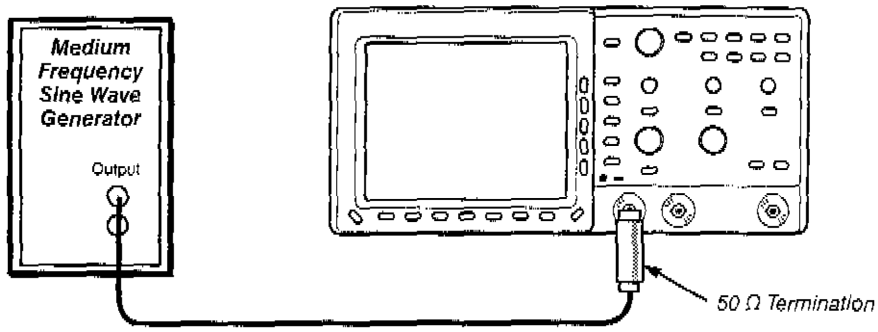


Figure 6-5: Hookup for Analog Bandwidth Check

1. Press **SAVE/RECALL SETUP** → **Recall Factory Setup** → **OK Confirm Factory Init**.
2. Set the **SEC/DIV** to 10 µs.
3. Press **TRIGGER MENU** → **Coupling** → **Noise Rej**.
4. Press **ACQUIRE** → **Mode** → **Average 16**.
5. Press **MEASURE** → **High–Low Setup** → **Min–Max**.
6. Press the main menu button **Select Measurement.** Now press the side menu button **more** until the menu label **Pk-Pk** appears in the side menu. Press the side menu button **Pk-Pk**.
7. Set the **VOLTS/DIV** to 10 mV.
8. Set the generator output so the **CHx Pk-Pk** readout equals 60 mV.
9. Press **SET LEVEL TO 50%** as necessary to trigger the display.
10. Increase the frequency of the generator output to 50 MHz (TDS 310), 100 MHz (TDS 320), or 200 MHz (TDS 350).
11. Set the **SEC/DIV** to 10 ns (TDS 310), 5 ns (TDS 320), or 2.5 ns (TDS 350).
12. Press **SET LEVEL TO 50%** as necessary to trigger the display.
13. Check that the **Pk-Pk** readout on screen (as shown in Figure 6-6) is ≥42.5 mV.

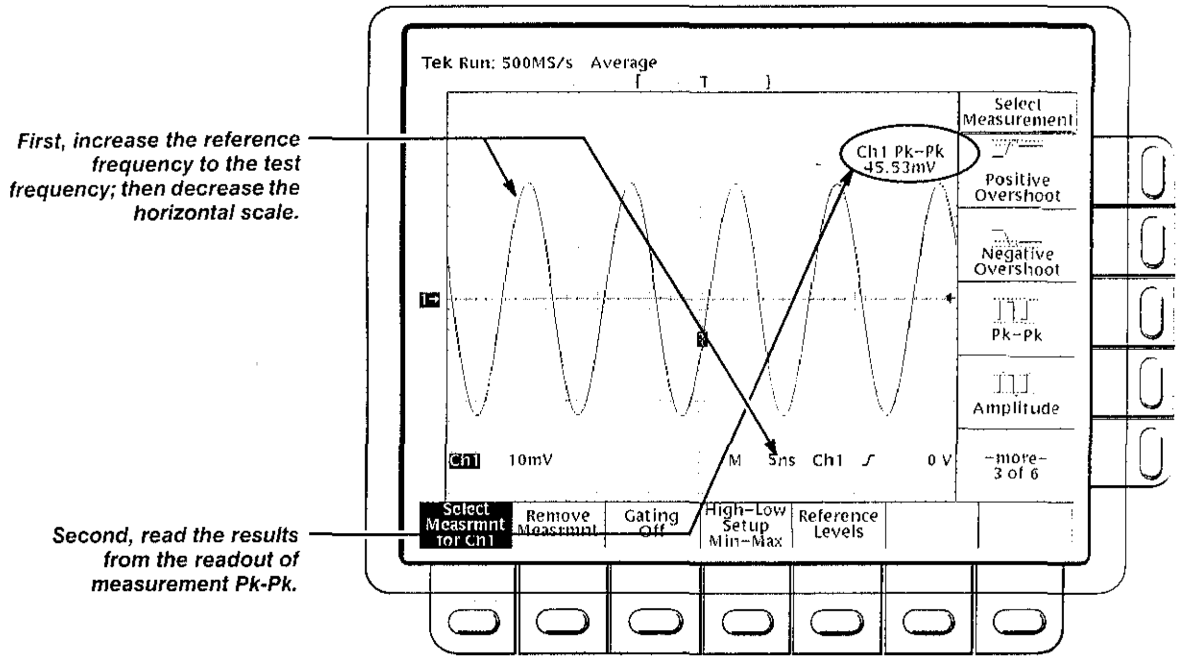


Figure 6-6: Measuring Analog Bandwidth

14. When finished checking, set the **SEC/DIV** back to the 10 µs setting, and set the generator output frequency back to 50 kHz.
15. Press **WAVEFORM OFF** to remove Channel 1 from the display.
16. Press **CH 2** and move the hookup to the **CH 2** input.
17. Press **TRIGGER MENU** → **Source** → **CH 2**.
18. Repeat steps 6 through 13 for **CH 2**.
19. Disconnect the test hook up from the **CH 2** input connector.

Time Base System Checks

This procedure checks those characteristics that relate to the Main and Delayed time base system and are listed as checked under *Warranted Characteristics* in the *Specifications* section.

Check Long-Term Sample Rate and Delay Time Accuracy

Equipment Required: One time-marker generator (Item 8), one precision coaxial cable, (Item 2) and one 50 Ω termination (Item 1).

Time Required: Approximately 5 minutes.

Prerequisites: *See page 6-11.*

Procedure:

1. Connect, through a 50 Ω precision coaxial cable and a 50 Ω termination, the time-mark output of a time-marker generator to **CH 1**, as shown in Figure 6-7. Set the output of the generator for 10 ms markers.

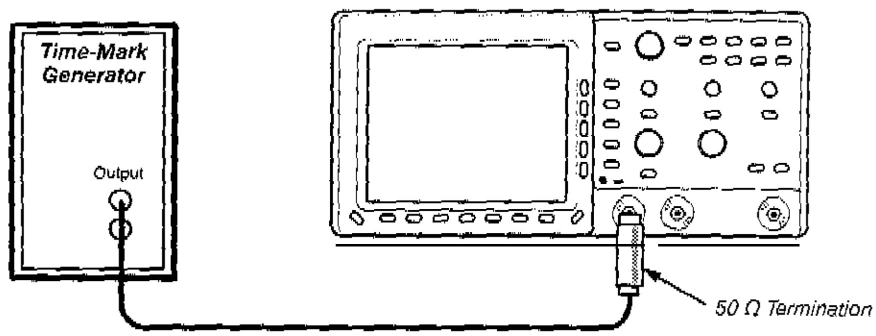


Figure 6-7: Hookup for Sample Rate Check

2. Press **SAVE/RECALL SETUP** → **Recall Factory Setup** → **OK Confirm Factory Init.**
3. Set the **VOLTS/DIV** to 500 mV.
4. Press **SET LEVEL TO 50%**; use the vertical **POSITION** knob to center the test signal on screen.
5. Set the **SEC/DIV** to 1 ms.
6. Press **HORIZONTAL MENU** → **Trigger Position** → **Set to 10%.**
7. Adjust the horizontal **POSITION** to move the trigger **T** to the right and on to the screen. Continue to position the trigger T to align it to the center vertical graticule line.
8. Press the main menu button **Time Base**; then press the side menu button **Delayed Only.**

9. Set the **SEC/DIV** of the **D** (delayed) time base to 1 ms. Then use the **General Purpose** knob to set delay time to 10 ms.
10. Set the **SEC/DIV** of the **D** (delayed) time base to 500 ns.

NOTE

*When you change the **SEC/DIV** in step 10, the delay time readout changes to 10.00001 or 9.99999. This is normal and has no effect on the verification*

11. Check that the rising edge of the marker crosses the center horizontal graticule line at a point within ±2.0 divisions of center graticule.
12. Disconnect the test hookup.

Delta Time Measurement Accuracy

Delta time measurement accuracy is verified by successful completion of the previous procedure.

Trigger System Checks

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

Check Edge Trigger Sensitivity, DC Coupled

Equipment Required: One medium-frequency leveled sine wave generator (Item 7), two precision 50 Ω coaxial cables (Item 2), one 50 Ω termination (Item 1), and one BNC T connector (Item 4).

Time Required: Approximately 10 minutes.

Prerequisites: *See page 6-11.*

Procedure:

1. Press **SAVE/RECALL SETUP → Recall Factory Setup → OK Confirm Factory Init**.
2. Set the **VOLTS/DIV** to 500 mV.
3. Set the **SEC/DIV** to 10 ns.
4. Press **TRIGGER MENU → Mode → Normal**.
5. Press **ACQUIRE → Mode → Average 16**.
6. Connect one 50 Ω cable to the output of the sine wave generator. Attach a BNC T connector to the other end of the cable. Connect a second 50 Ω cable to the other side of the BNC T connector.

7. Connect the BNC T connector to **CH 1**; connect the cable to the **EXT TRIG** input through a 50 Ω termination as shown in Figure 6-8.

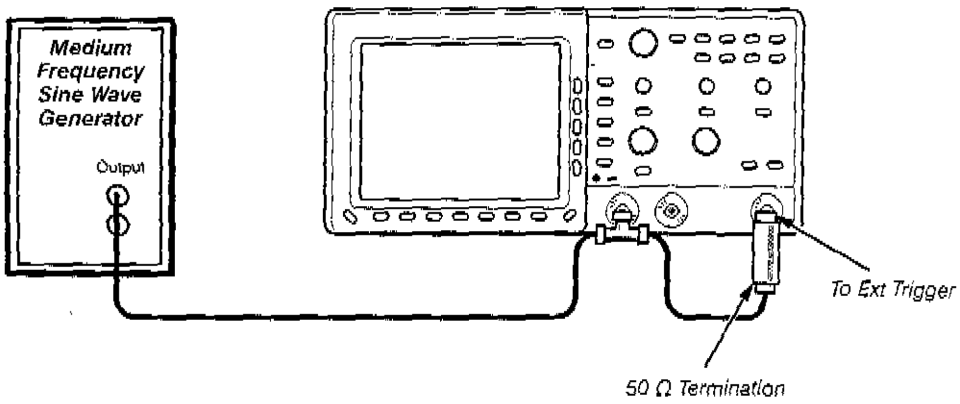


Figure 6-8: Hookup for Trigger Sensitivity Check

8. Set the generator frequency to 50 MHz (TDS 310), 100 MHz (TDS 320), or 200 MHz (TDS 350).
9. Press **MEASURE** → **High-Low Setup** → **Min-Max**.
10. Press the main menu button **Select Measurement**.
11. Press the side menu button **–more–** until **Amplitude** appears in the side menu. Press the side menu button **Amplitude**.
12. Press **SET LEVEL TO 50%**.
13. Set the test signal amplitude for about one division on screen. Fine adjust the generator output until the **CH 1 Amplitude** readout indicates the amplitude is 500 mV. (Readout may fluctuate around 500 mV.)
14. Press **TRIGGER MENU** → **Slope**.
15. Press **SET LEVEL TO 50%**. Check that a stable trigger is obtained for the test waveform on both the positive and negative slopes (see Figure 6-9). (Use the side menu to switch between trigger slopes; use the trigger **LEVEL** knob to stabilize the trigger if required.)

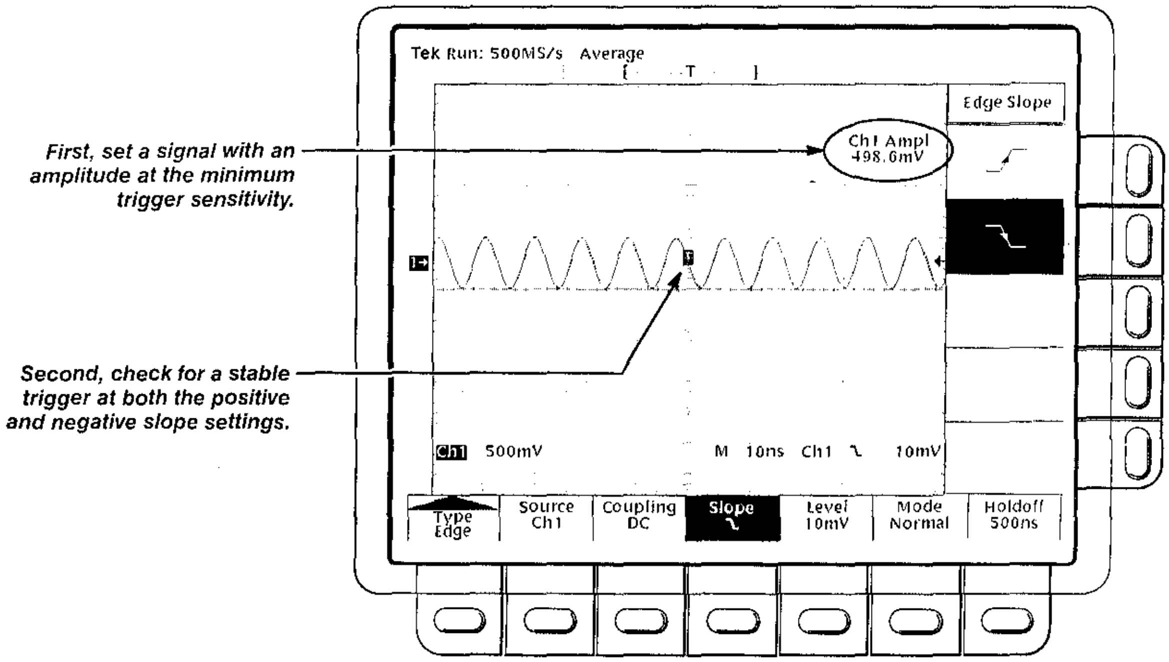


Figure 6-9: Measuring Trigger Sensitivity

16. Press **WAVEFORM OFF**.
17. Press **CH 2**.
18. Press **TRIGGER MENU** → **Source** → **Ch2**.
19. Disconnect the hookup from **CH 1** and connect it to **CH 2**.
20. Set the **VOLTS/DIV** to 500 mV.
21. Repeat steps 14 and 15 for Channel 2.
22. Press **TRIGGER MENU** → **Source** → **EXT/10**.
23. Press **MEASURE** → **Select Measrmnt** → **Amplitude**.
24. Increase the generator amplitude until the amplitude measurement reads 1.5 V.
25. Repeat steps 14 and 15 for the external trigger.
26. Disconnect the test hookup.

Trigger Level Accuracy, DC Coupled

Trigger level accuracy is verified by the successful completion of the Self Tests and the DC voltage measurement accuracy procedure on page 6-11.