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# Instrument: Agilent Technologies 16533/34A Digitizing Oscilloscope



The Agilent Technologies 16533A and 16534A digitizing oscilloscopes offer basic oscilloscope functionality. The oscilloscope can be easily correlated with other instruments in the Agilent Technologies 16700A/B-series logic analysis system.

### Getting Started


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- "Probing" on page 14
- "Acquiring a Waveform" on page 31
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- "Automatic Measurements and Algorithms" on page 61
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  Main System Help (see the *Agilent Technologies 16700A/B-Series Logic Analysis System* help volume)

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# 1

# Agilent Technologies 16533/34A Digitizing Oscilloscope

# Calibrating the Oscilloscope

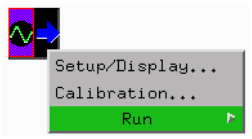
The oscilloscope requires a full operational accuracy calibration by you or a service department whenever

- it has been 6 months or 1,000 hours of use since last full calibration.
- the ambient temperature changes more than 10 degrees C from the temperature at the time of the last full calibration.
- the frame configuration changes.
- you need to optimize measurement accuracy.

You will get more accurate measurements from the oscilloscope if you perform the operational accuracy calibration at least once a year.

**NOTE:** Channel skew calibration requires a multi-board oscilloscope. The procedure cannot be performed on single-board (2-channel) oscilloscopes.

### To calibrate the oscilloscope




This is also covered in the *Logic Analysis System Installation Guide*. Since this procedure requires you to turn off the system, print this information if you do not have access to the *Installation Guide*.

1. If your oscilloscope has more than two channels, disconnect the short cables on the back of the *module* that connect the boards.
2. Unprotect the memory.
   a. Turn off the Agilent Technologies 16700A/B-series *frame*.
   b. Take the oscilloscope module out of the frame. See the *Logic Analysis System Installation Guide*.
   c. Set the PROTECT/UNPROTECT switch to UNPROTECT.

   d. Put the oscilloscope back in the frame.

3. Turn on the 16700A/B-series frame and wait for it to finish booting.
   You will get a more accurate calibration if you warm up the system for 30 minutes before calibrating the oscilloscope.
4. Select the oscilloscope icon, and choose *Calibration...*
5. Select the procedure *ADC through Logic Trigger*.
   The calibration software will tell you what cables need to be attached.
6. Select the *Run* button.
7. Select the procedure *Ext Trig Skew* and connect the cables as directed.
8. Select the *Run* button.
9. Optional - Calibrate the oscilloscope as a multi-board module.
   a. Perform the ADC through Logic Trigger and Ext Trig Skew calibrations on each oscilloscope board first.
   b. In the system window, choose Exit from the File menu.
   c. Connect the oscilloscopes together with the short board interconnect cables. Connect the first board's TRIG OUT to the next board's TRIG IN until all boards are connected.
   d. Start a *session*.
   e. Select the oscilloscope icon and choose *Calibration*.
   f. Select the procedure *Channel Skew* and connect the cables as directed.
10. After you have finished calibrating, protect the memory. Follow the steps given above for unprotecting, setting the switch to PROTECT instead.

**See Also**

*Logic Analysis System Installation Guide*

"Calibration Reference" on page 12

# Calibration Reference

### ADC

The ADC calibration procedure produces a linearization table which is applied to the data out of the analog-to-digital converters (ADC) to undo the effects of a non-linear, analog-to-digital conversion.

### Gain

The Gain calibration procedure measures the actual attenuation of the attenuators and measures the actual gain of the preamps.

### Offset

The Offset calibration procedure determines the actual offset value that places a null signal in center screen.

### Hysteresis

The Hysteresis calibration procedure determines the hardware setting which is closest to achieving a hysteresis of 0.28 screen divisions.

### Trigger Level

The Trigger Level calibration procedure determines the actual trigger level values for all possible voltage levels across the screen.

### Trigger Delay

The Trigger Delay calibration procedure determines a time delay which correctly lines up the point at which a trace crosses the trigger level with the trigger time.

### Logic Trigger

The Logic Trigger calibration procedure determines settings which affect the accuracy of duration trigger measurements.

### Ext Trig Skew

The Ext Trig Skew calibration procedure lines up the external trigger edge with the trigger time when triggering on the external channel.

### Channel Skew

The Channel Skew calibration procedure is only available for multi-board oscilloscope *modules*. It deskews the trigger channel and data channels which are on different boards.

# Probing

The probes covered in the topics below are 1:1 Passive Probes, Active Probes, Current Probes, Compensated Passive Divider Probes, Differential Probes, and Resistive Divider Probes.


- "Table of Compatible Probes" on page 14
- "Selecting the Proper Probe" on page 15
- "Compensating the Compensated Passive Divider Probe" on page 17
- "Probe Loading" on page 18
- "Descriptions of Probe Types" on page 22
- "Surface Mount Probing" on page 29


## Table of Compatible Probes

* Most frequently used

| Agilent Model Numbers | Probe Type | Band-width | Input Z | Div ratio | Input R | Input C |
|---|---|---|---|---|---|---|
| COMPENSATED DIVIDER | | | | | | |
| 10441A | Compensated | 500 MHz | 1 Mohm | 10:1 | 1 Mohm | 9 pF |
| *1160A | Compensated Passive Divider | 500 MHz | 1 Mohm | 10:1 | 10 Mohm | 9 pF |
| 1161A | Compensated Passive Divider | 500 MHz | 1 Mohm | 10:1 | 10 Mohm | 10 pF |
| 1162A | High Impedance Passive | 25 MHz | 1 Mohm | 1:1 | 1 Mohm | 50 pF + scope C |
| RESISTIVE DIVIDER | | | | | | |
| 1163A | Resistive Divider | 1.5 GHz | 50 ohm | 10:1 | 500 ohm | 1.5 pF |
| 54006A | Resistive Divider | 6 GHz | 50 ohm | 10:1<br>20:1 | 500 ohm<br>or 1Kohm | 0.25 pF |
| ACTIVE | | | | | | |
| *1144A | Active | 800 MHz | 50 ohm | 10:1 | 1 Mohm | 2 pF |

| | | | | | | |
|---|---|---|---|---|---|---|
| *1145A | Dual Channel Small Geometry Active | 750 MHz | 50 ohm | 10:1 | 1 Mohm | 2 pF |
| 1141A | Differential | 200 MHz | 50 ohm | 1:1<br>10:1<br>100:1 | 1 Mohm<br>9 Mohm<br>10 Mohm | 7 pF<br>3.5 pF<br>2.0 pF |
| 54701A | Active | 2.5 GHz | 50 ohm | 10:1 | 100 Kohm | 0.6 pF |
| CURRENT | | | | | | |
| 1146A | Current | 100 kHz | 1 Mohm | n/a | n/a | n/a |

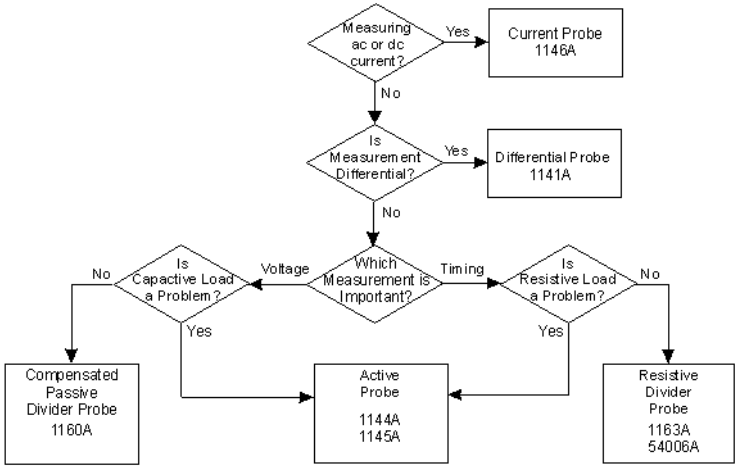
**See Also**

"Descriptions of Probe Types" on page 22

"Channel Setup Window" on page 33 for setting input impedance and coupling

## Selecting the Proper Probe

Use the flowchart below for selecting the proper type of probe. A comparison of features, tradeoffs, and applications of the probes are available after the flowchart.




### 1:1 Passive Probe

**Features** No attenuation of waveform.

**Tradeoffs** High capacitive loading and low bandwidth.

**Applications** Measuring small, low-bandwidth waveforms when no attenuation can be tolerated such as power supply ripple.

#### Active Probe

**Features** Best overall combination of low resistive and capacitive loading. High bandwidth.

**Tradeoffs** Higher cost, limited dynamic range, requires power.

**Applications** ECL, CMOS, GaAs probing, analog circuit probing, transmission line probing, source resistance ≥10 kohm, op amp probing, most accurate for general measurements of circuits of unknown impedance.

#### Compensated Passive Divider Probe

**Features** Very low resistive loading, accurate amplitude measurements, large dynamic range, and low cost.

**Tradeoffs** Capacitive loading <10 pF, lower bandwidth than active or 50-ohm resistive divider probes.

**Applications** General purpose probing, probing high-impedance nodes (≥10 Kohm), op amp probing, CMOS probing (if bandwidth is adequate), TTL probing (if bandwidth is adequate)

#### Current Probe

**Features** Measures both ac and dc currents on a scope, with minimal circuit loading.

**Tradeoffs** Large size.

**Applications** Power measurements, automotive measurements, industrial measurements, motors, dynamoes, and alternators.

#### Differential Probe

**Features** High common mode rejection ratio, easy viewing of small waveforms with large dc offsets, more accurate than subtracting one channel from another.

**Tradeoffs** Bigger than a passive probe, high cost, requires power, and lower bandwidth than other probes.

**Applications** Measuring waveforms not referenced to the scope ground, troubleshooting power supplies, and differential amplifier probing.

#### Resistive Divider Probe

**Features** Highest bandwidth, lowest capacitive load, lower cost than active probes, flat pulse response, good timing measurement accuracy.

**Tradeoffs** Relatively heavy resistive loading.

**Applications** ECL probing, GaAs probing, and transmission line probing.

**See Also**

"Descriptions of Probe Types" on page 22

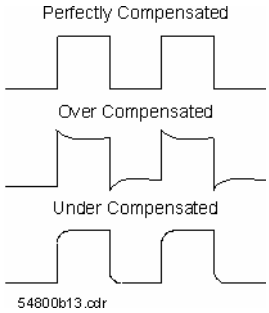
"Table of Compatible Probes" on page 14

## Compensating the Compensated Passive Divider Probe

Before you can have a flat frequency response when using a Compensated Passive Divider Probe, the probe's cable capacitance and scope input capacitance must be compensated. One of the compensating capacitors in the probe is adjustable so you can optimize the step response for flatness.

1. Connect the probe to the BNC Output, labeled *AC/DC CAL*, on the back of the oscilloscope.
2. Connect the probe ground lead to ground.
3. Select the oscilloscope icon and choose *Calibration...*
4. At the bottom of the calibration window, set BNC Output to *Probe Comp* and close the window.
5. Select the oscilloscope icon and choose *Setup/Display...*
6. Select the Autoscale menu and choose Continue.

7. You should see a waveform similar to one of the following.




8. If necessary, adjust the probe's compensating capacitor. Set the scope to keep running by selecting the *Run Repetitive* button.

## Probe Loading

There are two major factors influencing probe selection: the load the probe imposes on your circuit and the required bandwidth of your circuit with the probe. This is discussed in three sections, below.

Probe Resistance and Capacitance Characteristics (see page 18)

Probe Ground Lead Characteristics (see page 20)

Understanding System Bandwidth at the Probe Tip (see page 20)

### Probe Resistance and Capacitance Characteristics

The probe load has both resistive and capacitive components. In addition, the inductance in the probe ground lead causes ringing.

The probe resistance to ground forms a voltage divider network with the source resistance of your circuit. This reduces the waveform amplitude and the dc offset. For example, if the probe's resistance is 9 times the Thevenin equivalent resistance of your circuit, the waveform amplitude is reduced by about 10 percent. Therefore, if your waveform has a +5 V to 0.8 V range, the scope probe system shows a 4.5 V to 0.72 V range.

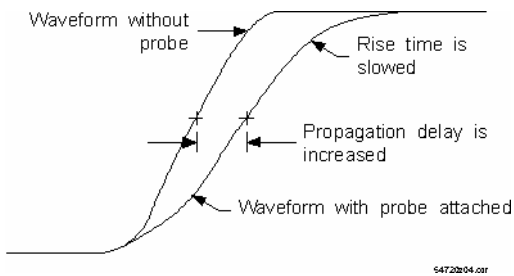
**NOTE:** At high frequencies, the probe reactance dominates the resistance.

The probe capacitive loading ($C_{in}$) to ground forms an RC circuit with the resistance of your circuit ($R_{source}$) and the resistance looking into the probe and scope ($R_{in}$). The time constant of this RC circuit slows the rise time of any transitions, increases the slew rate, and introduces delay in the actual transition time. The approximate rise time of a simple RC circuit is:
$t_{RC} = 2.2R_{Total}C_{in}$ where
$R_{Total} = [R_{in}R_{source}]/[R_{in} + R_{source}]$

Thus, for circuit resistance of 100 ohm, a scope probe system resistance of 1 Mohm, and a probe capacitance of 8 pF, the real rise time due to probe loading is:
$R_{Total}$ = [1 Mohm (100 ohm)]/[1 Mohm + 100 ohm], approximately 100 ohm.
$t_{RC}$ = 2.2(100 ohm)(8 pF), approximately 1.8 ns.

Therefore, the rise time of your circuit cannot be faster than approximately 1.8 ns, even though it might be faster without the probe.

If the output of the circuit under test is current-limited (as is often the case for CMOS), the slew rate is limited by the relationship dV/dT = I/C.




Perhaps you have connected a scope to a circuit for troubleshooting only to have the circuit operate correctly after connecting the probe. The capacitive loading of the probe can attenuate a glitch, reduce ringing or overshoot of your waveform, or slow an edge just enough that a setup or hold time violation no longer occurs.

### Probe Ground Lead Characteristics

**NOTE:** If you print this page, subscripts and superscripts appear on the main line of text. If a number seems to be in an odd place in the printed copy, it is probably a superscript.

The inductance of the probe's ground lead forms an LC circuit with the probe's capacitance and the output capacitance of the circuit under test, including any parasitic capacitance of PC board traces, and so on. The ringing frequency (F) of this circuit is:

$F = (2\ (3.14)\ (LC)^{1/2})^{-1}$

If the rise time of the waveform is sufficient to stimulate this ringing, the ringing can appear as part of your captured waveform. To calculate the ringing frequency, you can assume that the probe's ground lead has an inductance of approximately 25 nH per inch. So, a probe with a capacitance of 8 pF and a 4-inch ground lead has a ringing frequency of approximately:

$F = (2\ (3.14)\ [(25\ nH)\ (4\ inches)\ (8\ pF)]^{1/2})^{-1} = 178\ MHz$

The 178 MHz does not include your circuit capacitance. Therefore, a waveform with a rise time of less than 1.9 ns can stimulate ringing.

$t_{rise} = 0.35/178\ MHz = 1.9\ ns$

To minimize the ringing effect, you should use a probe ground lead that is as short as possible. Some probes add a ferrite bead to the ground lead to reduce ringing. However, adding the ferrite bead also increases the ground impedance which reduces the common mode rejection of the probe.

### Understanding System Bandwidth at the Probe Tip

System bandwidth is the bandwidth of the scope probe system. System bandwidth affects measurements because the probe becomes part of the circuit being measured. The rise time that is measured depends on the actual rise time, the rise time of the scope probe system, and the

rise time of the RC circuit formed by the source resistance and the scope probe system resistance and capacitance.

$t_{meas} = [t_{act}^2 + t_{RC}^2 + t_{sys}^2]^{1/2}$

where

$t_{meas}$ = the measured rise time.

$t_{act}$ = the actual rise time of the waveform being measured.

$t_{RC}$ = the rise time of the RC circuit formed by the source resistance and the scope probe system resistance and capacitance.

$t_{sys}$ = the rise time of the scope probe system.

**NOTE:**

Often the bandwidth of the scope probe system is specified. The rise time is calculated using the following equation.

$t_{sys} = 0.35/System_{BW}$

If the rise time of the scope probe system is not specified, it can be calculated using the following formula.

$t_{sys} = [t_{probe}^2 + t_{scope}^2]^{1/2}$

For example, if the scope probe system rise time is 600 ps, the probe loading rise time ($t_{RC}$) is 600 ps, and the waveform has a 1-ns rise time, then the measured rise time is:

$t_{meas} = [(1\ ns)^2 + (600\ ps)^2 + (600\ ps)^2]^{1/2} = 1.3\ ns$

The answer is in error by 30%.

However, if the scope probe system rise time is 190 ps, the probe loading rise time is 190 ps, and the waveform has a 1-ns rise time, then the measured rise time is:

$t_{meas} = [(1\ ns)^2 + (190\ ps)^2 + (190\ ps)^2]^{1/2} = 1.03\ ns$

Now the error is only 3%.

You may find it useful to memorize three system bandwidth rules:

1. The combined rise time of the scope probe system and the probe loading should be less than 1/3 of the rise time of the waveform you are measuring to keep errors below 5%, and less than 1/7 of the rise time of the waveform you are measuring to keep errors below 1%.
2. Rise time and bandwidth are related by the following approximations: rise time = 0.35/bandwidth and bandwidth = 0.35/rise time.

3. Rise times add approximately as the square root of the sum of the squares (for systems with minimal peaking).

**NOTE:** Because every scope probe has a different loading effect on your circuit, you should use the equation given for the type of scope probe you are using.

**See Also** "Descriptions of Probe Types" on page 22

## Descriptions of Probe Types

For each of the probe types listed below, the description gives a summary of features and tradeoffs and a short text description. Most of the probe types also give a sample rise time calculation.


- "1:1 Passive Probes" on page 22
- "Active Probes" on page 24
- "Compensated Passive Divider Probes" on page 25
- "Current Probes" on page 27
- "Differential Probes" on page 27
- "Resistive Divider Probes" on page 28


### 1:1 Passive Probes

**Features** No attenuation of waveform.

**Tradeoffs** High capacitive loading and low bandwidth.

**Applications** Measuring small, low-bandwidth waveforms when no attenuation can be tolerated such as power supply ripple.

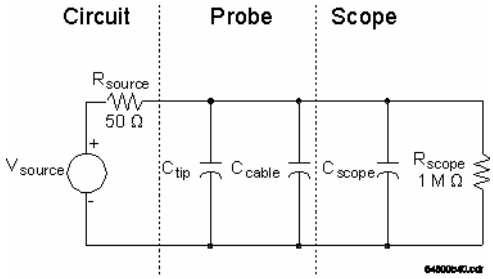
The 1:1 passive probes provide a way to connect the input impedance of the scope directly to your circuit with minimum attenuation due to the resistive loading of the probe. However, 1:1 probes do have very high capacitive loading which is much larger than that of the scope.

There are two types of 1:1 passive probes. One type is designed to work

with the scope's input set to high impedance (1 Mohm) and uses a lossy cable to keep the probe from ringing. The other type is designed to work with the scope's input set to low impedance (50 ohm) and uses a 50-ohm coaxial cable.

### Example Rise Time Calculation

Given the following circuit using the Agilent Technologies 1162A probe,




the input resistance is:
$R_{in} = R_{scope} = 1$ Mohm
The total resisitance is:
$R_{Total} = (R_{in}R_{source})/(R_{in} + R_{source})$
$R_{Total} = 1$ Mohm(50 ohm)/(1 Mohm + 50 ohm) = 50 ohm
From the Table of Compatible Probes, the probe capacitance is 50 pF. Therefore, the capacitive load is:
$C_{in} = C_{probe} + C_{scope} = 50$ pF + 7 pF = 57 pF
The rise time due to circuit loading is:
$t_{RC} = 2.2R_{Total}C_{in}$
$t_{RC} = 2.2(50 \text{ ohm})(57 \text{ pF}) = 6.2$ ns

From the Table of Compatible Probes, the scope probe system has a bandwidth of 25 MHz. Therefore, the rise time of the scope probe system is: $t_{Sys} = 0.35/System_{BW}$
$t_{Sys} = 0.35/25$ MHz = 14 ns

The measured rise time is: $t_{meas} = [t_{act}^2 + t_{RC}^2 + t_{sys}^2]^{1/2}$ $t_{meas} = [(140 \text{ ns})^2 + (6.2 \text{ ns})^2 + (14 \text{ ns})^2]^{1/2} = 140.8$ ns

## Active Probes

**Features** Best overall combination of low resistive and capacitive loading. High bandwidth.

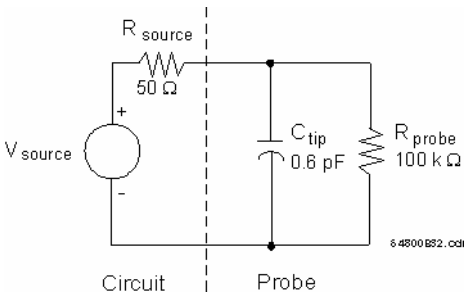
**Tradeoffs** Higher cost, limited dynamic range, requires power.

**Applications** ECL, CMOS, GaAs probing, analog circuit probing, transmission line probing, source resistance ≥10 kohm, op amp probing, most accurate for general measurements of circuits of unknown impedance.

An active probe has a buffer amplifier at the probe tip. This buffer amplifier drives a 50-ohm cable terminated in 50 ohms at the scope input. Active probes offer the best overall combination of resistive loading, capacitive loading, and bandwidth.

**Example Rise Time Calculation**

Given the following circuit using the Agilent Technologies 1152A probe,




the input resistance is:
$R_{in}$ = 100 kohm. The total input resistance is:
$R_{Total} = (R_{in}R_{source})/(R_{in} + R_{source})$
$R_{Total}$ = 100 ohm(50 ohm)/(100 ohm + 50 ohm) = 50 ohm
The rise time due to circuit loading is:
$t_{RC} = 2.2R_{Total}C_{tip}$
$t_{RC}$ = 2.2(50 ohm)(0.6 pF) = 66 ps

Because the rise time of the scope probe system is not given in the Table of Compatible Probes, we will have to calculate it using the

bandwidth of the probe (2.5 GHz) and the bandwidth of the scope (500 MHz). Therefore, the rise time of the scope probe system is:

$t_{probe} = 0.35/Probe_{BW} = 0.35/2.5\ GHz = 140\ ps$

$t_{scope} = 0.35/Scope_{BW} = 0.35/500\ MHz = 700\ ps$

$t_{sys} = [t_{probe}^{2} + t_{scope}^{2}]^{1/2}$

$t_{sys} = [(140\ ps)^{2} + (700\ ps)^{2}]^{1/2} = 714\ ps$

The measured rise time is:

$t_{meas} = [t_{act}^{2} + t_{RC}^{2} + t_{sys}^{2}]^{1/2}\ t_{meas} = [(2\ ns)^{2} + (66\ ps)^{2} + (714\ ps)^{2}]^{1/2} = 2.12\ ns$

## Compensated Passive Divider Probes

**Features** Very low resistive loading, accurate amplitude measurements, large dynamic range, and low cost.

**Tradeoffs** Capacitive loading <10 pF, lower bandwidth than active or 50-ohm resistive divider probes.

**Applications** General purpose probing, probing high-impedance nodes (≥10 Kohm), op amp probing, CMOS probing (if bandwidth is adequate), TTL probing (if bandwidth is adequate).

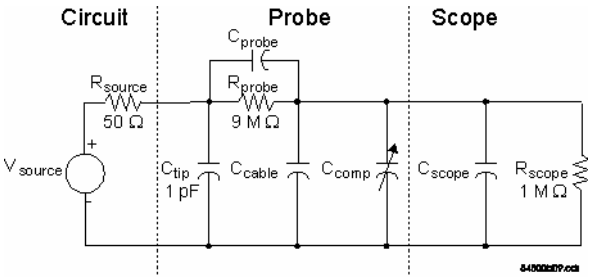
The compensated passive divider probe is the most common type of scope probe. The 9-Mohm resistor in the tip forms a 10:1 voltage divider with the 1-Mohm input resistance of the scope.

To have a flat frequency response, the probe tip capacitance is compensated by the probe's cable capacitance, a compensating capacitor, and the scope input capacitance. The compensating capacitor is adjustable so you can optimize the step response for flatness.

Not all 9-Mohm divider probes work with all 1-Mohm scope inputs. The probe data sheet shows the range of scope input capacitance it can accommodate. You must make sure that the input capacitance of the scope is within that range.

**Example Rise Time Calculation**

Given the following circuit using an Agilent Technologies 1160A probe,




the input resistance is:
$R_{in} = R_{probe} + R_{scope}$
$R_{in}$ = 9 Mohm + 1 Mohm = 10 Mohm

The capacitive load is:
$C_{in} = C_{tip} + \{[C_{probe}(C_{cable}+C_{comp}+C_{scope})]/$
$[C_{probe}+C_{cable}+C_{comp}+C_{scope}]\}$
This number is calculated for the scope and scope probe combination, and is shown in the Table of Compatible Probes.

The total resistance is: $R_{Total} = (R_{in}R_{source})/(R_{in} + R_{source})$
$R_{Total}$ = 10 Mohm(50ohm)/(10 Mohm + 50ohm) = 50 ohm

The rise time due to circuit loading is: $t_{RC} = 2.2R_{Total}C_{in}$
$t_{RC}$ = 2.2(50 ohm)(7.5 pF) = 825 ps

From the Table of Compatible Probes, the bandwidth of the scope probe system is 500 MHz. Therefore, the rise time of the scope probe system is:
$t_{sys} = 0.35/System_{BW}$
$t_{sys}$ = 0.35/500 MHz = 700 ps

The measured rise time is:
$t_{meas} = [(t_{act})^2 + (t_{RC})^2 + (t_{sys})^2]^{1/2}$
$t_{meas} = [(2\text{ ns})^2 + (825\text{ ps})^2 + (700\text{ ps})^2]^{1/2}$ = 2.27 ns

Remember that probe input impedance for compensated passive divider probes is complex. A simple RC network serves only as a first-order approximation.

## Current Probes

**Features** Measures both ac and dc currents on a scope, with minimal circuit loading.

**Tradeoffs** Large size.

**Applications** Power measurements, automotive measurements, industrial measurements, motors, dynamoes, and alternators.

Scopes are designed to measure voltage, but by using a current probe you can measure current. A current probe measures current in a wire by enclosing the wire. Therefore, no electrical connection is needed.

Current probes generally use one of two technologies. The simplest uses the principle of a transformer, with one winding of the transformer being the measured wire. Because transformers only work with alternating voltages and currents, current probes of this type cannot measure direct current.

The other type of current probe uses the Hall effect principle. The Hall effect produces an electric field in response to an applied magnetic field. While this technique requires a power supply, it measures both alternating and direct current.

## Differential Probes

**Features** High common mode rejection ratio, easy viewing of small waveforms with large dc offsets, more accurate than subtracting one channel from another.

**Tradeoffs** Bigger than a passive probe, high cost, requires power, and lower bandwidth than other probes.

**Applications** Measuring waveforms not referenced to the scope ground, troubleshooting power supplies, and differential amplifier probing.

A differential probe is a high-impedance differential amplifier with two probe tips; a non-inverting input and an inverting input. These two inputs feed a differential amplifier which in turn drives the 50-ohm input of the scope. The main advantage of differential probes is their ability to reject waveforms that are common to both inputs. This type of probe is often used in floating ground applications.

You could duplicate a differential probe by using two passive probes and subtracting the two scope channels. However, the electrical paths of the differential probe are carefully matched to give a high common mode rejection ratio (CMRR). The higher the CMRR, the smaller the waveforms you can view in the presence of unwanted noise.

### Resistive Divider Probes

**Features** Highest bandwidth, lowest capacitive load, lower cost than active probes, flat pulse response, good timing measurement accuracy.

**Tradeoffs** Relatively heavy resistive loading.

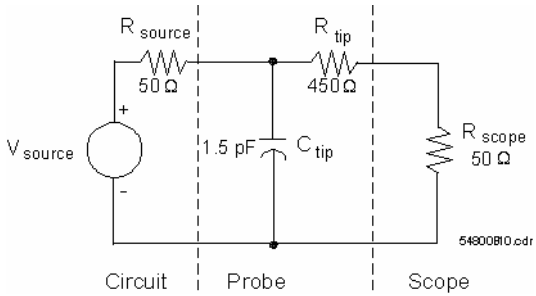
**Applications** ECL probing, GaAs probing, and transmission line probing.

Resistive divider probes are designed for scopes with a 50-ohm input impedance. The probe tips of the Agilent Technologies 1163A or 54006A have either a 450-ohm or 950-ohm series resistor. The probe cable is a 50-ohm transmission line. Because the cable is terminated in 50 ohms at the scope input, it looks like a purely resistive 50-ohm load when viewed from the probe tip. Therefore, the resistive divider probe is flat over a wide range of frequencies, limited primarily by the parasitic capacitance and inductance of the 450-ohm or 950-ohm resistor and the fixture that holds it. The resistive load of the probe to your circuit is either 500 ohm or 1 kohm, depending on the probe.

This type of probe has the smallest capacitive load of any probe. The small capacitance and wide bandwidth make this probe type a good choice for wide bandwidth measurements or time-critical measurements.

**Example Rise Time Calculation**

Given the following circuit using the Agilent Technologies 1163A probe,




the input resistance is:
$R_{in} = R_{tip} + R_{scope}$
$R_{in}$ = 450 ohm + 50 ohm = 500 ohm

The total resistance is:
$R_{Total} = (R_{in}R_{source})/(R_{in} + R_{source})$
$R_{Total}$ = 500 ohm(50ohm)/(500 ohm + 50ohm) = 45 ohm

The rise time due to circuit loading is:
$t_{RC} = 2.2R_{Total}C_{tip}$
$t_{RC}$ = 2.2(45 ohm)(1.5 pF) = 165 ps

From the Table of Compatible Probes, the bandwidth of the scope probe system is 1.5 GHz. Therefore, the rise time of the scope probe system is:
$t_{sys} = 0.35/System_{BW}$
$t_{sys}$ = 0.35/1.5 GHz = 230 ps

The measured rise time is:
$t_{meas} = [(t_{act})^2 + (t_{RC})^2 + (t_{sys})^2]^{1/2}$
$t_{meas} = [(2\ ns)^2 + (165\ ps)^2 + (230\ ps)^2]^{1/2}$ = 2.02 ns

## Surface Mount Probing

The Agilent Technologies 10467A 0.5 mm MicroGrabber Accessory Kit is designed for using the Agilent Technologies 116x family of probes when you are probing fine-pitch (0.5 mm to 0.8 mm) SMT (Surface

Mount Technology) devices. The kit contains enough parts for two probes.

The Agilent Technologies 116x probe tip plugs into the single-lead end of the dual-lead adapter. The MicroGrabber connects to the red lead. You can also use a MicroGrabber on the black lead, which you should connect to your circuit's ground. You can also connect the dual-lead end to circuit pins that are 0.635 mm (0.025 inch) in diameter.

The kit is intended for use with voltages no greater than ±40 V (dc and ac peak).

# Acquiring a Waveform

The two ways to acquire a waveform with the oscilloscope are *Autoscale* and *Run*. When you use *Run*, you can modify settings to fine-tune your measurement.

You can also save acquired waveforms using waveform memories. (see page 78)

### Autoscale

Autoscale automatically adjusts volts per division and offset so that the waveform fits into the display. It also attempts to set the seconds per division so that three periods of the waveform are displayed.

### Specifying a Measurement

To set up a measurement, first specify the channel setup then the trigger. Based on your waveform you may need to change the offset and scale to get accurate measurements.

A faster way to set up your measurement is to first autoscale, then adjust only the settings you are interested in.

### Running

The default acquisition mode is single-shot. To take another acquisition immediately after the first one, select the *Run Repetitive* button.

The scope does not support any modes other than real-time mode. You can turn on averaging or accumulate under the *Display* tab. However, because of the way the oscilloscope samples, this is not the same as the equivalent time mode of a stand-alone oscilloscope.

**NOTE:** Selecting the *Run* button in an instrument window only runs that instrument. To run all active instruments, select *Run All* in the System or Workspace window, or *Group Run* in the window of any instrument included in a group run. If the scope is triggered by another instrument, do not change settings while the scope is waiting for its trigger or it may not trigger.

**See Also** "Run/Group Run Function" on page 90

"Autoscale" on page 32

"Specifying a Measurement" on page 33

"Using Waveform Memories" on page 78

"Differences from a Standard Digitizing Oscilloscope" on page 77

"Combining the Oscilloscope with a Logic Analyzer" on page 35

## Autoscale

Autoscale automatically optimizes the waveform display for each channel that is turned on. It sets volts per division and offset so that the waveform fits into the middle of the display, and adjusts the timebase (horizontal axis) to show three periods. When signals have different periods, the signal on the lowest-numbered channel is used to set the horizontal scale. If none of the signals show activity, the timebase is set to 200 ns per division.

Autoscale also changes the trigger settings. The trigger channel is channel 1 unless the signal on channel 1 has no detectable voltage change. Triggering is limited to channels 1 and 2; no higher-numbered channels can be set, but they will be autoscaled. The trigger mode is set to the first rising edge and autotriggered. The trigger level is set to the 60% threshold of the signal. If both channel 1 and channel 2 have flat signals, the trigger source is set to channel 2 and the trigger level is set to channel 2's offset.

The settings changed by autoscale are:

| Setting | Default | Algorithm |
|---|---|---|
| V/div (Scale) | 200 mV/div | Waveform fits within the middle 6 divisions of the display |
| Channel Offset | 0 | Waveform is centered vertically |
| Sec/div (Scale) | 200 ns/div | Fit three periods on screen |
| Time offset (Delay) | 0 | Always centers waveform around trigger |
| Trigger mode | rising edge | Always sets trigger to rising edge |
| Trigger sweep | autotrigger | Always sets trigger to autotrigger |

```
Trigger level     not applicable Always sets level to near 60% threshold
                                 if a non-constant signal is detected

Trigger occurrence  1            Always sets occurrence to 1

Trigger source    channel 1      Checks channel 1 for an active signal;
                                 if signal is flat, sets to channel 2
```

## Specifying a Measurement

1. Connect probes. (see page 14)
2. Set up the channel. (see page 33)
3. Set the display mode. (see page 59)
4. Specify trigger. (see page 38)
5. Select the *Run Repetitive* button to start the acquisition.
6. Save particular waveforms to waveform memory. (see page 78)

The data is automatically displayed in the oscilloscope window. You can also connect it to a display tool in order to correlate the oscilloscope with a logic analyzer.

**See Also**

"Combining the Oscilloscope with a Logic Analyzer" on page 35

"Probing" on page 14

"Channel Setup Window" on page 33

"Display Setup Window" on page 59

"Triggering" on page 38

"Using Waveform Memories" on page 78

### Channel Setup Window

To access the Channel Setup window, select the *Setup...* button under the Channels tab. Use this window to specify your probe type and probe impedance. After the initial setup, you may want to use this window to adjust channel skew.

**On/Off** Use this button to turn the channel on or off. You can also do

this from the main oscilloscope window.

**Name** Channel names can be a maximum of 10 characters long. Customized names appear anywhere the channel is labeled.

**Probe** The probe attenuation factor. The arrow keys scroll through the standard probe attenuation values, or you can enter non-standard values by typing in the field. Probe attenuation affects the display and marker measurements.

**Input Z / Coupling** Probe input impedance. Incorrect impedance will cause bad measurements. See the "Table of Compatible Probes" on page 14 for suggested values.

**Skew** Adjust for channel-to-channel skew caused by differing electrical path lengths of the probes. To deskew the channels for multi-board oscilloscopes, run *Channel Skew* in the calibration utility.

**Preset** Select from TTL, ECL, and User. TTL sets the scale to 1 V/div and the offset to 2.50 V. ECL sets the scale to 250 mV/div and the offset to -1.3 V. User defaults to TTL values, but if you change the Scale or Offset settings, the Preset field changes to User.

**Scale** Scale affects the vertical axis of the waveform display. You can change it through either the arrow buttons or by typing in the field. It is the same scale field as in the main oscilloscope window.

**Offset** Offset moves the waveform vertically in the display window. Parts of the waveform that go offscreen are clipped, which may affect any automatic measurements you run. The offset field also appears in the main oscilloscope window.




You can also display the Channel Setup window by selecting a channel in the grid and choosing *Channels...* from the menu.

**See Also**

"Calibrating the Oscilloscope" on page 10

"Probing" on page 14

"Vertical and Horizontal Scaling" on page 52

# Combining the Oscilloscope with a Logic Analyzer

If you want to make a measurement with a logic analyzer and an oscilloscope, there are three cases:


- "Oscilloscope Triggers Logic Analyzer" on page 35
- "Logic Analyzer Triggers Oscilloscope" on page 36
- "Logic Analyzer and Oscilloscope Correlate Data" on page 36


**See Also**

The Intermodule Window (see the *Agilent Technologies 16700A/B-Series Logic Analysis System* help volume) for a generic approach.

## Oscilloscope Triggers Logic Analyzer

1. Select the toolbar's Workspace button.
2. In the Workspace window, drag both instruments on to the workspace.
3. Connect both to the same display tool.
4. In the Correlation Error dialog that appears, select *Group Run* for the scope and *Oscilloscope* for the logic analyzer.
5. Select the *Group Run* or *Run All* button to start the acquisition.
6. To view the waveforms together, open the display tool.
   - For a Waveform display, select one of the labels and choose *Insert before...* or *Insert after...*. In the Label Dialog, select the label you want to insert, then select the *Apply* button.
   - For the other tools, the oscilloscope labels are already available.

## Logic Analyzer Triggers Oscilloscope

**NOTE:** When the logic analyzer triggers the oscilloscope, if you are changing oscilloscope settings when the trigger occurs it may be missed. The message bar and Run Status window show "Waiting for IMB Arm" when this occurs. When this happens, select the *Stop* button and restart the acquisition.

1. Select the toolbar's Workspace button.
2. In the Workspace window, drag both instruments on to the workspace.
3. Connect both to the same display tool.
4. In the Correlation Error dialog that appears, select *Group Run* for the logic analyzer and the logic analyzer description for the oscilloscope.
5. A Trigger Advisory dialog box may appear. Select *Trigger Immediate*.
6. Select the *Group Run* or *Run All* button to start the acquisition.
7. To view the waveforms together, open the display tool.
   - For a Waveform display, select one of the labels and choose *Insert before...* or *Insert after...*. In the Label Dialog, select the label you want to insert, then select the *Apply* button.
   - For the other tools, the oscilloscope labels are already available.

## Logic Analyzer and Oscilloscope Correlate Data

1. Select the toolbar's Workspace button.
2. In the Workspace window, drag both instruments on to the workspace.
3. Connect both into same display tool.
4. In the Correlation Error dialog that appears, select *Group Run* for both instruments.
5. Select the *Group Run* or *Run All* button to start the acquisition.

6. To view the waveforms together, open the display tool.
   - For a Waveform display, select one of the labels and choose *Insert before...* or *Insert after...*. In the Label Dialog, select the label you want to insert, then select the *Apply* button.
   - For the other tools, the oscilloscope labels are already available.

# Triggering

The default trigger type is auto, which means the oscilloscope will trigger after 100 milliseconds. The trigger appears in the center of the acquisition. You can change where the trigger is in the *data set* by using the Delay field.

To specify more complicated triggers, select the *Trigger...* button at the bottom of the main oscilloscope window. This brings up the Trigger Setup Window.




You can also display the Trigger Setup window by selecting the trigger marker and choosing *Trigger...* from the menu.

The area to the right of the Trigger button indicates the current trigger. It does not show details such as occurence count.


- "Trigger Concepts" on page 38
- "Edge Triggering" on page 40
- "Pattern Triggering" on page 41
- "Delayed Triggering" on page 42
- "Getting a Stable Trigger" on page 43
- "The Trigger Setup Window" on page 44

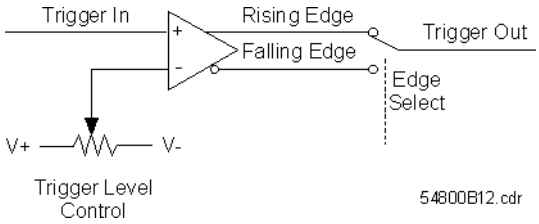

## Trigger Concepts

### Trigger Basics

The scope trigger circuitry helps you locate the waveform you want to view. There are several types of triggering, but the one that is used most often is edge triggering. Edge triggering identifies a trigger condition by looking for the slope (rising or falling) and voltage level

(trigger level) on the source you select. The trigger source is restricted to channel 1, channel 2, and the external trigger. If you have more channels on your oscilloscope, they cannot be used as trigger sources.

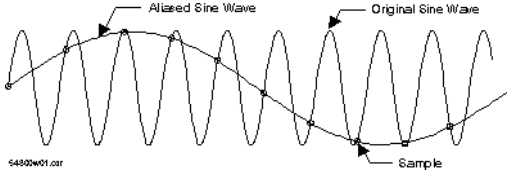
This figure shows the trigger circuit diagram.




Your waveform enters the positive input to the trigger comparator where it is compared to the trigger level voltage on the other input. The trigger comparator has a rising edge and a falling edge output. When a rising edge of your waveform crosses the trigger level, the rising edge comparator output goes high and the falling edge output goes low. When a falling edge of your waveform crosses the trigger level, the rising edge output goes low and the falling edge output goes high. The scope uses the output you have selected as the trigger output.

### Aliasing and Triggering

While aliasing does not cause unstable triggering, it does make it difficult to tell when the scope is triggered. An aliased waveform can appear as a lower frequency waveform that drifts across the display. To ensure that your waveform is not aliased, you should decrease the horizontal scale to its minimum value (maximum sampling rate), then increase it to view your waveform.



## Edge Triggering

Edge trigger is the default trigger setting. Edge mode sets the oscilloscope to trigger on an edge. You can set the source, trigger level, and slope in the oscilloscope main window. Selcting the *Trigger...* button brings up the Trigger Setup window, which lets you set the number of edges.




You can also display the Trigger Setup window by selecting the trigger marker and choosing *Trigger...* from the menu.

The oscilloscope identifies an edge trigger by looking for the specified slope (rising edge or falling edge) of your waveform. Once the slope is found, the oscilloscope will trigger when your waveform crosses the trigger level.

If you set the source to External, the trigger level is fixed at -1.30 V.

**NOTE:** The oscilloscope always fills a certain amount of acquisition memory before looking for a trigger. When counting edge occurrences, you may see more edges before the trigger than the number you specified. This happens because some edges were already in memory but are not included in the occurrence count.

When you set the trigger level on your waveform, it is usually best to set it to a voltage near the middle of your waveform. The middle range is best because there may be ringing or noise at the high and low ends which can cause false triggers.

When you adjust the arm level control, a horizontal dashed line with a T on the right-hand side appears, showing you where the arm level is with respect to your waveform. After a period of time the dashed line will disappear. You can get the line back by adjusting the arm level control again.

## Pattern Triggering

Pattern triggering is similar to the way that a logic analyzer captures data. This mode is useful when you are looking for a particular set of ones and zeros on a computer bus or control lines. You can use channel 1 and 2 and the external trigger to form the trigger pattern. Because you can set the voltage level that determines a logic 1 or a logic 0, any logic family that you are probing can be captured. Channels 3 through 8, available in multi-board oscilloscopes, cannot be used in the pattern.




You can display the Trigger Setup window by selecting the trigger marker and choosing *Trigger...* from the menu.

### When Pattern

There are five ways you can use to further qualify the pattern that you want to view. They are:

**Entered** When the scope finds the pattern, it triggers on the edge of the pulse that makes the pattern valid.

**Exited** The scope arms the trigger circuitry when it has found the pattern and triggers on the edge of the pulse that ends the pattern.

**Present >** The scope triggers when the pattern is found and is present for greater than the time value that you specify.

**Present <** The scope triggers when the pattern is found and is present for less than the time value that you specify.

**Range >** The scope triggers when the pattern is present within the time range that you specify.

**NOTE:** For *Present* >, *Present* <, and *Range* >, the oscilloscope does not trigger until the pattern is exited.

1. Set up a pattern by selecting the *X* button after each channel name.

*X* means the channel is not part of the pattern.
*Low* and *High* let you set the threshold voltages for channel 1 and channel 2.

2. Select the When Pattern that you want.
3. If you have selected Present >, Present <, or Range >, set the time values. The minimum is 20 ns, and the maximum is 160 milliseconds.
4. Close the Trigger Setup dialog box.

The area to the right of *Trigger...* shows the pattern you set up.

## Delayed Triggering

You can delay the trigger by setting the Delay field. The Delay field changes the acquisiton delay. Acquisition delay is the amount of time between the trigger event and the center of the acquisition. It is the only way to change the pre-trigger and post-trigger amounts in the Agilent Technologies 16533A or 16534A Digitizing Oscilloscope.

The value shown in the Delay field is the sum of the acquisition delay and the display delay. The display delay is controlled by the scrollbar, and indicates which portion of the acquisition is currently being displayed.

**To Store Mostly Post-Trigger Data**

1. Calculate 16,350 (about half the acquisition memory) divided by the sample rate. You should get a value in seconds.
2. Enter that value in the delay field.
   Use *n* for nanoseconds, *u* for microseconds, and *m* for milliseconds.
3. If the value is correct, the scrollbar will move to one end of its range and the current signal will not cross the entire display.
4. Select the *Run* button. The scrollbar returns to the middle.
   If you adjust the scrollbar before seleing the Run button, the oscilloscope treats the value as a display delay only.

To store mostly pre-trigger data, calculate the same value and enter it as a negative number.

**To Re-center the Trigger in the Acquisition**

1. Drag the scrollbar to the center of the scroll area. There is a slight delay in movement when the bar is at the center.
2. Set *Delay* at the bottom of the window to 0 seconds, and press enter. The scrollbar may jump away from the center. Do not reset it.
3. Select the *Run* button to get a new acquisition.

**See Also**

"Vertical and Horizontal Scaling" on page 52

## Getting a Stable Trigger

For most waveforms, the easiest way for you to get a stable trigger is to use Autoscale. Autoscale analyzes your waveform and sets the trigger mode to edge and the vertical scale, horizontal scale, and trigger level to best display your waveform.

### Manual Triggering

While Autoscale is the easiest way to obtain a stable trigger, there are times when you may need to set the trigger manually to capture more complex waveforms. To stabilize these waveforms:

- Set the Trigger Level to the proper point on the waveform.
  The proper point is usually somewhere around 50% to avoid possible ringing and noise at the top and base voltages.
- Increase the sampling rate to avoid aliasing.
  The sampling rate is controlled by the horizontal scale at the bottom of the screen. The maximum sampling rates are 1 gigasample per second for the 16533A and 2 gigasamples per second for the 16534A.
- Set the Trigger Sweep to *Triggered* for low-frequency waveforms.
  The Trigger Sweep field is in the Trigger Setup dialog.
- Remove noise from your waveform.



You can display the Trigger Setup window by selecing the trigger marker and choosing *Trigger...* from the menu.

**See Also**

"The Trigger Setup Window" on page 44

"Autoscale" on page 32

"Changing the Sample Rate" on page 54

## The Trigger Setup Window

The Trigger Setup window is for setting up complex triggers. You access it by selecting the *Trigger...* button at the bottom of the main oscilloscope window.

The two selections that are always availabe in the window are *Mode* and *Sweep*. *Mode* specifies the type of condition you want to trigger on. *Sweep* indicates whether the oscilloscope should wait for the condition (*Triggered*) or trigger immediately if the condition doesn't show up in 100 milliseconds (*Auto*).

**Edge**

Edge mode sets the oscilloscope to trigger on an edge. You can specify the source, trigger level, slope, and occurrence.

The oscilloscope identifies an edge trigger by looking for the specified slope (rising edge or falling edge) of your waveform. Once the slope is found, the oscilloscope will trigger when your waveform crosses the trigger level.

If you set the source to External, the trigger level is fixed at -1.30 V.

**Pattern**

Use pattern mode for triggering on glitches or unusually long pulses, or for a trigger involving 2 channels.

#### To Trigger on a Glitch

1. Select the *Trigger...* button.
2. Set the mode to *Pattern* and the sweep to *Triggered*.

3. Specify the glitch source by setting it to high or low. An *X* means the channel is not part of the pattern.
4. Select the option button under When Pattern and choose *Present* <.
5. Set the duration field to less than your clock's pulse width.

**Immediate**

Use immediate mode when the oscilloscope is triggered by another instrument in the measurement, or to acquire data as soon as you select the *Run* button. No other levels or settings may be specified for this mode.




You can also display the Trigger Setup window by selecting the trigger marker and choosing *Trigger...* from the menu.

**See Also**

"Edge Triggering" on page 40

"Pattern Triggering" on page 41

"Trigger Concepts" on page 38

# Changing Waveform Display and Grid


- "Zooming In" on page 46
- "Changing the Persistence of the Waveform" on page 46
- "Viewing Noisy Waveforms with Averaging" on page 48
- "Changing Display Colors" on page 50
- "Changing the Grid" on page 50


## Zooming In

To zoom in on a particular area of your waveform, drag a selection rectangle over the area and release.

To undo zoom, select in the display area and choose *Undo Zoom*. You can also choose *Undo Zoom* from the *Setup* menu.

Zoom may change your vertical scale (V/div), offset value, horizontal scale (timebase or s/div), and scrollbar position to match the current section of the waveform as though you had acquired it in that state. When the new settings exceed limits, the display change does not occur. This is most likely to happen with extreme negative delays and detailed vertical scaling (V/div). You may be able to zoom in if you enclose a larger area in the zoom.

If you Run then Undo Zoom, the original settings will be restored, but your waveform may look wrong. The gaps are due to clipping; the Agilent Technologies 16533A or 16534A oscilloscopes treat clipped data by leaving it at the top and bottom edges of the display.

## Changing the Persistence of the Waveform

Normally, a waveform is displayed only for one *acquisition*. When the next run occurs, the previous waveform is erased and the newly

acquired waveform is drawn on the display.

By using accumulate, you can see a visual history of a waveform's acquisitions over time. For example, you can see the accumulated peak-to-peak noise of a waveform over time which may appear significantly different than in only one acquisition. You can see timing jitter, the variance of the waveform from the trigger event, by accumulating acquisitions on the display. By using accumulate, viewing a waveform's extremes over time is much easier.

Waveform mode sets the amount of time a waveform sample appears on the display. Automated measurements cannot be performed on accumulated waveforms but will be performed on the most recent waveform in acquisition memory. Waveform accumulation does not occur beyond the display area boundary.

The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope have three waveform modes: Normal, Accumulate, and Average.

#### Normal

In the normal waveform mode, a waveform data point is displayed for at least 10 ms or one trigger cycle then erased. If no further triggers occur, the last acquisition is left on the display. This is the default setting. Use this mode for the fastest display update rate.

#### Accumulate

Accumulate is most like infinite persistence. In the accumulate waveform mode, a waveform sample point is displayed until settings are changed. All sample points are shown at full intensity. Use accumulate to measure jitter or eye diagrams, see a waveform's envelope, look for timing violations, and find infrequent events.

#### Average

When Averaging is enabled, the # *Avgs* control tells the oscilloscope the number of waveforms you want to use in calculating the average value for each sample point. The Agilent Technologies 16533A or 16534A oscilloscopes can average from 2 to 512 waveform acquisitions but the larger the number of acquisitions, the more time it will take to accumulate all the waveforms you have requested.

**NOTE:**

If you are using *Accumulate* or *Average* and you change the vertical or horizontal scaling, position, offset, trigger source or level, zoom, or drag the waveform then the display is redrawn and any accumulated waveforms are cleared. Only the last acquisition is displayed.

Set up markers and any measurements before using accumulate or averaging. Adding markers or clearing measurements later can erase acquired waveforms.

**See Also**

"Viewing Noisy Waveforms with Averaging" on page 48

"Display Setup Window" on page 59

## Viewing Noisy Waveforms with Averaging

The *Waveform Average* mode under *Display* tells the oscilloscope to acquire waveforms from several *acquisitions* and average them all together, point by point. The greater the number of averages, the less impact each new waveform has on the composite averaged waveform. The perceived display update rate is slowed down as the number of averages is increased because the averaged waveform doesn't change as much.

Sometimes, a waveform consists of a signal along with some random or asynchronous noise. By using Waveform Average, these noise sources can average to zero over time while the underlying waveform is preserved. This will improve the accuracy of waveform measurements because measurements are made on a more stable waveform and measurement variances are reduced. The effective resolution of the displayed waveform also improves as more acquisitions are averaged together, providing the input waveform is repetitive and has a stable trigger point.

Incidentally, if Waveform Average is enabled but the scope is not properly triggering (perhaps the scope is set to Auto trigger and the wrong trigger channel is selected), you may not see the waveform you expect on the display. In this case, the input waveform is asynchronous to the scope and will average to zero over time even though a non-zero

input waveform is being measured.

When Waveform Average is enabled, the # *Avgs* control sets the number of waveforms you want to use in calculating the average value for each sample point. The Agilent Technologies 16533A or 16534A can average from 2 to 512 waveform acquisitions but the larger the number of acquisitions, the more time it will take to accumulate all the waveforms you have requested.

The following formula is used to calculate the average for each data point:

$$Ave_n = \frac{1}{n}\sum_{i=1}^{n} S_i$$

$$= \frac{1}{n}\sum_{i=1}^{n-1} S_i + \frac{1}{n} S_n$$

$$= \frac{1}{n}(n-1)Ave_{n-1} + \frac{1}{n} S_n$$

$$= \frac{n-1}{n} Ave_{n-1} + \frac{S_n}{n}$$

For n between 1 and M. After terminal count is reached (n greater than or equal to M),

$$Ave_n = \frac{M-1}{M} Ave_{n-1} + \frac{S_n}{M}$$

where:

$Ave_n$ = the average sample value
n = the current average number
M = setting of # Avgs control (terminal count)
$S_i$ = the $i^{th}$ sample.

**See Also** "Changing the Persistence of the Waveform" on page 46

"Trigger Concepts" on page 38

"Getting a Stable Trigger" on page 43

## Changing Display Colors

The display colors which indicate channels, memories, and markers are editable. These colors are also used by the display tools in the rest of the logic analysis system.

### To Change Colors

1. In the menu bar, select *Setup*.
2. Select *Display...*
   The Display Setup dialog appears.
3. Under Colors, select the channel to modify.
4. Select the color you want it to be.
5. Select the *Edit Colors...* button to change a color's value.

**NOTE:** If you *Close* the Color Edit box, the new color values will be used in this *session* only. If you *Apply* the color values, they will be used in this session and following sessions. To restore the factory colors, select the *Reset Defaults* button.

## Changing the Grid

The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope has a 10 by 8 display graticule grid which you can turn on or off. When on, a grid line is place on each vertical and horizontal division. When the grid is off, a frame with tic marks surrounds the graticule edges.

You can dim the grid's intensity or turn the grid off to better view waveforms which the graticule lines might obscure. Otherwise, you can use the grid to estimate waveform measurements such as amplitude and period. The grid intensity control doesn't affect printing. You must

explicitly turn the grid off to remove the grid from a hardcopy.

1. In the menu bar, select *Setup*.
2. Select *Display...*
   The Display Setup dialog appears.
3. Select the Grid Type option button to change the grid to axes-only scales, frame-only scale, or a background grid. The intensity field controls the brightness. You cannot change the grid color.

# Vertical and Horizontal Scaling

The vertical scale is volts per division (V/div). Changing the vertical scale affects the height of the waveform. Extreme changes to the vertical scale can affect your offset values. If the waveform extends beyond the top or bottom of the display, data will be clipped. You cannot measure clipped data, and when you adjust the offset or vertical scale, clipped data stays at the top or bottom edge with a break in the waveform.

The horizontal scale is seconds per division (s/div). Changing the horizontal scale compresses and expands a waveform, and changes the sampling rate. The automatic measurements only measure what is currently shown in the display window, however.

Compressing the waveform may cause your sample rate to slow down. Similarly, expanding your waveform may cause your sample rate to increase, up to 1 gigasample per second for the 16533A or 2 gigasamples per second for the 16534A. See the table in “Changing the Sample Rate” on page 54 for timebase and sampling rates.

The vertical (V/div) scale control is located under the *Channels* tab. The horizontal (s/div) scale control is located at the bottom left corner of the oscilloscope window.

### Scrolling

The scrollbar below the display indicates what portion of the current *data set* you are viewing. Its size shows the percentage of the data you are looking at, and its location indicates the location of the data within the data set.

You can scroll through your data set by dragging the scrollbar. You can also use the Delay field, but this may change your acquisition delay as described in “Delayed Triggering” on page 42.

To scroll short distances, drag the waveforms or trigger reference marker. Individual waveforms can also be dragged vertically. Dragging waveforms does change the delay and offset fields and will affect your next acquisition.

When you select the *Run* button after having moved the scrollbar, the display shows the same section of the data set that you were viewing before. For example, if you had the scrollbar at the right end, you were viewing the last part of the data set. When you select the *Run* button, the oscilloscope acquires more data and again displays the last portion.

Sometimes you may not be able to move the scrollbar through the entire scrolling area. This is because you have increased the sample rate. The scrolling area indicates the size of the next acquisition, but you can only move the scrollbar through the area filled with the current data set. You can use the Delay arrows to move the scrollbar past its dragging limits.

**See Also**

"Delayed Triggering" on page 42

"Changing the Sample Rate" on page 54

"Channel Setup Window" on page 33

# Changing the Sample Rate

The s/div scale controls the sample rate. The relationship is shown in a table at the end of this topic.

The sample rate is displayed in the bottom left corner of the display area. The maximum sample rate is 1 gigasamples per second for the 16533A and 2 gigasamples per second for the 16534A. The minimum sample rate is 500 samples per second.

### Aliasing

Aliasing occurs when the sample rate is not at least four times as fast as the high frequencies of your waveform. If you cannot see why the oscilloscope triggered, or if the waveform moves around on screen, or if the waveform looks slower than it should, suspect aliasing. To increase your sample rate, set the s/div scale to a higher number, then run again.

**See Also**

"Trigger Concepts" on page 38

| **s/div** | Sample Rate |
|---|---|
| **< 200 ns** | 2 GSa/s |
| **500 ns** | 1 GSa/s |
| **1 us** | 500 MSa/s |
| **2 us** | 250 MSa/s |
| **5 us** | 100 MSa/s |
| **10 us** | 50 MSa/s |
| **20 us** | 25 MSa/s |
| **50 us** | 10 MSa/s |
| **100 us** | 5 MSa/s |
| **200 us** | 2.5 MSa/s |
| **500 us** | 1 MSa/s |
| **1 ms** | 500 KSa/s |

| | |
|---|---|
| **2 ms** | 250 KSa/s |
| **5 ms - 20 ms** | 100 KSa/s |
| **50 ms** | 50 KSa/s |
| **100 ms** | 25 KSa/s |
| **200 ms** | 10 KSa/s |
| **500 ms** | 5 KSa/s |
| **1 s** | 2.5 KSa/s |
| **2 s** | 1 KSa/s |
| **5 s** | 500 Sa/s |

# Comparing Channels

The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope do not support waveform math (A+B or A-B). However, you can easily overlay waveforms by putting the 0 V indicators () on top of each other, and making sure the waveforms have the same scale. The automatic measurements are done on only one waveform, however.

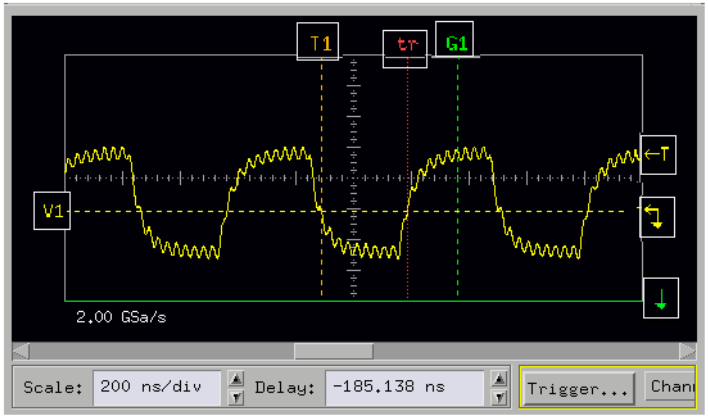
Using waveform memories, you can also compare a waveform from a previous *acquisition* to the current display. The waveform must be loaded into memory when it is captured. The captured waveform can be displayed either with the current scale settings or with the ones used when it was captured.

**See Also**

"Using Markers" on page 75

"Using Waveform Memories" on page 78

# What Do the Display Symbols Mean?




All the indicators around the edge of the grid are draggable.




Local voltage marker. The color indicates which channel it is measuring.




Local time marker. Time markers are channel independent.




Trigger event indicator.




Global marker. The global markers measure time and retain their position within the total acquisition of all instruments in a *Group Run*.




Trigger level indicator. The color indicates which channel it is set on.



0 V (ground) indicator. The color indicates which channel it is set on. The 0 V indicator is controlled by the offset setting. When offset is negative, the 0 V indicator is above the center line. When offset is positive, the 0 V indicator is below the center line. Also referred to as *offset indicator*.



Offscreen indicator. The color indicates which channel it is set on. The offscreen indicator appears when the 0 V indicator moves offscreen.

**See Also** "Using Markers" on page 75

# Display Setup Window

The settings under *Display* control how waveforms are displayed. Only "Acquisition Memory to Display" affects *acquisitions*.

### Waveform Mode

**Normal** is the default setting. It shows the current acquisition only.

**Accumulate** draws subsequent waveforms in the same area, without erasing previous waveforms. The accumulated waveforms are erased if any settings are changed, however.

**Average** averages the current acquisition with the specified number of prior acquisitions. All acquisitions are equally weighted. The averaged waveforms are replaced with the current acquisition if any settings are changed.

### Acquisition Memory to Display

For lower time resolutions, these settings allow you to optimize the oscilloscope for greater detail or longer duration. *All* gives greater detail by sampling more frequently. *Partial* stretches the acquisition memory over a longer duration by slowing down the sample rate. These settings do not make a difference when the horizontal scale is finer than 1.00 microsecond/division for a 16533A, or 500 nanoseconds/division for a 16534A.

### Setup...

The *Setup...* button opens the Display Setup window. This window contains the same controls under the Display tab, and also lets you change the graticule and waveform colors.

### Clear Display

The *Clear Display* button removes all channels from the graticule. It does not affect waveform memories or markers.

**See Also**

"Changing the Persistence of the Waveform" on page 46

"Changing Display Colors" on page 50

"Changing the Grid" on page 50

# Automatic Measurements and Algorithms

Automatic measurements are simpler and usually more accurate to make than the corresponding measurement done manually. (Manual measurements and simple statistics are done using markers; see "Using Markers" on page 75.) Blank values in the automatic measurement field means that requirements for that measurement were not met. For specific measurements, see the list below.


- "How the Scope Makes Measurements" on page 62
- "Average Voltage (Vavg)" on page 63
- "Base Voltage (Vbase)" on page 66
- "Fall Time" on page 64
- "Frequency" on page 65
- "Maximum Voltage (Vmax)" on page 69
- "Minimum Voltage (Vmin)" on page 69
- "Negative and Positive Pulse Width (±Width)" on page 64
- "Overshoot" on page 68
- "Peak-to-Peak Voltage (Vpp)" on page 68
- "Period" on page 63
- "Preshoot" on page 67
- "Rise Time" on page 63
- "Time of Maximum Voltage (Tmax)" on page 70
- "Time of Minimum Voltage (Tmin)" on page 70
- "Top Voltage (Vtop)" on page 66
- "Voltage Amplitude (Vamp)" on page 70
- "Vdcrms (Root Mean Square Voltage, DC)" on page 71


**See Also**

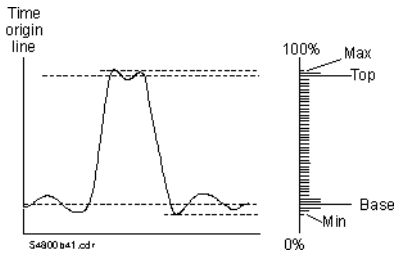
"About the Measurements" on page 71

"Increasing the Accuracy of Your Measurements" on page 73

"Autoscale" on page 32

## How the Scope Makes Measurements

Automatic parametric measurements are calculated from a histogram. Measurements are done as soon as valid data is available. The absolute minimum and maximum are derived from the histogram.




Next, the statistical top and base values are calculated. The top 40% of the histogram is scanned for the top value and the bottom 40% is scanned for the base value. The center 20% of the histogram is not scanned to prevent selecting the middle of a tri-state waveform.

The measurement algorithm decides whether the absolute maximum and minimum values should be used, as in the case of triangle waveforms, or the statistical top and base should be used, as in the case of square waveforms.

After the top and base are calculated, the IEEE 10%, 50%, and 90% thresholds are calculated. These thresholds determine edges and are used by all timing measurements. For example, rise time is measured from the lower threshold to the 90% threshold of a rising edge. Period, frequency, and pulse width measurements use the 50% threshold.

Once the thresholds have been calculated, the edges can be determined. A rising edge is defined as a transition that passes through the 10%, 50%, and 90% threshold levels. A falling edge is defined as a transition that passes through the 90%, 50%, and 10% threshold levels. For an edge to be detected, it must complete the transition through all

three threshold levels.

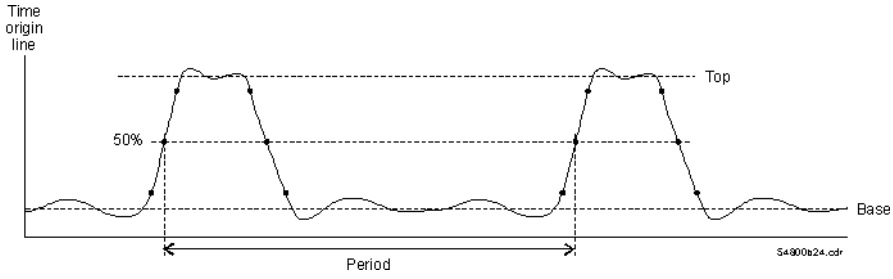
Once the oscilloscope locates rising and falling edges, it calculates rise time, fall time, and frequency. If too few sample points fall along an edge, the measurement is not made. The oscilloscope ignores incomplete transitions.

## Average Voltage (Vavg)

Vavg is the average voltage of waveform data over the display. It does not include data that is offscreen. The value is calculated by summing all the data points on the screen and dividing by the number of them.

## Period

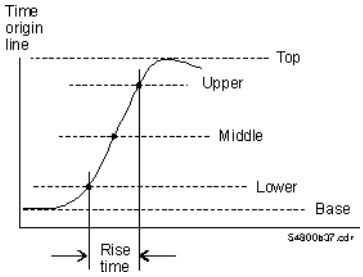
Period is defined as the time between the 50% threshold crossings of two consecutive, like-polarity edges.




The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope starts the measurement at the leftmost edge of the display.

## Rise Time

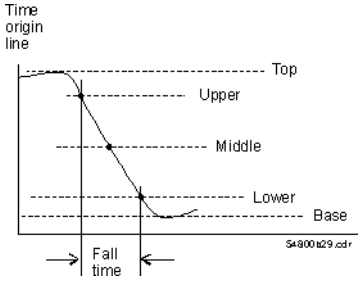
Rise time is defined as the time at the 90% threshold minus the time at the 10% threshold on the edge you are measuring.




The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope starts the measurement at the leftmost edge of the display.

## Fall Time

Fall time is defined as the time at the 10% threshold minus the time at the 90% threshold on the edge you are measuring.

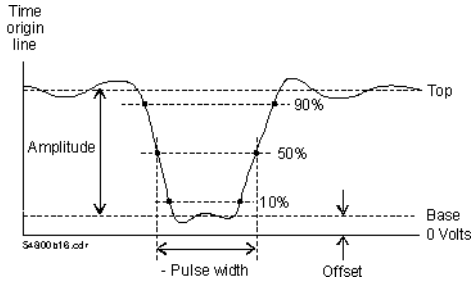



The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope starts the measurement at the leftmost edge of the display.

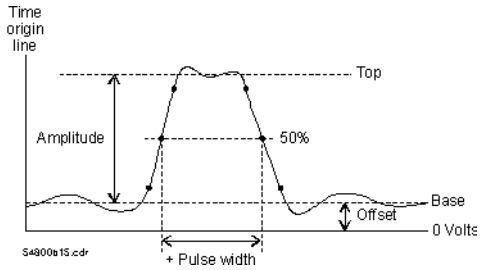
## Negative and Positive Pulse Width (±Width)

Negative pulse width is defined as the time from the 50% threshold of the first falling edge to the 50% threshold of the next rising edge.

Positive pulse width is defined as the time from the 50% threshold of the first rising edge to the 50% threshold of the next falling edge.




**Negative Pulse Width**

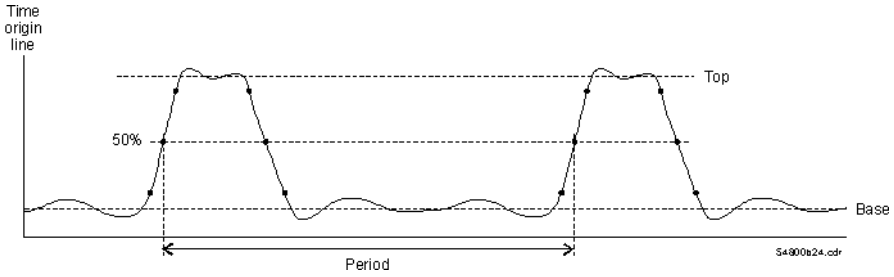



**Positive Pulse Width**

The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope starts the measurement at the leftmost edge of the display.

## Frequency

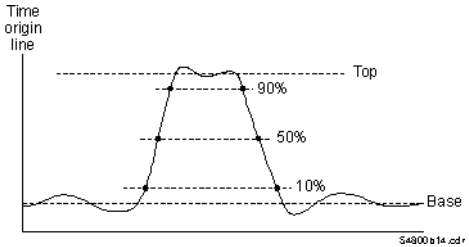
Frequency is defined as 1/Period. Period is the time between the 50% threshold crossings of two consecutive, like-polarity edges.




The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope starts the measurement on the first edge of the leftmost portion of the display.

## Base Voltage (Vbase)

Vbase is the voltage of the statistical minimum level of the waveform display, which is defined as the most frequently occurring voltage in the histogram of the bottom 40% of the waveform.



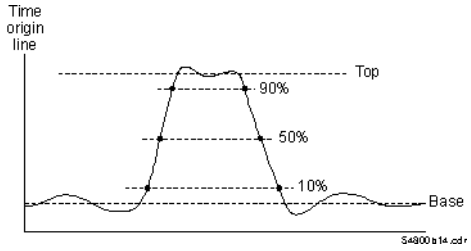

Vbase may be equal to Vmin for many waveforms, such as triangle waveforms. Similarly, Vtop may be equal to Vmax.

This measurement is position-independent and the entire display is used for the measurement.

## Top Voltage (Vtop)

Vtop is the voltage of the statistical maximum level of the waveform

display, which is defined as the most frequently occurring voltage in the histogram of the top 40% of the waveform.

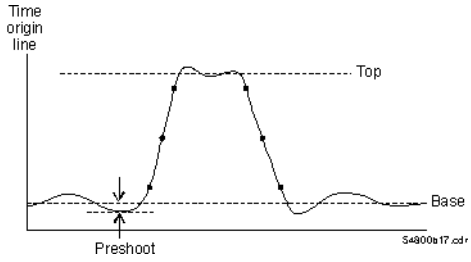



Vtop may be equal to Vmax for many waveforms, such as triangle waveforms. Similarly, Vbase may be equal to Vmin.

This measurement is position-independent and the entire display is used for the measurement.

## Preshoot

Preshoot is a waveform distortion that precedes an edge transition.




If the edge is rising, preshoot will be 100*(base - local minimum)/ (top - base). The local minimum is found half way from the 10% threshold level to the 10% threshold level at the previous falling edge.

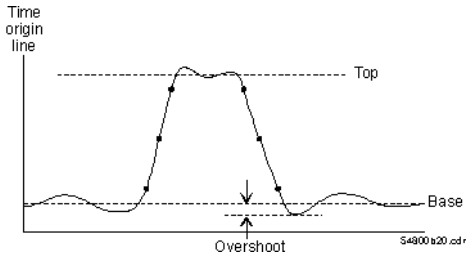
If the edge is falling, preshoot will be 100*(local maximum - top)/(top - base). The local maximum is found half way from the 90% threshold level to the previous 90% threshold level at the previous rising edge.

The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope starts the measurement at the first edge of the leftmost portion of the

display.

## Overshoot

Overshoot is a waveform distortion that follows a major edge transition.



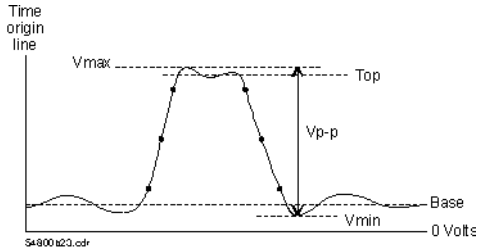

If the edge is rising, the overshoot will be 100*(local maximum - top)/(top - base). The local maximum is found half way from the 90% threshold level to the next 90% threshold level at the falling edge.

If the edge is falling, the overshoot will be 100*(base - local minimum)/(top - base). The local minimum is found half way from the 10% threshold level to the next 10% threshold level at the next rising edge.

The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope starts the measurement at the first edge on the leftmost portion of the display.

## Peak-to-Peak Voltage (Vpp)

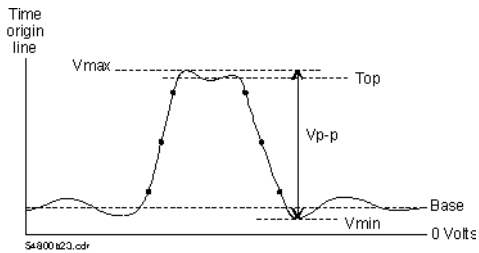
Peak-to-peak voltage is defined as Vmax - Vmin. Vmax is the absolute maximum voltage of the display. Vmin is the absolute minimum voltage of the display.




This measurement is position-independent and the entire display is used for the measurement.

## Minimum Voltage (Vmin)

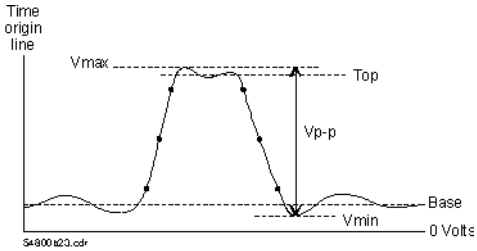
Vmin is the absolute minimum voltage of the waveform display.




This measurement is position-independent and the entire display is used for the measurement.

## Maximum Voltage (Vmax)

Vmax is the absolute maximum voltage of the waveform display.




This measurement is position-independent and the entire display is used for the measurement.

## Time of Minimum Voltage (Tmin)

Tmin is the first time that the minimum voltage occurs on the display.

This measurement is position-independent and the entire display is used for the measurement.

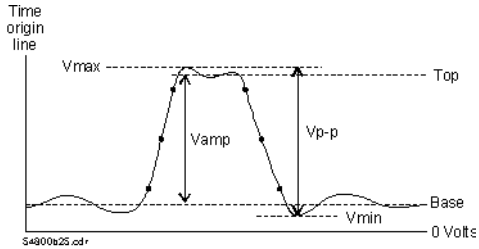
## Time of Maximum Voltage (Tmax)

Tmax is the first time that the maximum voltage occurs on the display.

This measurement is position-independent and the entire display is used for the measurement.

## Voltage Amplitude (Vamp)

Vamp is the amplitude of the waveform display. Vamp = Vtop - Vbase.




This measurement is position-independent and the entire display is used for the measurement.

## Vdcrms (Root Mean Square Voltage, DC)

Vdcrms is the root-mean-square voltage of the waveform. The equation used is:

$$V_{dcrms} = \sqrt{\frac{v(t)^2}{n}}$$

This measurement is position-independent and the entire display is used for the measurement. Data points offscreen are not included.

## About the Measurements

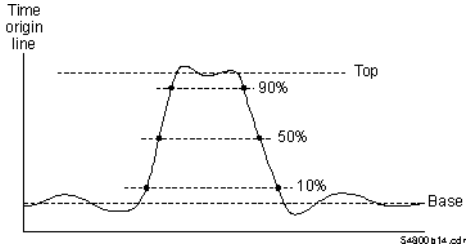
The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope makes measurements after every trigger event, always maintaining continuity between the measurement results and the oscilloscope display. This makes sure that no aberration in the waveform under observation is missed.

If the waveform is clipped, the oscilloscope cannot make some automatic measurements. These measurements will show *clipped* where a value would normally appear. Other indicators you may see are:

| | |
|---|---|
| **?** | Value is questionable. This can occur because the signal is clipped, there are not enough points, or the amplitude is too small. |
| **<** | The result is less than or equal to the value shown. This can occur when the waveform is clipped low or not enough points are available. |
| **>** | The result is greater than or equal to the value shown. This can occur when the waveform is clipped high or not enough points are available. |
| **(blank)** | No value could be calculated. The most common reason is missing edges, such as when the display shows less than a full period of a waveform. |

The Agilent Technologies 16533A or 16534A will interpolate sample points if necessary to determine pulse parameters for automatic measurements. Excessive interpolation can lead to jitter on measurements; if this occurs you may have to increase the sample rate.

By default, the oscilloscope uses the IEEE thresholds of 10, 50, and 90 percent for pulse measurements. A rising or falling edge is only recognized after passing through all three thresholds. These thresholds appear on the example pulse waveform as shown below:




### Period and Frequency Measurements

At least one full cycle of the waveform with at least two like edges must be displayed for period and frequency measurements. Automatic waveform measurements use a single pulse and may have significant errors introduced by interpolation and trigger inaccuracies. The leftmost cycle is used for making measurements.

#### Pulse Width Measurements

For either the -Width or +Width measurements, a complete pulse must be displayed to make a valid measurement. Remember that an edge must pass through all three thresholds to be recognized as an edge. Therefore, it is important that the pulse be positioned so that both pulse edges transition through all three thresholds and are displayed on the screen. Pulse width is measured from the leftmost valid edge to the next valid edge.

#### Rise Time, Fall Time, Preshoot, and Overshoot Measurements

The leading, rising edge of the waveform must be displayed for rise time and rising edge preshoot and overshoot measurements. The trailing, falling edge of the waveform must be displayed for fall time and falling edge preshoot and overshoot measurements. The leftmost edge is used for measurements.

Remember that an edge must pass through all three thresholds to be recognized as an edge. Therefore, it is important that the pulse be positioned so that all three thresholds are displayed on the screen. Rise time, fall time, preshoot, and overshoot measurements will be more accurate if you expand the edge of the waveform by choosing a faster sweep speed. Expanding the waveform will provide more data points on an edge, reduce interpolation, and thus provide a more accurate measurement.

## Increasing the Accuracy of Your Measurements

Things you can do to make your measurements more accurate:

- Deskew the oscilloscope channels.
  To deskew the oscilloscope channels, perform the *Channel Skew* procedure as part of calibrating the oscilloscope (see page 10).
- Use automatic measurements where possible.
- For positive and negative pulse width, make sure enough top and bottom voltages are showing to accurately calculate the top and base voltages.
- When using markers, increase the sampling rate.

- Minimize the effect of DC errors on time measurements by
  - measuring between identical edges (same slew rate, amplitude and offset).
  - using the same DC level to reference each endpoint of the interval.
  - performing the measurement on the fastest-slewing portion of each edge.
  - making the waveform as large as possible.
- Calibrate (see page 10) your oscilloscope after it has warmed up.

**See Also**

"Getting a Stable Trigger" on page 43

# Using Markers

The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope has both local and global markers. The local markers can only be used within the oscilloscope window. The global markers retain their position across the data sets of all instruments that are part of the same group run as the oscilloscope.

The global markers are G1 and G2 and only measure time. The local markers consist of four voltage markers, V1 - V4, and two time markers, T1 and T2.

To access the markers, select the *Markers* tab then select the *Setup...* button. The Marker Setup dialog appears, from which you can turn on any of the markers by selecting the appropriate button. From this dialog, you can also change the channel of the voltage markers.

The information after this does not apply to automatic time markers. Those are covered in a separate topic listed below.

When the markers are turned on, you can set their values by dragging them. If a marker moves offscreen because of scrolling or from typing in a value in the Marker Setup window, you can return it to the edge of the display by selecting the arrow buttons in the Marker Setup window.




You can also place markers by selecting the area you want the marker on and choosing *Place Marker* and the marker you want from the menu. If your cursor is on a marker already, select *Markers...* to display the Marker Setup dialog.

**See Also**

"What Do the Display Symbols Mean?" on page 57

"About Automatic Time Markers" on page 76

Working with Global Markers in Correlated Displays (see the *Markers* help volume)

## About Automatic Time Markers

Automatic time markers indicate the time at which a specified voltage crossing occurs. For instance, if you scroll the display, an automatic time marker defined for the third edge will automatically reposition itself on the edge third from the left. A regular time marker would remain placed on the waveform and scroll with it off the display.

When you turn on an automatic time marker, *Min T2-T1*, *Max T2-T1*, and *Mean T2-T1* appear at the bottom of the Markers area. You can gather statistics as long as both time markers are on, and one is an automatic marker. Changing any part of the display will clear statistics.

#### To turn on automatic time markers

1. Under the *Markers* tab, select the *Setup...* button.
2. Select the time marker button.
3. Choose *Marker [OFF]* to turn on the marker.
4. Choose *Automatic [OFF]* to put it in automatic mode.
5. Select the *Define Automatic Marker...* button.
   If you did not put the marker in automatic mode, the area to the right of T1 or T2 is a time from trigger setting.
6. Specify the automatic setting. Percentage level is based on the automatically calculated top and base voltage.

Automatic time markers cannot be dragged when they are on their specified edge. If the specified edge does not exist, they can be dragged like regular time markers.

**See Also**

"Top Voltage (Vtop)" on page 66

"Base Voltage (Vbase)" on page 66

"How the Scope Makes Measurements" on page 62

# Differences from a Standard Digitizing Oscilloscope

There are some differences between an Agilent Technologies 16533A or 16534A Digitizing Oscilloscope and a standard stand-alone digitizing oscilloscope.

- Clipped data (data that is offscreen at acquisition) stays at the top or bottom edge of the display area when the clipped waveform is resized or has the offset moved. The waveform appears to have a gap in it where the clipped data was.
- Repetitive run is repetitive real-time acquisitions, not what is also referred to as equivalent-time mode.
- When there are not enough data points to map at least one sample to each column of pixels in the display, the sin(x)/x interpolation filter is on. You cannot turn it off.
- There is only one graticule area. All oscilloscope channels are sampled and displayed at the same rate.
- The Agilent Technologies 16533A or 16534A oscilloscope is easier to use in conjunction with a logic analyzer because arming is handled by the Agilent Technologies 16700A/B-series frame. You do not need to connect any wires between the two modules.

# Using Waveform Memories

The four waveform memories store copies of waveforms for display within the oscilloscope tool. The memories cannot be exported to other display *tools*.

### To Use Waveform Memory

This procedure assumes you already have acquired a waveform that you want to store.

1. Under the *Memories* tab, select the *Setup...* button.
2. In the *Load Waveform* area, select the waveform source.
   The button text depends on your setup, but the default is channel 1.
3. Select the *Load* button.
   Sources can be any channel or another waveform memory. If the source does not contain any data (for example, the channel was off during the last *acquisition*), "Waveform data is not valid!" appears briefly at the top of the Waveform Memory Setup window. If the display is set to accumulate or average, only the last acquired waveform is loaded.
4. To view the memory, select the *Off* radio button.
5. To make the memory display independent of the main display controls, select the box to the left of *Horizontal*. This enables the independent horizontal scale controls.

Waveform memories are erased between *sessions*. They are not cleared when the display is cleared. In all other ways, waveform memories are treated like channels by the display functions.

# Loading and Saving Oscilloscope Configurations

Oscilloscope settings and data can be saved to a configuration file. You can also save any tools connected to the oscilloscope. Later, you can restore your data and settings by loading the configuration file into the oscilloscope.

- Loading Configuration Files (see the *Agilent Technologies 16700A/B-Series Logic Analysis System* help volume)
- Saving Configuration Files (see the *Agilent Technologies 16700A/B-Series Logic Analysis System* help volume)

# When Something Goes Wrong


- "Error Messages" on page 80
- "Calibration Problems" on page 80
- "Triggering Problems" on page 80
- "Other Problems" on page 81


## Error Messages


- No valid signals have been found. (see page 82)
- Incorrect Calibration Factors for this software revision. (see page 83)
- Waiting for IMB Arm. (see page 83)


## Calibration Problems

#### Calibration is not possible because NV RAM is protected

Unprotect the NV RAM and try again.

#### Calibration Procedure did not complete successfully

The Calibration window shows which tests passed and failed. If any test failed and all cables were correctly hooked up, you should contact your Agilent Technologies Service Center.

## Triggering Problems

#### Scope loses trigger when changes made to offset

The trigger level may be too high or too low to reliably trigger before autotrigger. Sometimes this over-sensitivity to offset is caused by too

high an attenuation factor in the channel setup.

#### Low frequency waveform appears to have unstable trigger

See "Getting a Stable Trigger" on page 43.

#### Nothing happening

If the scope is being triggered by another instrument, and you were changing some settings, the scope may have missed its trigger signal.

The other common causes when the trigger is set to *Triggered* are

- trigger level occurs outside normal signal
- the oscilloscope is waiting for a rare event

You can either stop the oscilloscope or set the trigger to *Auto* to look for these conditions.

## Other Problems

#### Autoscale failed to find a waveform

Check that either channel 1 or channel 2 is on. Autoscale autoscales all channels, but can only trigger on channel 1 or 2.

Also check for correct channel setup. The wrong setup can attenuate a proper signal into an apparent DC signal.

#### Waveform has gaps when offset is changed or V/div increased

If a waveform is clipped, when you move the offset the clipped portion of the waveform will stay at the top or bottom of the display, with a break in the rest of the waveform. This also happens if you increase V/div so that more of the waveform fits in the display. Those portions that were off the display during acquisition contain uncertain data and so are not displayable.

To get good data, make the changes to your settings and run again.

#### Trigger won't return to center

The trigger delay is affected by both the scrollbar position and the value in the delay field. To re-center the trigger in the acquisition,

1. Drag the scrollbar to the center of the scroll area. There is a slight delay in movement when the bar is at the center.
2. Set *Delay* at the bottom of the window to 0 seconds, and press enter. The scrollbar may jump away from the center. Do not reset it.
3. Select the *Run* button to get a new acquisition.

The trigger is now in the center of the acquisition as well as the display window.

#### Scope keeps stopping

The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope default to single-shot acquisition. To have the oscilloscope keep running, select the *Run Repetitive* button.

**NOTE:** The Agilent Technologies 16533A or 16534A Digitizing Oscilloscope does not do equivalent-time sampling. All runs in the repetitive run mode are single acquisitions.

#### Scope locked up

The *logic analysis system* may be busy. Wait a few minutes and try again. If the problem persists, exit the *session* and cycle power on the *frame*.

If you can find a sequence of steps that always or frequently causes this to happen, *please* contact the Agilent Technologies Sales Office to report this bug.

### Error Message: No Valid Signals

This message only comes up when autoscale is run and the oscilloscope is unable to detect any line activity. Possible causes are:

- No channels are turned on. Autoscale does not check channels that are turned off.

- The oscilloscope board is damaged. Run calibration to check for signal detection.

Autoscale does detect flat, dc signals so that is not a cause.

## Error Message: Incorrect Calibration Factors

This message appears when you have upgraded your oscilloscope software, but not re-calibrated the Agilent Technologies 16533A or 16534A oscilloscope.

See the *Logic Analysis System Installation Guide* or "Calibrating the Oscilloscope" on page 10 for instructions on calibrating the oscilloscope.

## Status Message: Waiting for IMB Arm

This message appears when the oscilloscope is being triggered by another instrument in the *logic analysis system*. The instrument that will trigger the oscilloscope has not yet found its own trigger, and therefore hasn't sent the *IMB Arm* signal to the oscilloscope.

If the other instrument has already triggered, perform the Self Test (see page 83) on the oscilloscope. If any of the tests fail, contact your Agilent Technologies Sales Office for service.

**Performing the Self Tests.** To verify that the oscilloscope hardware is operational, run the Self Test utility. The Self Tst function of the logic analysis system performs functional tests on both the system and any installed modules.

**NOTE:** The operational accuracy calibration requires that the oscilloscope hardware meets specifications. The self test only requires that the hardware function. An oscilloscope can pass self-test and still fail calibration.

### To Run the Self-Test Utility

1. If you have any work in progress, save it to a configuration file. (see the *Agilent Technologies 16700A/B-Series Logic Analysis System* help volume)

2. From the system window, select the *System Administration* toolbar button.
3. Select the *Admin* tab, then select the *Self Test...* button.
   The system closes all windows before starting up Self Test.
4. Select *Master Frame*.
   If the module is in an expansion frame, select *Expansion Frame*.
5. Select the oscilloscope.
6. In the Self Test dialog box, select *Test All*.
   You can also run individual tests by selecting them. Tests that require you to do something must be run this way.

If any test fails, contact your local Agilent Technologies Sales Office or Service Center for assistance.

# Specifications and Characteristics

**NOTE:** Specifications are valid after a 30 minute warm-up period, and within 10 °C from the firmware calibration temperature.

**NOTE:** Definition of Terms

To understand the difference between specifications (see page 88) and characteristics (see page 88), and what gets a calibration procedure (see page 88) and what gets a function test (see page 89), refer to appropriate links within this note.


- Specifications (see page 85)
- Operating Environment (see page 85)
- Characteristics (see page 86)


## Specifications

Note: Specifications refer to the input to the BNC connector.

```
Bandwidth
  16533A                          dc to 250 MHz
  16534A                          dc to 500 MHz

dc offset accuracy                 +/- (1% of offset + 2% of full scale)

dc voltage measurement accuracy    +/- (1.25% of full scale + offset accuracy
                                   + 0.016 div)

Time interval measurement accuracy +/- [(0.005% of delta T) + (2e-6 x delay
setting)
at maximum sampling rate, on a     + 100 ps]
single card, on a single acquisition

Trigger sensitivity from 10 mV/div to 10 V/div
  dc to 50 MHz                     0.25 div
  50 MHz to 500 MHz                0.5 div

Trigger sensitivity at 4 mV/div
  dc to 50 MHz                     0.63 div
  50 MHz to 500 MHz                1.25 div

Input resistance                   1 Mohm +/- 1%
                                   50 ohm +/- 1%
```

## Operating Environment

```
Power Requirements
  All power supplies required for operating the oscilloscope are
  supplied through the backplane connector in the logic analysis system.

Operating Environment Characteristics
  The oscilloscope module's reliability is enhanced when operating
  the module within the following ranges:

  - Indoor use only.
  - Temperature:  +20 degrees C to +35 degrees C
                  (+68 degrees F to +95 degrees F)
  - Humidity: 20% to 80% noncondensing
```

## Characteristics

### General

| | |
|---|---|
| Maximum sampling rate | |
| 16533A | 1 GSa/S |
| 16534A | 2 GSa/S |
| Number of channels | 2 to 8 channels using the same timebase and trigger. |
| Waveform record length | 32768 points |

### Vertical (Voltage)

(characteristics refer to the input at the BNC connector)

| | |
|---|---|
| Vertical sensitivity range | 4 mV/div to 10 V/div in 1:2:4 steps |
| Vertical resolution | 8 bits over 4 vertical divisions |
| Rise time (calculated from bandwidth) | |
| 16533A | 1.4 ns |
| 16534A | 700 ps |
| dc gain accuracy | +/- (1.25% of full scale + 0.08% per degree C difference from calibration temperature) |
| dc offset range (1:1 probe) | |
| Vertical sensitivity | Offset range |
| 4 mV/div - 100 mV/div | +/- 2 V |
| 100 mV/div - 400 mV/div | +/- 10 V |
| 400 mV/div - 2.5 V/div | +/- 50 V |
| 2.5 V/div - 10 V/div | +/- 250 V |
| Probe attenuation | Any ratio from 1:1 to 1000:1 factor |
| Channel-to-channel isolation (with channel sensitivities equal) | |
| dc to 50 MHz | 40 dB |
| 50 MHz to 250 MHz (16533A) | 30 dB |
| 50 MHz to 500 MHz (16534A) | 30 dB |
| Maximum safe input voltage | |
| 1 Mohm | +/- 250 Vdc + peak ac (&<10KHz), CAT I |
| 50 ohm | 5 Vrms, CAT I |

| | |
|---|---|
| Input coupling | |
| 1 Mohm | ac, dc |
| 50 ohm | dc only |
| Input C | approximately 7 pF |

Number of channels: 2,4,6, or 8 simultaneous channels using the same trigger OR up to 10 channels with independent triggers for each pair of channels. Maximum of 20 channels with Agilent Technologies 16701A expansion frame.

## Horizontal (Time)

| | |
|---|---|
| Timebase ranges | 0.5 ns/div to 5 s/div |
| Timebase resolution | 10 ps |
| Delay range, pre-trigger | 81.8 s, 5 divisions |
| Delay range, post-trigger | 2.5e3 seconds |
| Time interval measurement accuracy for sampling rates other than maximum, for bandwidth-limited signals (signal rise time > 1.4/sample rate) on a single card, on a single acquisition | +/- [(0.005% of delta T) + (2e-6 x delay setting) + (0.15/sample rate)] |
| Time interval measurement accuracy for 2, 3, or 4 cards operation on a single timebase, for measurements made between channels on different cards, at maximum sampling rate | +/- [(0.005% of delta T) + (2e-6 x delay setting) + 550 ps] |

## Trigger

| | |
|---|---|
| Trigger level range | Within display window (vertical offset +/- 2 divisions) |
| Immediate trigger mode | Triggers immediately after arming condition is met |
| Edge trigger mode | Triggers on rising or falling edge on channel 1 or channel 2 |
| Pattern trigger mode | Triggers on entering or exiting a specified pattern across both channels |
| Auto condition trigger mode | Self-triggers if trigger is not satisfied within approximately 100 ms after arming |
| Events delay trigger mode | The trigger can be set to occur on the nth occurrence of an edge or pattern, n <= 32000 |
| Intermodule trigger mode | Arms another measurement module or activates a trigger output on the rear panel BNC connector when the trigger condition is met |

## What is a Specification

A *Specification* is a numeric value, or range of values, that bounds the performance of a product parameter. The product warranty covers the performance of parameters described by specifications. Products shipped from the factory meet all specifications. Additionally, the products sent to Agilent Technologies Customer Service Centers for calibration and returned to the customer meet all specifications.

Specifications are verified by *Calibration Procedures*.

## What is a Characteristic

Characteristics describe product performance that is useful in the application of the product, but that is not covered by the product warranty. Characteristics describe performance that is typical of the majority of a given product, but not subject to the same rigor associated with specifications.

Characteristics are verified by *Function Tests*.

## What is a Calibration Procedure

Calibration procedures verify that products or systems operate within the specifications. Parameters covered by specifications have a corresponding calibration procedure. Calibration procedures include both performance tests and system verification procedure. Calibration procedures are traceable and must specify adequate calibration standards.

Calibration procedures verify products meet the specifications by comparing measured parameters against a pass-fail limit. The pass-fail limit is the specification less any required guardband.

The term "calibration" refers to the process of measuring parameters and referencing the measurement to a calibration standard rather than

the process of adjusting products for optimal performance, which is referred to as an "operational accuracy calibration".

## What is a Function Test

Function tests are quick tests designed to verify basic operation of a product. Function tests include operator's checks and operation verification procedures. An operator's check is normally a fast test used to verify basic operation of a product. An operation verification procedure verifies some, but not all, specifications, and often at a lower confidence level than a calibration procedure.

# Run/Group Run Function

### Using Run - Run All - Group Run

The Run/Stop functions are initiated by selecting icons in the icon bar at the top of the tool windows. All instrument, display, and analysis tool windows will have one of the Run icons shown below to initiate the run function.

When two or more instrument tools are configured, they can be run either independently or as a group. If run in a group, it is called an Intermodule measurement. Use the Intermodule Window (see the *Agilent Technologies 16700A/B-Series Logic Analysis System* help volume) to coordinate the arming in a "Group Run". A common "Group Run" configuration is to configure one instrument to trigger and then arm another instrument to start evaluation of its own trigger condition.

 The Run Single icon appears if you have a single instrument configured in your measurement and you want to run a single acquisition.

 The Run All icon always appears in the System, Workspace and Run Status windows. Also appears in instrument and display windows when you are using multiple instruments in your measurement and these instruments ARE NOT configured in an intermodule measurement (Group Run). This choice runs a single acquisition on all instruments in the configuration.

 The Group Run icon appears in all windows when you are using multiple instruments, and these instruments are configured into a Group Run. This choice runs a single acquisition on all instruments in the Group Run configuration.

 The Run Repetitive icon appears in all windows. It is used to run a *Run Single*, *Run All*, and a *Group Run* acquisition repetitively. The current run mode will continue to run until *Cancel* is selected.

### Using Stop

 The Stop icon terminates all of the run functions shown above.

- Stops a single instrument running a measurement (perhaps waiting for a trigger condition).
- Stops all instruments running separate measurements (easily viewed from the Workspace window).
- Stops all instruments running in a Group Run configuration.

### See Also

"Demand Driven Data" on page 92

"Checking Run Status" on page 91

## Checking Run Status

The *Run Status* dialog provides status information about the currently configured instruments, and the status of the run with respect to the trigger specification.

To access the *Run Status* dialog, select the *Run Status* icon in the System Window, or, select *Window -> System -> Run Status*



## Demand Driven Data

When an analyzer measurement occurs, acquisition memory is filled with data that is then transferred to the display memory of the analysis or display tools you are using, as needed by those tools. In normal use, this *demand driven data* approach saves time by not transferring unnecessary data.

Since acquisition memory is cleared at the beginning of a measurement, stopping a run may create a discrepancy between acquisition memory and the memory buffer of connected tools. Without a complete trace of acquisition memory, the display memory will appear to have 'holes' in it which appear as filtered data.

This situation will occur in these cases:

- If you stop a repetitive measurement after analyzer data has been cleared and before the measurement is complete.
- If a trigger is not found by the analyzer and the run must be stopped to regain control.

To make sure all of the data in a repetitive run is available for viewing:

- In the workspace, attach a Filter tool to the output of the analyzer.
- In the Filter, select "Pass Matching Data"
- In the filter terms, assure the default pattern of all "Don't Cares" (Xs).

This configuration will always transfer all data from acquisition memory. While this configuration will increase the time of each run, it will guarantee that repetitive run data is available regardless of when it is stopped.

**absolute** Denotes the time period or count of states between a captured state and the trigger state. An absolute count of -10 indicates the state was captured ten states before the trigger state was captured.

**acquisition** Denotes one complete cycle of data gathering by a measurement module. For example, if you are using an analyzer with 128K memory depth, one complete acquisition will capture and store 128K states in acquisition memory.

**analysis probe** A probe connected to a microprocessor or standard bus in the device under test. An analysis probe provides an interface between the signals of the microprocessor or standard bus and the inputs of the logic analyzer. Also called a *preprocessor*.

**analyzer 1** In a logic analyzer with two *machines*, refers to the machine that is on by default. The default name is *Analyzer<N>*, where N is the slot letter.

**analyzer 2** In a logic analyzer with two *machines*, refers to the machine that is off by default. The default name is *Analyzer<N2>*, where N is the slot letter.

**arming** An instrument tool must be armed before it can search for its trigger condition. Typically, instruments are armed immediately when *Run* or *Group Run* is selected. You can set up one instrument to arm another using the *Intermodule Window*. In these setups, the second instrument cannot search for its trigger condition until it receives the arming signal from the first instrument. In some analyzer instruments, you can set up one analyzer *machine* to arm the other analyzer machine in the *Trigger Window*.

**asterisk (*)** See *edge terms*, *glitch*, and *labels*.

**bits** Bits represent the physical logic analyzer channels. A bit is a *channel* that has or can be assigned to a *label*. A bit is also a position in a label.

**card** This refers to a single instrument intended for use in the Agilent Technologies 16700A/B-series mainframes. One card fills one slot in the mainframe. A module may comprise a single card or multiple cards cabled together.

**channel** The entire signal path from the probe tip, through the cable and module, up to the label grouping.

**click** When using a mouse as the

pointing device, to click an item, position the cursor over the item. Then quickly press and release the *left mouse button*.

**clock channel** A logic analyzer *channel* that can be used to carry the clock signal. When it is not needed for clock signals, it can be used as a *data channel*, except in the Agilent Technologies 16517A.

**context record** A context record is a small segment of analyzer memory that stores an event of interest along with the states that immediately preceded it and the states that immediately followed it.

**context store** If your analyzer can perform context store measurements, you will see a button labeled *Context Store* under the Trigger tab. Typical context store measurements are used to capture writes to a variable or calls to a subroutine, along with the activity preceding and following the events. A context store measurement divides analyzer memory into a series of context records. If you have a 64K analyzer memory and select a 16-state context, the analyzer memory is divided into 4K 16-state context records. If you have a 64K analyzer memory and select a 64-state context, the analyzer memory will be divided into 1K 64-state records.

**count** The count function records periods of time or numbers of state transactions between states stored in memory. You can set up the analyzer count function to count occurrences of a selected event during the trace, such as counting how many times a variable is read between each of the writes to the variable. The analyzer can also be set up to count elapsed time, such as counting the time spent executing within a particular function during a run of your target program.

**cross triggering** Using intermodule capabilities to have measurement modules trigger each other. For example, you can have an external instrument arm a logic analyzer, which subsequently triggers an oscilloscope when it finds the trigger state.

**data channel** A *channel* that carries data. Data channels cannot be used to clock logic analyzers.

**data field** A data field in the pattern generator is the data value associated with a single label within a particular data vector.

**data set** A data set is made up of all labels and data stored in memory of any single analyzer machine or

instrument tool. Multiple data sets can be displayed together when sourced into a single display tool. The Filter tool is used to pass on partial data sets to analysis or display tools.

**debug mode** See *monitor*.

**delay** The delay function sets the horizontal position of the waveform on the screen for the oscilloscope and timing analyzer. Delay time is measured from the trigger point in seconds or states.

**demo mode** An emulation control session which is not connected to a real target system. All windows can be viewed, but the data displayed is simulated. To start demo mode, select *Start User Session* from the Emulation Control Interface and enter the demo name in the *Processor Probe LAN Name* field. Select the *Help* button in the *Start User Session* window for details.

**deskewing** To cancel or nullify the effects of differences between two different internal delay paths for a signal. Deskewing is normally done by routing a single test signal to the inputs of two different modules, then adjusting the Intermodule Skew so that both modules recognize the signal at the same time.

**device under test** The system under test, which contains the circuitry you are probing. Also known as a *target system*.

**don't care** For *terms*, a "don't care" means that the state of the signal (high or low) is not relevant to the measurement. The analyzer ignores the state of this signal when determining whether a match occurs on an input label. "Don't care" signals are still sampled and their values can be displayed with the rest of the data. Don't cares are represented by the *X* character in numeric values and the dot (.) in timing edge specifications.

**dot (.)** See *edge terms*, *glitch*, *labels*, and *don't care*.

**double-click** When using a mouse as the pointing device, to double-click an item, position the cursor over the item, and then quickly press and release the *left mouse button* twice.

**drag and drop** Using a Mouse: Position the cursor over the item, and then press and hold the *left mouse button*. While holding the left mouse button down, move the mouse to drag the item to a new location. When the item is positioned where you want it, release the mouse button.

Using the Touchscreen:
Position your finger over the item, then press and hold finger to the screen. While holding the finger down, slide the finger along the screen dragging the item to a new location. When the item is positioned where you want it, release your finger.

**edge mode** In an oscilloscope, this is the trigger mode that causes a trigger based on a single channel edge, either rising or falling.

**edge terms** Logic analyzer trigger resources that allow detection of transitions on a signal. An edge term can be set to detect a rising edge, falling edge, or either edge. Some logic analyzers can also detect no edge or a *glitch* on an input signal. Edges are specified by selecting arrows. The dot (.) ignores the bit. The asterisk (*) specifies a glitch on the bit.

**emulation module** A module within the logic analysis system mainframe that provides an emulation connection to the debug port of a microprocessor. An E5901A emulation module is used with a target interface module (TIM) or an analysis probe. An E5901B emulation module is used with an E5900A emulation probe.

**emulation probe** The stand-alone equivalent of an *emulation module*. Most of the tasks which can be performed using an emulation module can also be performed using an emulation probe connected to your logic analysis system via a LAN.

**emulator** An *emulation module* or an *emulation probe*.

**Ethernet address** See *link-level address*.

**events** Events are the things you are looking for in your target system. In the logic analyzer interface, they take a single line. Examples of events are *Label1 = XX* and *Timer 1 > 400 ns*.

**filter expression** The filter expression is the logical *OR* combination of all of the filter terms. States in your data that match the filter expression can be filtered out or passed through the Pattern Filter.

**filter term** A variable that you define in order to specify which states to filter out or pass through. Filter terms are logically OR'ed together to create the filter expression.

**Format** The selections under the logic analyzer *Format* tab tell the

logic analyzer what data you want to collect, such as which channels represent buses (labels) and what logic threshold your signals use.

**frame** The Agilent Technologies or 16700A/B-series logic analysis system mainframe. See also *logic analysis system*.

**gateway address** An IP address entered in integer dot notation. The default gateway address is 0.0.0.0, which allows all connections on the local network or subnet. If connections are to be made across networks or subnets, this address must be set to the address of the gateway machine.

**glitch** A glitch occurs when two or more transitions cross the logic threshold between consecutive timing analyzer samples. You can specify glitch detection by choosing the asterisk (*) for *edge terms* under the timing analyzer Trigger tab.

**grouped event** A grouped event is a list of *events* that you have grouped, and optionally named. It can be reused in other trigger sequence levels. Only available in Agilent Technologies 16715A or higher logic analyzers.

**held value** A value that is held until the next sample. A held value can exist in multiple data sets.

**immediate mode** In an oscilloscope, the trigger mode that does not require a specific trigger condition such as an edge or a pattern. Use immediate mode when the oscilloscope is armed by another instrument.

**interconnect cable** Short name for *module/probe interconnect cable*.

**intermodule bus** The intermodule bus (IMB) is a bus in the frame that allows the measurement modules to communicate with each other. Using the IMB, you can set up one instrument to *arm* another. Data acquired by instruments using the IMB is time-correlated.

**intermodule** Intermodule is a term used when multiple instrument tools are connected together for the purpose of one instrument arming another. In such a configuration, an arming tree is developed and the group run function is designated to start all instrument tools. Multiple instrument configurations are done in the Intermodule window.

**internet address** Also called Internet Protocol address or IP address. A 32-bit network address. It

is usually represented as decimal numbers separated by periods; for example, 192.35.12.6. Ask your LAN administrator if you need an internet address.

**labels** Labels are used to group and identify logic analyzer channels. A label consists of a name and an associated bit or group of bits. Labels are created in the Format tab.

**line numbers** A line number (Line #s) is a special use of *symbols*. Line numbers represent lines in your source file, typically lines that have no unique symbols defined to represent them.

**link-level address** Also referred to as the Ethernet address, this is the unique address of the LAN interface. This value is set at the factory and cannot be changed. The link-level address of a particular piece of equipment is often printed on a label above the LAN connector. An example of a link-level address in hexadecimal: 0800090012AB.

**local session** A local session is when you run the logic analysis system using the local display connected to the product hardware.

**logic analysis system** The Agilent Technologies 16700A/B-series mainframes, and all tools designed to work with it. Usually used to mean the specific system and tools you are working with right now.

**machine** Some logic analyzers allow you to set up two measurements at the same time. Each measurement is handled by a different machine. This is represented in the Workspace window by two icons, differentiated by a *1* and a *2* in the upper right-hand corner of the icon. Logic analyzer resources such as pods and trigger terms cannot be shared by the machines.

**markers** Markers are the green and yellow lines in the display that are labeled *x*, *o*, *G1*, and *G2*. Use them to measure time intervals or sample intervals. Markers are assigned to patterns in order to find patterns or track sequences of states in the data. The x and o markers are local to the immediate display, while G1 and G2 are global between time correlated displays.

**master card** In a module, the master card controls the data acquisition or output. The logic analysis system references the module by the slot in which the master card is plugged. For example, a 5-card Agilent Technologies 16555D would be referred to as *Slot C:*

*machine* because the master card is in slot C of the mainframe. The other cards of the module are called *expansion cards*.

**menu bar** The menu bar is located at the top of all windows. Use it to select *File* operations, tool or system *Options*, and tool or system level *Help*.

**message bar** The message bar displays mouse button functions for the window area or field directly beneath the mouse cursor. Use the mouse and message bar together to prompt yourself to functions and shortcuts.

**module/probe interconnect cable**

The module/probe interconnect cable connects an E5901B emulation module to an E5900B emulation probe. It provides power and a serial connection. A LAN connection is also required to use the emulation probe.

**module** An instrument that uses a single timebase in its operation. Modules can have from one to five cards functioning as a single instrument. When a module has more than one card, system window will show the instrument icon in the slot of the *master card*.

**monitor** When using the Emulation Control Interface, running the monitor means the processor is in debug mode (that is, executing the debug exception) instead of executing the user program.

**panning** The action of moving the waveform along the timebase by varying the delay value in the Delay field. This action allows you to control the portion of acquisition memory that will be displayed on the screen.

**pattern mode** In an oscilloscope, the trigger mode that allows you to set the oscilloscope to trigger on a specified combination of input signal levels.

**pattern terms** Logic analyzer resources that represent single states to be found on labeled sets of bits; for example, an address on the address bus or a status on the status lines.

**period (.)** See *edge terms*, *glitch*, *labels*, and *don't care*.

**pod pair** A group of two pods containing 16 channels each, used to physically connect data and clock signals from the unit under test to the analyzer. Pods are assigned by pairs in the analyzer interface. The number of pod pairs available is determined

by the channel width of the instrument.

**pod** See *pod pair*

**point** To point to an item, move the mouse cursor over the item, or position your finger over the item.

**preprocessor** See *analysis probe*.

**primary branch** The primary branch is indicated in the *Trigger sequence step* dialog box as either the *Then find* or *Trigger on* selection. The destination of the primary branch is always the next state in the sequence, except for the Agilent Technologies 16517A. The primary branch has an optional occurrence count field that can be used to count a number of occurrences of the branch condition. See also *secondary branch*.

**probe** A device to connect the various instruments of the logic analysis system to the target system. There are many types of probes and the one you should use depends on the instrument and your data requirements. As a verb, "to probe" means to attach a probe to the target system.

**processor probe** See *emulation probe*.

**range terms** Logic analyzer resources that represent ranges of values to be found on labeled sets of bits. For example, range terms could identify a range of addresses to be found on the address bus or a range of data values to be found on the data bus. In the trigger sequence, range terms are considered to be true when any value within the range occurs.

**relative** Denotes time period or count of states between the current state and the previous state.

**remote display** A remote display is a display other than the one connected to the product hardware. Remote displays must be identified to the network through an address location.

**remote session** A remote session is when you run the logic analyzer using a display that is located away from the product hardware.

**right-click** When using a mouse for a pointing device, to right-click an item, position the cursor over the item, and then quickly press and release the *right mouse button*.

**sample** A data sample is a portion of a *data set*, sometimes just one point. When an instrument samples the target system, it is taking a single

measurement as part of its data acquisition cycle.

**Sampling** Use the selections under the logic analyzer Sampling tab to tell the logic analyzer how you want to make measurements, such as State vs. Timing.

**secondary branch** The secondary branch is indicated in the *Trigger sequence step* dialog box as the *Else on* selection. The destination of the secondary branch can be specified as any other active sequence state. See also *primary branch*.

**session** A session begins when you start a *local session* or *remote session* from the session manager, and ends when you select *Exit* from the main window. Exiting a session returns all tools to their initial configurations.

**skew** Skew is the difference in channel delays between measurement channels. Typically, skew between modules is caused by differences in designs of measurement channels, and differences in characteristics of the electronic components within those channels. You should adjust measurement modules to eliminate as much skew as possible so that it does not affect the accuracy of your measurements.

**state measurement** In a state measurement, the logic analyzer is clocked by a signal from the system under test. Each time the clock signal becomes valid, the analyzer samples data from the system under test. Since the analyzer is clocked by the system, state measurements are *synchronous* with the test system.

**store qualification** Store qualification is only available in a *state measurement*, not *timing measurements*. Store qualification allows you to specify the type of information (all samples, no samples, or selected states) to be stored in memory. Use store qualification to prevent memory from being filled with unwanted activity such as no-ops or wait-loops. To set up store qualification, use the *While storing* field in a logic analyzer trigger sequence dialog.

**subnet mask** A subnet mask blocks out part of an IP address so that the networking software can determine whether the destination host is on a local or remote network. It is usually represented as decimal numbers separated by periods; for example, 255.255.255.0. Ask your LAN administrator if you need a the subnet mask for your network.

**symbols** Symbols represent patterns and ranges of values found on labeled sets of bits. Two kinds of symbols are available:

- Object file symbols - Symbols from your source code, and symbols generated by your compiler. Object file symbols may represent global variables, functions, labels, and source line numbers.
- User-defined symbols - Symbols you create.

Symbols can be used as *pattern* and *range* terms for:

- Searches in the listing display.
- Triggering in logic analyzers and in the source correlation trigger setup.
- Qualifying data in the filter tool and system performance analysis tool set.

**system administrator** The system administrator is a person who manages your system, taking care of such tasks as adding peripheral devices, adding new users, and doing system backup. In general, the system administrator is the person you go to with questions about implementing your software.

**target system** The system under test, which contains the microprocessor you are probing.

**terms** Terms are variables that can be used in trigger sequences. A term can be a single value on a label or set of labels, any value within a range of values on a label or set of labels, or a glitch or edge transition on bits within a label or set of labels.

**TIM** A TIM (Target Interface Module) makes connections between the cable from the emulation module or emulation probe and the cable to the debug port on the system under test.

**time-correlated** Time correlated measurements are measurements involving more than one instrument in which all instruments have a common time or trigger reference.

**timer terms** Logic analyzer resources that are used to measure the time the trigger sequence remains within one sequence step, or a set of sequence steps. Timers can be used to detect when a condition lasts too long or not long enough. They can be used to measure pulse duration, or duration of a wait loop. A single timer term can be used to delay trigger until a period of time after detection of a significant event.

**timing measurement** In a timing measurement, the logic analyzer samples data at regular intervals according to a clock signal internal to the timing analyzer. Since the analyzer is clocked by a signal that is not related to the system under test, timing measurements capture traces of electrical activity over time. These measurements are *asynchronous* with the test system.

**tool icon** Tool icons that appear in the workspace are representations of the hardware and software tools selected from the toolbox. If they are placed directly over a current measurement, the tools automatically connect to that measurement. If they are placed on an open area of the main window, you must connect them to a measurement using the mouse.

**toolbox** The Toolbox is located on the left side of the main window. It is used to display the available hardware and software tools. As you add new tools to your system, their icons will appear in the Toolbox.

**tools** A tool is a stand-alone piece of functionality. A tool can be an instrument that acquires data, a display for viewing data, or a post-processing analysis helper. Tools are represented as icons in the main window of the interface.

**trace** See *acquisition*.

**trigger sequence** A trigger sequence is a sequence of events that you specify. The logic analyzer compares this sequence with the samples it is collecting to determine when to *trigger*.

**trigger specification** A trigger specification is a set of conditions that must be true before the instrument triggers.

**trigger** Trigger is an event that occurs immediately after the instrument recognizes a match between the incoming data and the trigger specification. Once trigger occurs, the instrument completes its *acquisition*, including any store qualification that may be specified.

**workspace** The workspace is the large area under the message bar and to the right of the toolbox. The workspace is where you place the different instrument, display, and analysis tools. Once in the workspace, the tool icons graphically represent a complete picture of the measurements.

**zooming** In the oscilloscope or timing analyzer, to expand and contract the waveform along the time base by varying the value in the s/Div

field. This action allows you to select specific portions of a particular waveform in acquisition memory that will be displayed on the screen. You can view any portion of the waveform record in acquisition memory.

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