User Manual

Tektronix

CSA7000B Series
Serial Mask Testing &
Serial Pattern Trigger

TDS7000B Series
Option SM Serial Mask Testing
Option ST Serial Pattern Trigger

071-1228-00

This document applies to firmware version 3.0.0 and above.

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Preface

This is the user manual for Serial Mask Testing and Serial Pattern Trigger functions. These functions are standard on the CSA7000B Series instruments. Some of these functions are standard and others are available as options for the TDS7000B Series instruments.

This manual:

- Describes the capabilities of the Serial Mask Testing and Serial Pattern Trigger functions, and how to install the optional functions on TDS7000B instruments
- Explains how to access and operate the features

Manual Structure

This manual is organized into the following chapters:

- *Getting Started* provides an overview of the Serial Mask Testing and Serial Pattern Trigger functions, and shows you how to install the optional functions on TDS7000B instruments.
- *Operating Basics* describes how to access the functions using the front panel and the instrument graphical user interface.
- *Reference* provides detailed steps for doing the most common Serial Mask Testing and Serial Pattern Trigger tasks.

Related Manuals

The following table lists other documents that support the operation and service of the CSA7000B and TDS7000B Series instruments. The part numbers of these documents are listed in the *Accessories* section of your instrument user manual.

Manual name	Description
Online Help	An online help system that is integrated with the User Interface application that ships with the CSA7000B and TDS7000B instruments
References	A quick reference to the major features of the instrument and how they operate
User Manual[1]	The user manual for the CSA7000B and TDS7000B instruments
Programmer Online Guide	An alphabetical listing of the programming commands and other information related to controlling the instrument over the GPIB and TekVISA interfaces
Service Manual	A description of how to service the instrument to the module level. This optional manual must be ordered separately

1 **You can insert this user manual behind the Appendices section of your instrument user manual.**

Contacting Tektronix

Phone	1-800-833-9200*
Address	Tektronix, Inc. Department or name (if known) 14200 SW Karl Braun Drive P.O. Box 500 Beaverton, OR 97077 USA
Web site	www.tektronix.com
Sales support	1-800-833-9200, select option 1*
Service support	1-800-833-9200, select option 2*
Technical support	Email: techsupport@tektronix.com 1-800-833-9200, select option 3* 6:00 a.m. – 5:00 p.m. Pacific time

* **This phone number is toll free in North America. After office hours, please leave a voice mail message.**
Outside North America, contact a Tektronix sales office or distributor; see the Tektronix web site for a list of offices.

Getting Started

This section of the user manual provides a high-level description of the Serial Mask Testing and Serial Triggering functions. These functions are standard with CSA7000B Series instruments. Some of these functions are standard and some of the functions are options for TDS7000B Series Digital Phosphor Oscilloscopes.

This section also describes how to install the optional Serial Mask Testing and Serial Triggering functions on TDS7000B Series instruments.

Product Description

The following text is an overview of the Serial Mask Testing and Serial Triggering features.

Serial Mask Testing

The Serial Mask Testing feature provides optical and electrical mask testing, communication triggering, and automatic communication signal measurements.

Mask testing consists of two tasks: signal violation detection and pass/fail testing. Signal violation detection lets you test communications signals for time or amplitude violations against a predefined mask. Each mask consists of one or more polygonal regions called segments. The signal waveform data should stay outside of the segments defined by the mask. Any signal data that occurs inside a mask segment is called a mask segment violation or "hit."

You can select from any of the included standard telecommunications masks (optional on TDS7000B Series instruments) or you can define your own custom masks. Selecting a mask automatically sets the instrument communications triggers to properly display most communication signals in the mask.

Pass/Fail testing defines the mask testing parameters, including the number of waveforms to test, how many mask hits are allowed before failing a test, setting a mask margin tolerance value, and what action to perform at the completion of a test.

Communication triggering enables you to trigger on and display waveforms for industry-standard communications signals. Appendix B lists the supported standards on which you can trigger.

Automatic communication signal measurements enable you to make automatic measurements on communications signals. Appendix C lists the available measurements.

The Serial Mask Testing key features are:

- Predefined masks (optional on TDS7000B instruments) for testing or triggering on industry-standard signals, such as ITU-T G.703, ANSI T1.102, Fibre Channel, Ethernet, InfiniBand, SONET, Serial ATA, USB, IEEE 1394b, RapidIO, OIF, PCI-Express, and their subsets
- On CSA7000B instruments, optical mask standards have calibrated digital filters, enabling operation as an optical reference receiver
- Autoset, which quickly adjusts the instrument vertical and horizontal parameters to display a waveform in a mask
- Autofit, which positions the signal on each acquisition to minimize mask segment hits
- Mask margins, which allow you to adjust the default mask margin tolerances
- Pass/Fail testing to continuously test a specified number of waveforms against a mask
- A mask editor for creating, saving, and recalling user-defined masks
- Waveform database technology to do mask testing based on waveforms accumulated in a database, rather than a single waveform stored in acquisition memory
- Communications triggers (optional on TDS7000B instruments) to trigger the instrument on industry-standard communications signals
- Automatic measurements on communications signals
- Clock recovery from the serial data stream

NOTE. *If a standard or function listed in this manual is not available on your instrument, it is because it is optional or the configuration or bandwidth of your instrument cannot test that standard.*

The CSA7000B Series instruments, when used with the O/E Electrical Out-to-CH1 Input Adapter (013-0327-xx), are calibrated optical reference receivers with digital filtering, enabling you to do mask standard compliance testing.

Although the TDS7000B Series instruments are not calibrated optical reference receivers, you can use them with mask testing to evaluate general optical signal characteristics and waveshape, using an external O/E converter.

Serial Pattern Trigger

Serial Pattern Trigger lets you define a serial data pattern on which to trigger the instrument.

The Serial Pattern Trigger key features are:

- User-defined serial data pattern of up to 64 bits on NRZ data streams up to 1.25 GBaud
- Clock recovery from the serial data stream

Installing Optional Serial Mask Testing and Serial Pattern Trigger Functions on TDS7000B Series Instruments

To enable the optional Serial Mask Testing and/or Serial Triggering functions on TDS7000B instruments, you must have a valid Option Installation Key. Do the following steps:

1. From the oscilloscope menu bar, touch the **Utilities** menu, select **Option Installation**, and then touch **Continue**.
2. Enter the authorization key using the instrument keyboard.
3. Touch **Continue**.
4. Reboot your instrument to enable the new option(s).
5. Attach the option configuration label(s) on the rear panel of the instrument to indicate that the option(s) is installed on this instrument.

Operating Basics

This chapter describes how to access the Serial Mask Testing and Serial Pattern Triggering features, and provides a brief description of each function's settings. See the *Reference* section in this manual for detailed instructions on using the Serial Mask Testing and Serial Pattern Triggering functions.

Serial Mask Testing Functions

Serial Mask Testing provides three sets of functions: optical and electrical serial mask testing, communications triggering, and automatic communication signal measurements. This section describes how to access these functions.

Accessing Serial Mask Testing Functions

To access the Serial Mask Test functions, touch the **Masks** tool bar button. The instrument displays the Masks control window, as shown in Figure 1.

Figure 1: Masks control window

Table 1 describes the Masks control window tab functions. Refer to the *Reference* chapter beginning on page 9 of this manual, as well as the online help, for more information about these functions.

Table 1: Masks control window functions

Tab	Function
Mask	Set the mask type, communications standard, polarity, mask on/off, and autofit/autoset alignment parameters
Source	Set the input waveform source
Tolerance	Set the mask margin tolerance values

Table 1: Masks control window functions (cont.)

Tab	Function
Pass/Fail Setup	Set the mask test pass/fail parameters
Pass/Fail Results	Display the pass/fail test results

Accessing Serial Mask Testing Communications Trigger Functions

To access the Serial Mask Testing communication trigger functions (optional on TDS7000B instruments), do the following steps:

1. Touch the **Trig** tool bar button. The instrument displays the Trigger control window.
2. Select the **A Event** tab.
3. Touch either of the Trigger Type buttons. Select the **Comm** Trigger Type. The instrument displays the communication signal trigger functions, as shown in Figure 2.

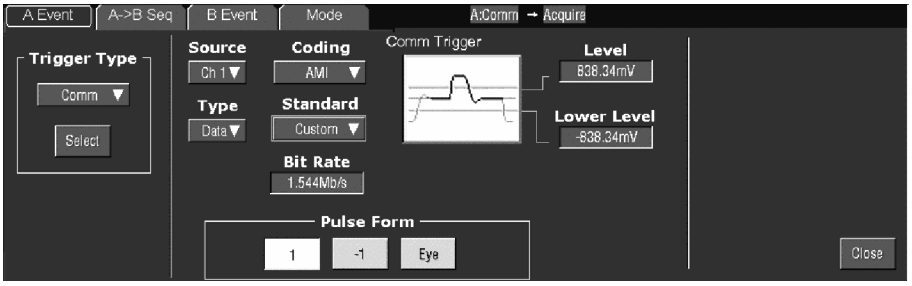


Figure 2: Communication signal trigger functions

Table 2 describes the communication trigger functions. Refer to the *Reference* chapter beginning on page 9 of this manual, as well as the online help, for more information about these functions.

Table 2: Communication trigger functions

Menu	Function
Source	Sets the waveform data source (Ch1-Ch4)
Type	Sets the waveform source type (Data, Clock, or Recovered Clock); the recovered clock function is only available for NRZ coded signals
Polarity	Sets the edge (positive or negative) on which to trigger; this function is only available when Type is set to Clock
Coding	Sets the communications code type from a drop-down menu (AMI, BZ3S, B6ZS, B8ZS, CMI, HDB3, MLT3, NRZ)

Table 2: Communication trigger functions (cont.)

Menu	Function
Standard	Sets the signal standard for the selected code from a drop-down menu
Bit Rate	Sets or displays the bit rate for the selected standard; if you change the default bit rate, the signal standard changes to Custom
Comm Trigger Upper/Lower Level	Sets the source signal threshold levels for the selected code; this function displays a single level field or upper/lower level fields depending on the selected code and standard
Pulse Form	Sets the comm signal pulse format on which to trigger; this function is displayed when required by a selected standard

Accessing Serial Mask Testing Automatic Measurement Functions

Serial Mask Testing also provides a number of communications-related automatic measurements.

To access the communications signal automatic measurements, do the following steps:

1. Touch the **Meas** tool bar button. The instrument displays the Measurement control window.
2. Select the **Comm** tab. The instrument displays the communication measurement functions, as shown in Figure 3.

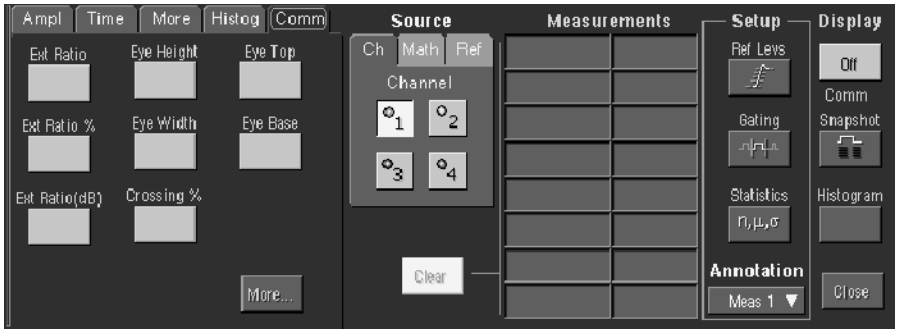


Figure 3: Communication measurement functions

Refer to the user manual for your instrument for information on setting up and taking automatic measurements. Refer to Appendix C of this manual for a list and description of the communication measurements.

Accessing Serial Pattern Trigger Functions

To access the Serial Pattern Trigger functions, do the following steps:

1. Touch the **Trig** tool bar button. The instrument displays the Trigger control window.
2. Select the **A Event** tab.
3. Touch either of the Trigger Type buttons. Select the **Serial** Trigger Type. The instrument displays the serial pattern trigger functions, as shown in Figure 4.

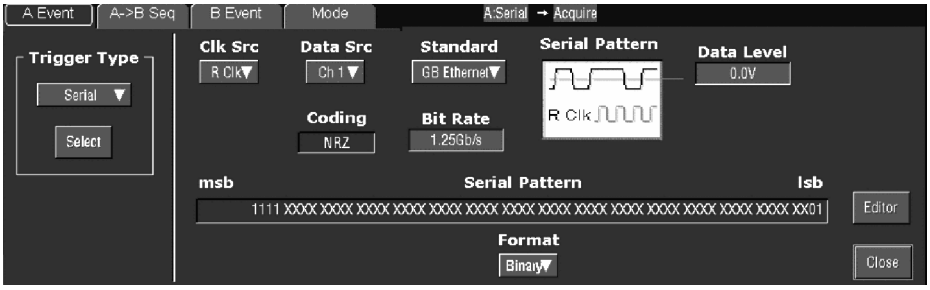


Figure 4: Serial pattern trigger control window

Table 3 describes the Serial Pattern Trigger functions. Refer to the *Reference* chapter beginning on page 9 of this manual, as well as the online help, for more information about these functions.

Table 3: Serial trigger functions

Menu	Function
Data Src	Sets the serial trigger waveform data source (Ch1-Ch4)
Clk Src	Sets the serial trigger clock source (Ch1-Ch4, Recovered Clock); the recovered clock function is only available for NRZ coded signals
Clk Polarity	Sets the source waveform polarity (positive or negative); this function is available only when Clk Src is set to a different value than Data Src
Coding	Shows the serial trigger communications code type, which is always NRZ
Standard	Sets the serial trigger signal standard
Bit Rate	Sets or displays the bit rate for the selected standard
Data Level Clk Level	Sets the data and clock source threshold levels for the selected code
Editor	Opens the serial pattern data editor which lets you define the serial pattern on which to trigger
Format	Displays the serial trigger pattern data in binary or hexadecimal format

Reference

This chapter contains instructions for performing the following tasks:

- *Mask Testing* (starting on this page) describes how to set up and run mask tests, as well as how to create, edit, and save user masks.
- *Communication (Comm) Triggering* (page 30) describes how to trigger on industry-standard communication signals, and provides information on the recovered clock (R Clk) feature.
- *Serial Pattern Trigger* (page 34) describes how to trigger on user-defined serial data.

Mask Testing

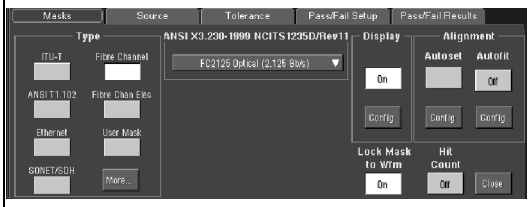
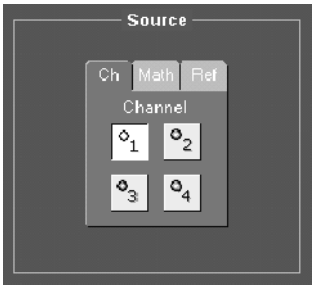
Mask testing sets the instrument to test communications signals against industry-standard (optional on TDS7000B instruments) or user defined masks to verify the timing, amplitude, and waveform shape of the signal. This section provides step-by-step instructions on how to access and operate the mask test features.

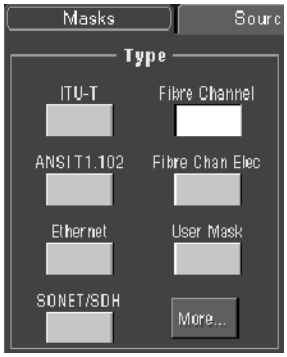
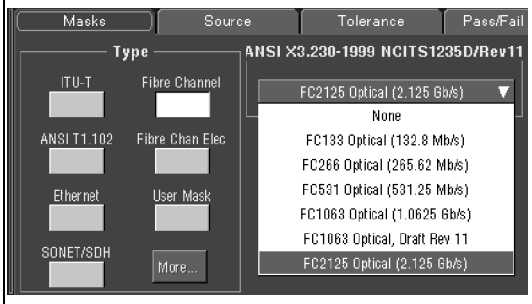
The mask testing instructions cover the following subjects:

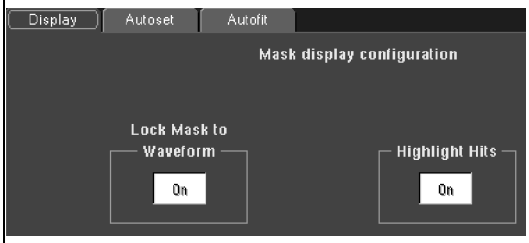
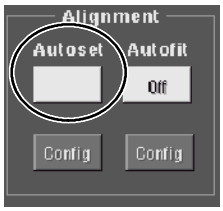
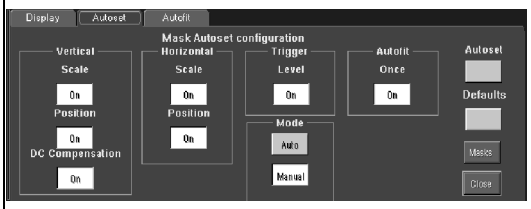
- Mask test setup
- Running a mask test
- Creating a user mask from a defined mask
- Saving a user mask to disk
- Recalling a user mask from disk
- Editing a user mask
- Creating a new user mask
- Mask testing key points (general and optical)

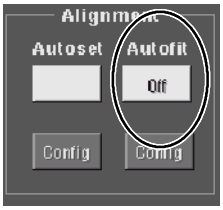
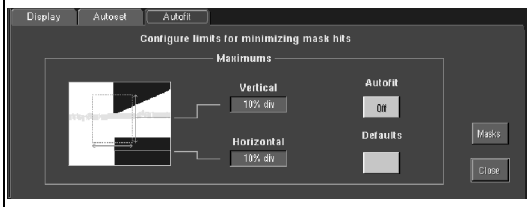
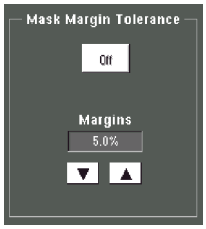
Mask Test Setup

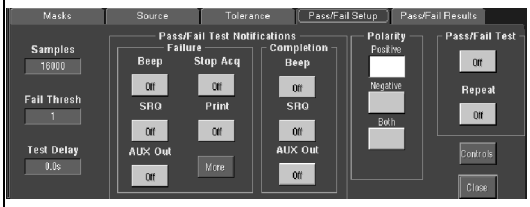
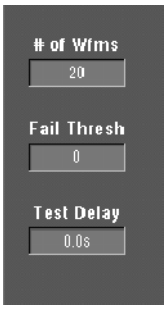
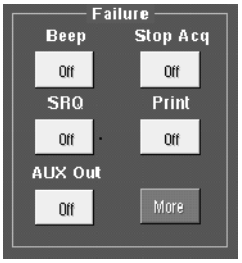
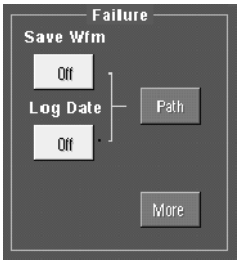
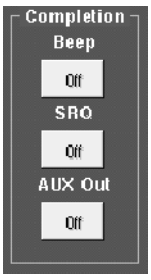
To set the instrument to perform mask tests, do the following procedure.

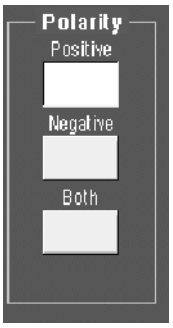
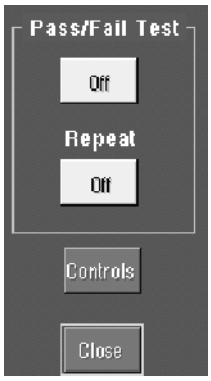
Overview	To mask test a waveform	Related control elements and resources
Prerequisites	**1.** Connect the instrument to the source signal, or save the source signal to a math or reference waveform memory location.	
Access the Mask Setup window	**2.** From the button bar, touch Masks. The instrument displays the Mask control window.	 
Select a mask test signal source	**3.** Select the Source tab and then the channel, math, or reference tab and then select the waveform source to use as the mask test source. You can only mask test one waveform at a time.	

Overview	To mask test a waveform (cont.)	Related control elements and resources
Select the mask type	**4.** To specify the mask Type, select the Masks tab. Touch the appropriate button in the Type field. Touch the More button to display further selections. The window lists mask types and standards that are available on your instrument, which depends on the bandwidth, options, and configuration of your instrument. Selecting a mask type and standard adjusts the instrument horizontal, vertical, and trigger settings to those appropriate for displaying a waveform of the specified type. If the signal is not within the mask, touch the Autoset button to center the waveform in a mask. If Autoset did not align the signal in the mask, adjust the instrument vertical and horizontal controls. If you touch the Autoset button and the Autoset Undo preference is On, the instrument will display an Autoset Undo window. Touch the Undo button to return to the previous settings, or touch the Close button to remove the window.	
Select the mask standard	**5.** To specify the mask standard, select a standard from the drop-down list. (CSA7000B Series only) Optical mask type/standard combinations also display an optical Bessel-Thompson Filter button that lets you turn on or off the fourth-order Bessel-Thompson frequency filter (default is On). When the filter is On, the CSA7000B series is an Optical Reference Receiver. ***CAUTION.*** *Do not exceed the maximum nondestructive optical input specified in your instrument user manual.* *Verify that your optical input signal is within the linear operating range of the optical-to-electrical converter and the optical reference receiver.*	

Overview	To mask test a waveform (cont.)	Related control elements and resources
Select display parameters	**6.** In the Masks tab, touch the Display button to toggle mask display on or off. The mask must be turned on to do mask testing. **7.** Touch the Hit Count button to turn on or off hit counting. The hit count is shown in the Pass/Fail Results tab. **8.** Touch the Display Config button to set mask hit highlighting and to lock the mask to the waveform. Lock Mask to Waveform resizes the mask to reflect changes in the horizontal or vertical settings of the instrument. This control is also on the main mask setup window.	 
Autoset the signal	**9.** In the Masks tab, touch the Autoset button to have the instrument automatically adjust instrument settings to align the waveform to the mask based on the characteristics of the input signal. Autoset is done on the first waveform acquired after touching the Autoset button. If the Autoset Undo preference is On, the instrument will display an Autoset Undo window. Touch the Undo button to return to the previous settings, or touch the Close button to remove the window. The Autoset Config button opens a configuration window that lets you set the vertical, horizontal, and trigger autoset parameters, activate autofit or autoset, choose the autoset mode, return to the default autoset configuration, or return to the Mask Setup control window. On CSA7000B series instruments when using the O/E Electrical Out-to-CH1 Input Adapter, autoset defaults to CH 1, and the instrument will ignore the other channels.	 

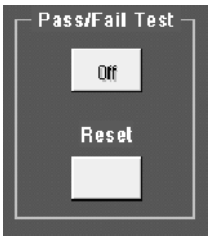
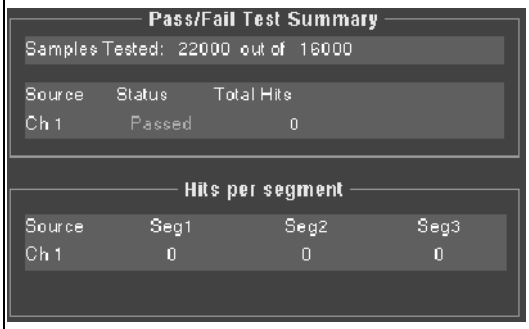
Overview	To mask test a waveform (cont.)	Related control elements and resources
Enable and set waveform autofit parameters	**10.** In the Masks tab, touch the Autofit button to enable the waveform autofit function. Autofit checks each waveform for any mask hits. If there are hits, autofit repositions the waveform to minimize hits. The number of hits reported is the number after autofit has minimized hits. The Autofit Config button lets you set the autofit maximum waveform repositioning parameters (as a percentage of the horizontal and vertical divisions), return to default settings, or return to the Mask Setup control window. Use the keypad to change the vertical or horizontal autofit parameters. **11.** Touch the Masks button to return to the Mask control window.	 
Set mask test tolerance margins	**12.** Touch the Masks Setup window Tolerance tab to set the percentage of margin used in the mask test. Use the control knob, keypad, pop-up keypad, or up and down arrow buttons to enter the mask margin tolerance percentage. The range of values is -50% to 50%. Margin tolerance settings greater than 0% expand the size of the segments, making the mask test harder to pass; margin tolerance settings less than 0% (negative percent) reduces the size of the segments, making the mask test easier to pass.	

Overview	To mask test a waveform (cont.)	Related control elements and resources
Set mask test pass and fail parameters	**13.** Select the Pass/Fail Setup tab of the Masks control window.	
	14. Use the control knob, keypad, or pop-up keypad to enter the number of waveforms to test (number of samples in some modes), the failure threshold (the number of waveforms that must fail to fail the test), and the delay time (the time from when mask test starts to when the instrument begins sampling).	
	15. Use the Failure field buttons to set what the instrument does when a mask test fails; have the instrument beep (BEEP), send an SRQ out on the GPIB bus (SRQ), send a trigger pulse out on the AUX OUT connector (AUX Out), stop signal acquisition immediately (Stop Acq), and/or print the instrument screen image to a printer (Print).	
	16. Touching the More button displays more failure functions. Save Wfm saves the waveform data of the first waveform that causes the test to fail to a .wfm file. Log Date saves time, date, and basic test information of the first waveform that causes the test to fail to an ASCII text (.txt) file. Both files are saved to the location specified by the Path button. The file name format is YYMMDD-HHMMSS, where YY is year, MM is month, DD is day, HH is hour, MM is minutes, and SS is seconds.	
	17. Use the Completion field buttons to set what the instrument does at the completion of a mask test.	

Overview	To mask test a waveform (cont.)	Related control elements and resources
Set mask test pass and fail parameters (cont.)	**18.** Use the Polarity buttons to set mask and waveform polarity. Positive tests the positive waveform pulses. Negative inverts the mask and tests the negative waveform pulses. Both tests the first half of the tested waveforms in positive polarity mode, then tests the remaining waveforms in negative polarity mode.	
	19. Toggle the Repeat button to On to set the instrument to repeat (continue) mask testing on the completion of each test.	

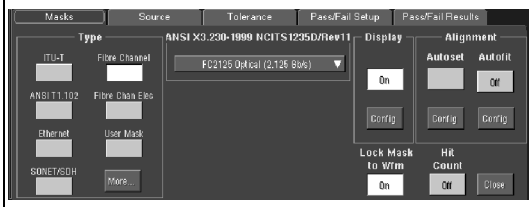
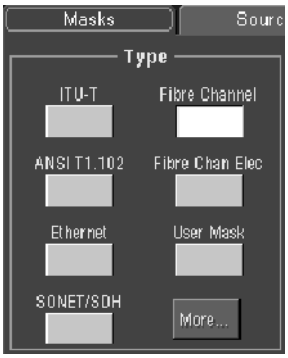
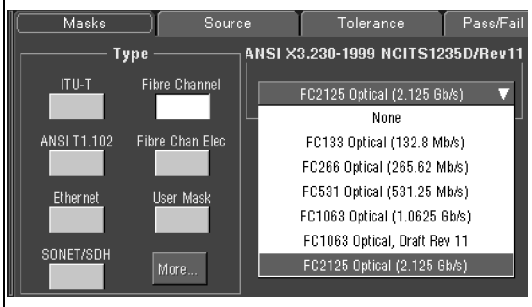
Running a Mask Test

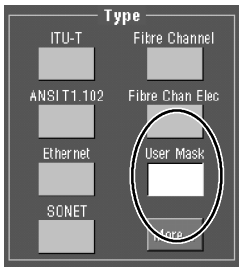
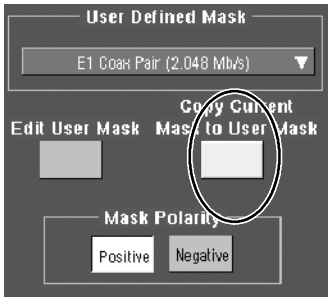
To start and stop mask tests, do the following procedure.

Overview	Running a mask test	Control elements and resources
Prerequisites	**1.** You must have set up the instrument to perform mask testing as described in *Mask Test Setup* on page 10.	
Start the mask pass/fail test	**2.** From the button bar, touch Masks and select the Pass/Fail Results tab. The instrument opens the Pass/Fail Results control window.	
	3. Touch the Pass/Fail Test On/Off button to turn on mask pass/fail testing. You can touch Reset prior to running tests to clear the Pass/Fail Test Summary fields. You can also use the Pass/Fail Test button in the Pass/Fail Setup control window.	
	The instrument begins mask testing and displays the test summary information in the Pass/Fail Test Summary fields. If a mask has more than three segments, the window displays a horizontal scroll bar below the Hits per Segment field that lets you scroll the field to view other segment hit data.	
Stop the mask pass/fail test	**4.** Touch the Pass/Fail test button to turn off mask pass/fail testing. Testing will also stop when the testing meets the parameters in the Pass/Fail Setup control window.	

Creating a User Mask from a Defined Mask

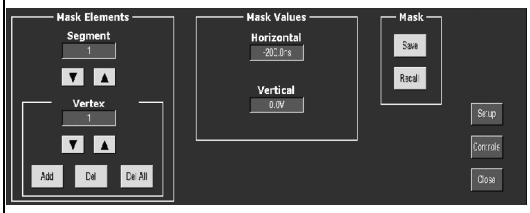
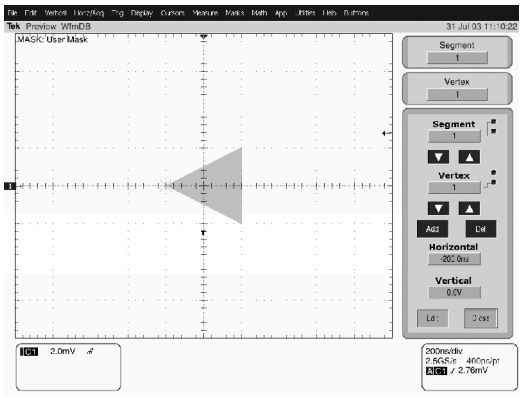
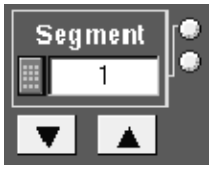
Refer to *Mask Key Points* on page 28 before creating or editing a mask. To create a user mask from a defined mask, do the following procedure.

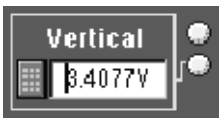
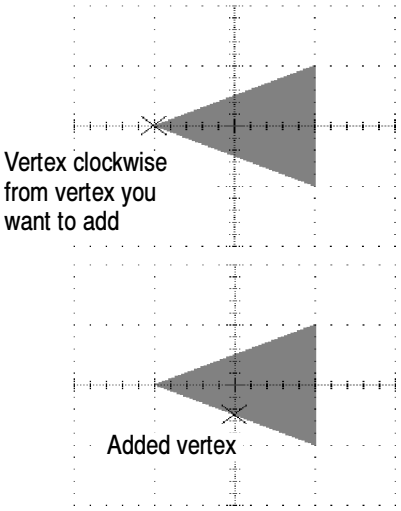
Overview	Creating a user mask from a defined mask	Control elements and resources
Access the mask setup window	**1.** From the button bar, touch Masks and select the Masks tab. The instrument displays the Mask control window.	 
Select the mask type and standard	**2.** Touch the appropriate button in the Type field to select a mask type. Touch the More button to display further selections. **3.** Select a standard from the drop-down list. The control window lists mask types and standards that are available on your instrument, which depend on the bandwidth, options, and configuration of your instrument.	 

Overview	Creating a user mask from a defined mask (cont.)	Control elements and resources
Copy the current mask	**4.** Touch the User Mask button.	
	5. Touch the Copy Current Mask to User Mask button. The instrument copies the current mask to the user mask memory.	
Edit the user mask	**6.** Refer to *Editing a User Mask* on page 19.	
Save the user mask to disk	**7.** Refer to *Saving a User Mask to Disk* on page 21. You do not need to save the edited user mask to disk, as the instrument retains the current user mask in nonvolatile memory. However, if you plan on creating a number of user masks, you will need to store the user masks on disk, as the instrument can only load one user mask at a time.	

Editing a User Mask

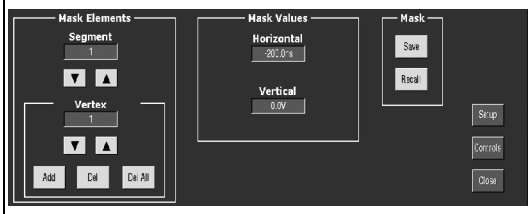
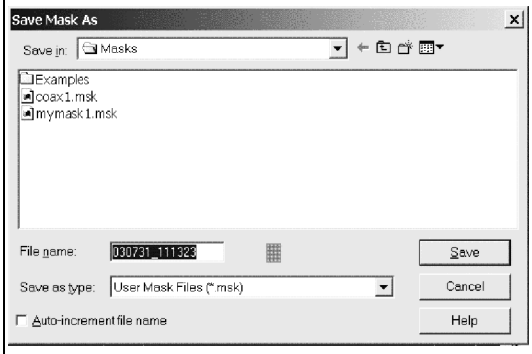
To edit a user mask, do the following procedure.

Overview	Editing a user mask	Control elements and resources
Access the mask edit window	**1.** From the button bar, touch Masks and select the Masks tab. **2.** Touch the User Mask button. **3.** Touch the Edit User Mask button. The instrument displays the Mask Edit control window.	 
Enable the mask edit controls	**4.** Touch the Controls button to open the mask edit controls window on the right side of the screen. This provides the maximum area to display the mask, making editing easier.	
Select a segment	**5.** Touch the Segment field and use the arrow buttons, multipurpose knob, or keypad to select a segment to edit. The selected (active) segment is highlighted. Each mask can have up to 16 segments.	
Select a vertex	**6.** Touch the Vertex field and use the arrow buttons, multipurpose knob, or keypad to select the vertex to edit. The active vertex is indicated with an X on the template segment. Each segment can have up to 50 vertices.	

Overview	Editing a user mask (cont.)	Control elements and resources
Move a vertex	**7.** Touch the Horizontal field and use the multipurpose knob or keypad to change the selected vertex horizontal position. **8.** Touch the Vertical field and use the multipurpose knob or keypad to change the selected vertex vertical position.	 
Add or delete a vertex	**9.** To add a vertex, select the closest vertex that is clockwise from where you want to place a new vertex. Touch Add to add a vertex midway between the selected vertex and the next counter-clockwise vertex. **10.** To delete a vertex, enter or select the vertex number. Then touch Delete to delete the selected vertex. The remaining vertices located counter-clockwise from the deleted vertex are renumbered.	 
Save the user mask to disk	**11.** Refer to *Saving a User Mask to Disk* on page 21.	

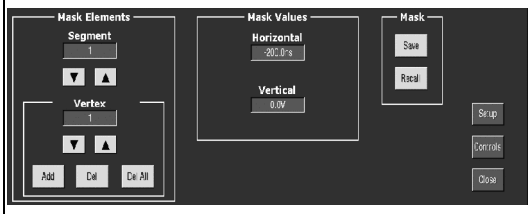
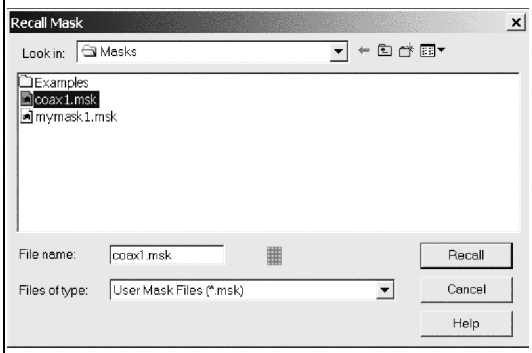
Saving a User Mask to Disk

To save a mask to a folder on the instrument disk, do the following procedure.

Overview	Saving a user mask to disk	Control elements and resources
Access the Mask Setup window	**1.** From the button bar, touch Masks and select the Masks tab. **2.** Touch the User Mask button. **3.** Touch the Edit User Mask button. The instrument displays the Mask Edit control window.	 
Save the user mask to disk	**4.** Touch the Mask Save button. The instrument opens the Save Mask As dialog. The default save location is in the TekScope/Masks folder. **5.** Enter the mask name in the File Name field. The default save type is User Mask Files (*.msk). **6.** Touch Save to save the mask to disk.	 

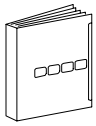
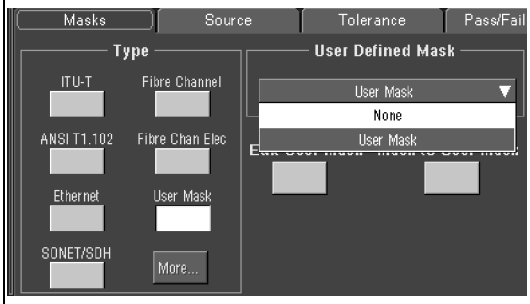
Recalling a User Mask From Disk

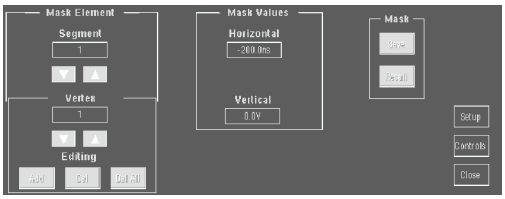
To recall a mask that was stored on disk, do the following procedure.

Overview	Recalling a user mask	Control elements and resources
Access the Mask Setup window	**1.** From the button bar, touch Masks and select the Masks tab. **2.** Touch the User Mask button. **3.** Touch the Edit User Mask button. The instrument displays the Mask Edit control window.	 
Recall the user mask from disk	**4.** Touch the Mask Recall button. The instrument opens the Recall Mask dialog. The default recall location is the TekScope/Masks folder. If the mask files are in another folder, use the navigation controls to access the appropriate folder. **5.** Select the mask name. **6.** Touch Recall to load the user mask into user mask memory on the instrument.	 

Creating a New User Mask

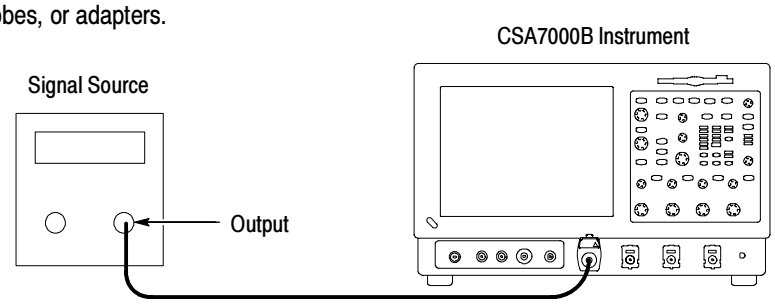
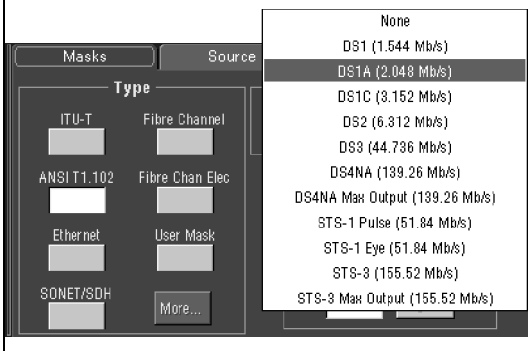
To create a new user mask that is not based on an existing mask, do the following procedure.

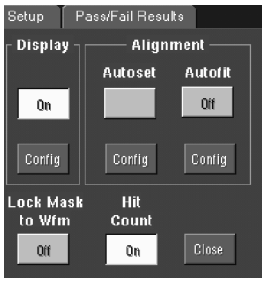
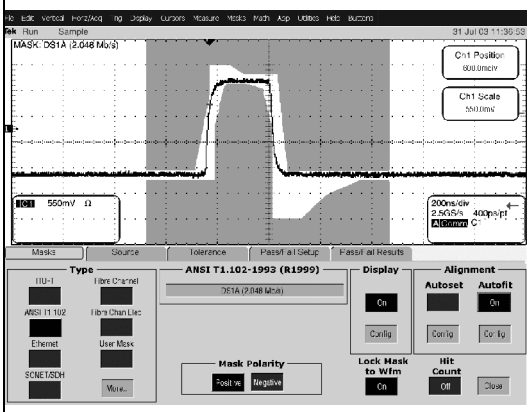
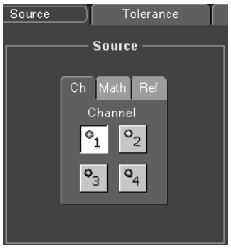
Overview	Creating a new mask	Control elements and resources
Set instrument settings	**1.** Use the communications trigger features to trigger the instrument on a signal. The instrument saves these settings with the mask information.	 See the instrument user manual for information on displaying waveforms.
Create an empty user mask	**2.** From the button bar, touch Masks and select the Masks tab. **3.** Touch the User Mask button.	
	4. Touch the mask standard field to display the drop-down list. **5.** Select None from the list. **6.** Touch the Copy Current Mask to User Mask button. If you are asked if you want to overwrite the current user mask, touch the Yes button.	

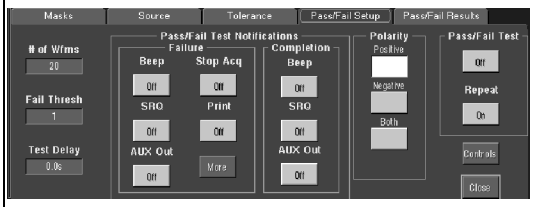
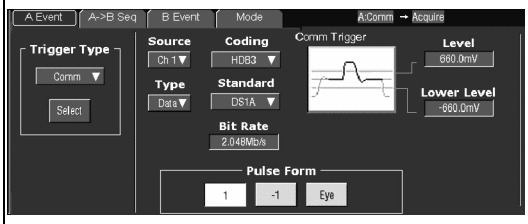
Overview	Creating a new mask (cont.)	Control elements and resources
Create and edit new mask segments	**7.** Touch the Edit User Mask button to display the user mask edit functions. **8.** Touch the Segment field and use the arrow buttons, multipurpose knob, or keypad to enter or select segment 1. **9.** Touch the Vertex Add button. The instrument draws the default new segment shape, a triangle. **10.** Use the instructions in *Editing a User Mask*, starting at step 5 on page 19, to edit a segment. **11.** Repeat steps 8 through 10, selecting an unused and sequential segment number, to create and edit more segments.	
Save the user mask to disk	**12.** Refer to *Saving a User Mask to Disk* on page 21.	

Mask Testing Example

The following procedure is an example of setting up the instrument to perform mask testing on a DS1A signal. This example uses a DS1A signal and a CSA7000B Instrument, but the example can easily be modified for other communications signals and other instruments.

Overview	Creating a new mask	Control elements and resources
Install the test hookup	**1.** Connect your DS1A signal to CH 1 through suitable cables, probes, or adapters.	
	2. Press **DEFAULT SETUP**.	
Set instrument settings	**3.** From the button bar, touch **Masks** and select the Masks tab.	
	4. Touch the **ANSI T1.102** button. If not using an DS1A signal, touch the button appropriate for the signal that you are using.	
	5. Touch the mask standard field to display the drop-down list. **6.** Select **DS1A (2.048 Mb/s)** from the list (if not using a DS1A signal, select the standard appropriate for the signal that you are using). The mask is displayed, but may not be aligned with the signal.	

Overview	Creating a new mask (cont.)	Control elements and resources
Align the mask and the signal6	**7.** To align the signal with the mask, touch the Alignment **Autoset** button. The signal is aligned with the mask. If you need to minimize the number of mask hits on each acquisition, touch **Autofit**. This display assumes that the autoset undo preference is off or that you touch Close to close the Autoset Undo control window.	 
Select the source	**8.** In this example, we are using the default source, Ch 1.	
Change the tolerance	**9.** Set the Mask Margin Tolerance to the percentage of margin used in the mask test (this example uses the default OFF): ■ *OFF* to test the signal to the selected mask standard ■ On with greater than 0% to expand the size of the mask segments, making the test harder to pass ■ On with less than 0% to reduce the size of the mask segments, making the test easier to pass	

Overview	Creating a new mask (cont.)	Control elements and resources
Setup pass/fail testing	**10.** Select the pass/fail test controls (this example uses the defaults, except Pass/Fail Test Repeat is selected): ■ The number of samples or waveforms to test, the minimum number of waveforms to test, and the delay before the test begins ■ Notifications/actions when the test fails or completes ■ Polarity of the signal to test ■ Start the test and cause the test to repeat	
View the test results	**11.** View the results of the pass/fail test (in this example there have been no hits, and the current test is passing): ■ Pass/Fail Test Summary displays the number of samples/waveforms tested, the total number of hits (failures), and settings that you selected for the test ■ Hits per segment displays the number of hits in each segment of the mask ■ Pass/Fail Test allows you to reset the test and to turn the test on and off	
Triggers set automatically	**12.** When you turn on masks, the instrument automatically sets up the triggers. To see the trigger settings used by this example, do the following step: From the button bar, touch Trig. The instrument selected Comm triggers, the Ch 1 source, HDB3 coding, the Data type, and the DS1A standard, and set the bit rate and pulse form.	
For more information	**13.** For additional information on setting up and using serial mask testing, refer to other sections of this user manual and the instrument online help.	

Mask Key Points

There are a number of mask test key points to be aware of prior to using, editing, or creating a mask.

Mask Testing. Only one mask standard is active at any time. If you have a mask selected/enabled and then select a new mask, the new mask replaces the previous mask. You cannot test to multiple standards simultaneously.

Autofit and Persistence Interaction. The Autofit function moves the waveform vertically and horizontally in a mask to reduce the number of segment hits within a mask. If persistence is set to infinite or variable, each Autofit waveform movement clears existing persistence data. If Autofit makes frequent waveform movements, there may be little or no displayed waveform persistence data.

Segments and Mask Hits. Each mask can have a maximum of 16 segments. Segments can overlap. The number of mask hits is the sum of all hits in all segments, regardless of whether or not segments overlap. For example, if a waveform crosses over an area where two segments overlap, both segments will count the waveform hit.

Vertices. Each segment can have a maximum of 50 vertices. Vertices are numbered counterclockwise, with vertex one generally located at the bottom left of each segment. The active (selected) vertex is indicated by an X. The instrument automatically assigns numbers to vertices during mask creation or editing.

Mask Margin Tolerance. Mask margin tolerance moves the mask segment boundaries by the specified percentage. Negative margins reduce the size of the segment, making it easier to pass a mask test. Turning mask margin tolerance off redraws the mask segment margins to their default values, but leaves the numeric value as it is, allowing you to quickly toggle between default and user-set margin values.

Standards and Bandwidth. When the instrument system bandwidth (which includes the instrument, attached probes, and/or cabling) falls into the range of 1.5 to 1.8 (0.8 for optical signals) times the data signal bit rate, the third harmonic of the data signal is significantly attenuated. The instrument displays useful qualitative information, but quantitative rise-time measurements under these conditions may not be accurate.

For example, a 1394b standard signal at the S800b rate has a bit rate of 983.0 Mb/s. 1.5 to 1.8 times this value is a range of 1.47 to 1.77 GHz. Therefore, you should not use a 1.5 GHz measurement system for making quantitative rise-time measurements of this standard.

When just the instrument bandwidth falls within 1.5-1.8 (0.8 for optical signals) times the bit rate of a selected mask standard, the instrument displays the message “Consider system bandwidth when testing at this bit rate.” in the status area above the graticule.

Optical Mask Testing Key Points (CSA7000B Series Only)

There are a number of optical mask test key points to be aware of prior to doing optical mask testing on the CSA7000B Series instruments.

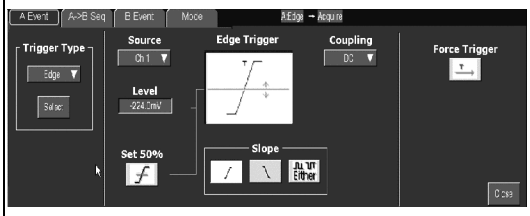
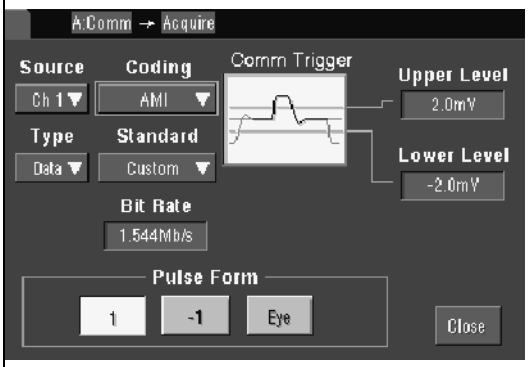
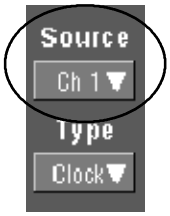
- The CSA7000B Series instruments, when equipped with the O/E Electrical Out-to-Ch1 Input Adapter, are calibrated optical reference receivers. This means that the instrument optical to electrical converter and instrument input channel have been tuned to have a fourth-order Bessel-Thompson response, as well as the correct frequency response for each supported standard by use of digital filters.
- When the O/E Electrical Out-to-Ch1 Input Adapter is installed, if you select an optical mask, and the Bessel-Thompson filter mode is On, then only channel 1 is available. Trying to turn on any other channels, or perform certain functions such as changing the acquisition mode, results in an error message. Turning the Bessel-Thompson filter mode to Off enables access to the other instrument channels, though channel 1 is no longer in the calibrated optical reference receiver (ORR) mode.
- Optical signal mask testing is available for Fibre Channel, InfiniBand, SONET, 1394b, and 1G Ethernet standards.
- If a listed standard is not available on your instrument, it is because the bandwidth of your instrument is not high enough to test that standard.
- You can use O/E Adapters on different CSA7000B instruments without affecting the optical reference receiver calibration on an instrument.
- CSA7000B Series instruments provides recovered clock and recovered data signal outputs on the instrument front panel, as well as using the signals for internal triggering.

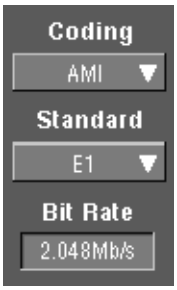
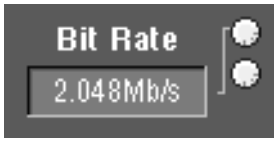
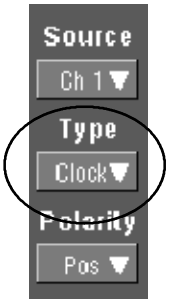
Communication (Comm) Triggering

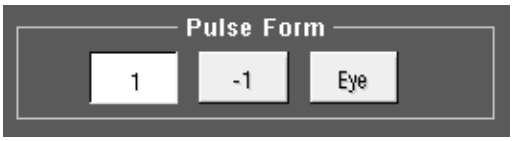
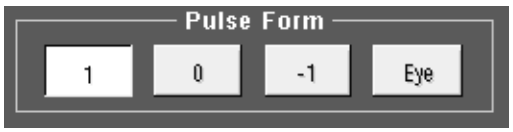
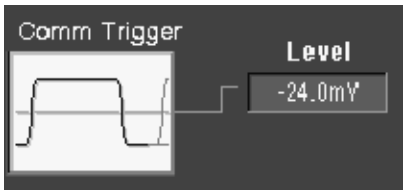
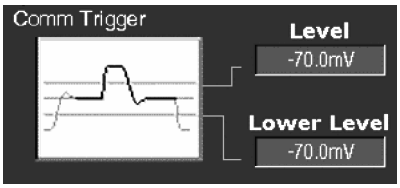
Communication (Comm) triggering (optional on TDS7000B instruments) sets the instrument to trigger on industry-standard communication signals. This section describes how to access and operate the communication trigger features.

Communication Triggering

To set the instrument to trigger on communication signals, do the following procedure.

Overview	Communication triggering	Related control elements and resources
Access the trigger control window	**1.** From the button bar, touch Trig and select the A Event trigger tab. The instrument opens the Trigger Setup control window.	 
Select a communications trigger	**2.** Touch the Comm button. The instrument displays the Comm Trigger controls.	 
Select comm trigger source	**3.** Touch the Source button to select the signal source channel. Select from channel 1 through channel 4.	

Overview	Communication triggering (cont.)	Related control elements and resources
Select comm trigger coding and standard	**4.** Touch the Coding button and select the appropriate code type for your signal from the list. The code selected determines which standards are available as well as other parameters, such as trigger threshold and pulse form. **5.** Touch the Standard button, and select the appropriate signal standard from the list. The standard selected determines the bit rate. **6.** The Bit Rate field shows the bit rate for the selected standard. Touch the Bit Rate field, and use the multipurpose knob or keypad to enter the serial data stream bit rate for nonstandard bit rates. ***Note.*** *Changing the bit rate means the instrument is not triggering in accordance with the standard. The Standard type changes to Custom when you change the bit rate value.*	 
Select comm trigger type	**7.** Touch the Type button to select the signal type. Select from Data, Clock, and R Clk (recovered clock). Recovered clock is only available for NRZ coded signals. Data or clock sets the instrument to trigger on a data stream or clock signal on the input source, respectively. Refer to *Recovered Clock (R Clk) Key Points* on page 33 for information on the Recovered Clock function. **8.** If Type is set to Clock, the instrument displays the Polarity button. Touch Polarity to set the clock signal polarity for the instrument to trigger on Pos(itive) or Neg(ative) clock edges.	

Overview	Communication triggering (cont.)	Related control elements and resources
Select comm trigger pulse form	**9.** Depending on the code setting, the instrument displays different sets of Pulse Form buttons. Touch the appropriate Pulse form button to select a pulse form setting, where each button means: AMI: Isolated +1, Isolated -1, and eye diagram CMI: +1 (binary 1), 0 (binary zero), -1 (inverse of binary 1), and eye diagram NRZ and MLT3: eye diagram only (no buttons displayed)	 
Select comm trigger threshold levels	**10.** Depending on the code and standard setting, the instrument displays the Clock Level field with one or two threshold fields. Touch each Level field and use the multipurpose knob or keypad to enter the comm signal threshold level values.	 

Recovered Clock (R Clk) Key Points

The following are key recovered clock (R Clk) points:

- Recovered clock is a synchronous clock signal derived from the serial communications signal by using a Phase Lock Loop (PLL) clock recovery circuit.
- The recovered clock function only applies to NRZ source signals with a signal bit rate that is less than or equal to 3.125 Gb/s. The recovered clock and recovered data (up to 1.25 Gb/s) are also available at the front panel of a CSA7000B Series instrument.
- When you select recovered clock, the instrument attempts to trigger on and acquire a lock on the derived clock signal. If the source data stream is interrupted or is very distorted, then the instrument may not acquire a lock or may lose signal lock, causing an unstable waveform display.

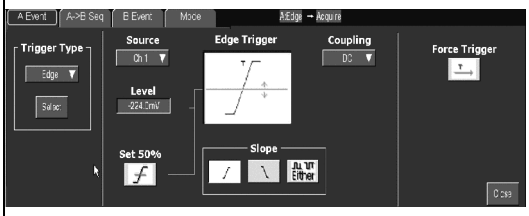
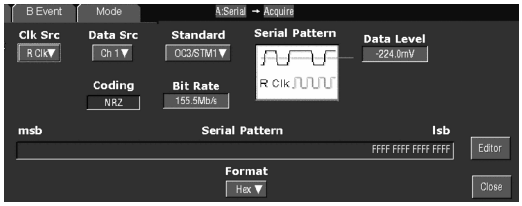
  If this occurs, verify that the source signal is correct, and then push the LEVEL (Push to set 50%) front-panel knob to force the instrument to reacquire a lock on the data stream.

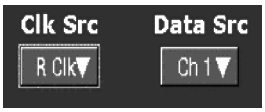
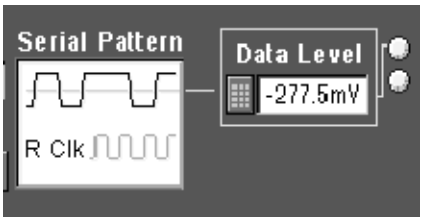
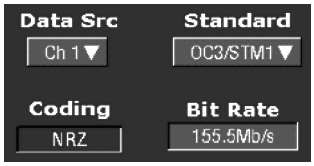
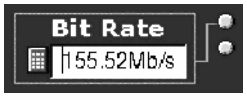
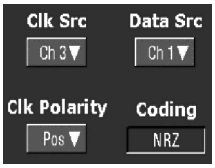
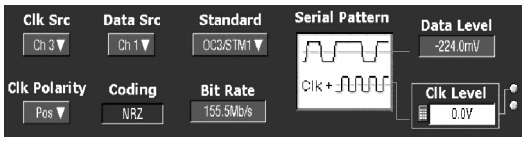
Serial Pattern Trigger

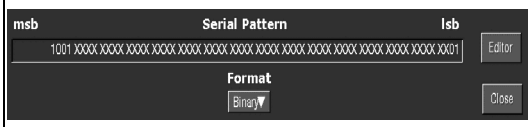
Serial pattern trigger sets the instrument to trigger on a user-defined NRZ data stream pattern. This section describes how to access and operate the serial pattern trigger function.

Serial Pattern Trigger Setup

To set the instrument to trigger on a user-defined serial data stream, do the following procedure.

Overview	Serial trigger setup	Related control elements and resources
Access the trigger control window	**1.** From the button bar, touch Trig, and select the A Event trigger tab. The instrument opens the Trigger Setup control window.	 
Select serial trigger	**2.** Touch the Serial button. The instrument displays the Serial Trigger controls.	 

Overview	Serial trigger setup (cont.)	Related control elements and resources
Select data source	**3.** Touch the Data Src button to select the serial data source. Select from channel 1 through channel 4.	
	4. Touch the Data Level field and use the multipurpose knob or keypad to enter the serial data stream data threshold level.	
Select serial trigger coding and standard	**5.** The Coding button always shows NRZ code type. **6.** Touch the Standard button, and select the appropriate standard from the list. The standard selected determines the bit rate.	
	7. The Bit Rate field shows the bit rate for the selected standard. Touch the Bit Rate field, and use the multipurpose knob or keypad to enter the serial data stream bit rate for nonstandard bit rates. ***Note**: Changing the bit rate means the instrument is not triggering in accordance with the standard.*	
Select clock source, polarity, and level	**8.** Touch the Clk Src button to select the serial data clock source. Select from channel 1 through channel 4 and R Clk (recovered clock). Recovered clock is only available for NRZ coded signals. Refer to *Recovered Clock (R Clk) Key Points* on page 33 for information on the Recovered Clock function.	
	9. If the clock source is different than the data source (except for R Clk), the instrument displays the Clk Polarity button and the Clk Level field. Touch Clk Polarity to set the clock signal polarity to Pos(itive) or Neg(ative). Touch the Clk Level field, and use the arrow buttons, multipurpose knob, or keypad to enter the clock signal threshold level.	

Overview	Serial trigger setup (cont.)	Related control elements and resources
View the current serial trigger pattern	**10.** The Serial Pattern Data field shows the current serial pattern. Touch the Format button to select the pattern display format from the drop-down list. Available formats are binary and hexadecimal.	 msb Serial Pattern lsb 1001 XXXX XXXX XXXX

Appendix A: Supported Mask Types and Standards

Tables 4 through 17 list all supported mask types and standards.

***NOTE**. The standards available for an instrument depend on the options, bandwidth, and configuration of that instrument.*

Table 4: ITU-T masks

None	32Mb 32.064 Mb/s	97Mb 97.728 Mb/s	DS1 Rate 1.544 Mb/s
DS2 Rate Sym 6.312 Mb/s	DS2 Rate Coax 6.312 Mb/s	DS3 Rate 44.736 Mb/s	E1 Sym Pair 2.048 Mb/s
E1 Coax Pair 2.048 Mb/s	E2 8.448 Mb/s	E3 34.368 Mb/s	E4 Binary 0 139.26 Mb/s
E4 Binary 1 139.26 Mb/s	STM1E Binary 0 155.52 Mb/s	STM1E Binary 1 155.52 Mb/s	

Table 5: ANSI T1.102 masks

None	DS1 1.544 Mb/s	DS1A 2.048 Mb/s	DS1C 3.152 Mb/s
DS2 6.312 Mb/s	DS3 44.736 Mb/s	DS4NA 139.26 Mb/s	DS4NA Max Output 139.26 Mb/s
STS-1 Pulse 51.84 Mb/s	STS-1 Eye 51.84 Mb/s	STS-3 155.52 Mb/s	STS-3 Max Output 155.52 Mb/s

Table 6: Ethernet masks

None	100Base-TX STP 125 Mb/s	100Base-TX UTP 125 Mb/s	1000B-SX/LX 1.25 Gb/s
1000B-CX Norm, TP2 1.25 Gb/s	1000B-CX Abs, TP2 1.25 Gb/s	1000B-CX Abs, TP3 1.25 Gb/s	XAUI, Near 3.125 Gb/s
XAUI, Far 3.125 Gb/s	EFM 125 Mb/s (draft)		

Table 7: SONET/SDH masks

None	OC1/STM0 51.84 Mb/s	OC3/STM1 155.52 Mb/s	OC12/STM4 622.08 Mb/s	OC48/STM16 2.4883 Gb/s
OC48-FEC 2.666 Gb/s				

Table 8: Fibre Channel masks

None	FC133 Optical 132.8 Mb/s	FC266 Optical 265.6 Mb/s	FC531 Optical 531.2 Mb/s
FC1063 Optical 1.0625 Gb/s	FC1063 Optical Draft Rev 11	FC2125 Optical 2.125 Gb/s	

Table 9: Fibre Channel Electrical masks

None	FC133E Elec. 132.8 Mb/s	FC266E Elec. 265.6 Mb/s	FC531E Elec. 531.2 Mb/s
FC1063E Elec. 1.0625 Gb/s	FC1063E Norm, Beta, Transm	FC1063E Norm, Delta, Transm	FC1063E Norm, Gamma, Transm
FC1063E Abs, Beta, Transm	FC1063E Abs, Delta, Transm	FC1063E Abs, Gamma, Transm	FC1063E Abs, Beta, Recv
FC1063E Abs, Delta, Recv	FC1063E Abs, Gamma, Recv	FC2125E Norm, Beta, Transm	FC2125E Norm, Delta, Transm
FC2125E Norm, Gamma, Trans	FC2125E Abs, Beta, Transm	FC2125E Abs, Delta, Transm	FC2125E Abs, Gamma, Transm
FC2125E Abs, Beta, Recv	FC2125E Abs, Delta, Recv	FC2125E Abs, Gamma, Recv	FC4250E Abs, Beta, Recv
FC4250E Abs, Beta, Transm	FC4250E Abs, Delta, Recv	FC4250E Abs, Delta, Transm	FC4250E Abs, Gamma, Recv
FC4250E Abs, Gamma, Transm	FC4250E Norm, Beta, Transm	FC4250E Norm, Delta, Transm	FC4250E Norm, Gamma, Transm

Table 10: InfiniBand masks

None	2.5 Optical 2.5 Gb/s	2.5 Electrical 2.5 Gb/s

Table 11: Serial ATA masks

None	G1 Tx 1.5 Gb/s	G1 Rx 1.5 Gb/s
G2 Tx 3.0 Gb/s	G2 Rx 3.0 Gb/s	

Table 12: USB 1.1/2.0 masks

None	FS 12 Mb/s	HS:T1 480 Mb/s	HS:T2 480 Mb/s
HS:T3 480 Mb/s	HS:T4 480 Mb/s	HS:T5 480 Mb/s	HS:T6 480 Mb/s

Table 13: 1394b masks

None	S400b T1 491.5 Mb/s	S400b T2 491.5 Mb/s	S400β Optical 491.5 Mb/s
S800b T1 983.0 Mb/s	S800b T2 983.0 Mb/s	S800β Optical 983.0 Mb/s	S1600b T1 1.966 Gb/s
S1600b T2 1.966 Gb/s	S1600β Optical 1.966 Gb/s		

Table 14: Rapid IO LP-LVDS masks

None	Drv 500 Mb/s	Drv 750 Mb/s	Drv 1.0 Gb/s
Drv 1.5 Gb/s	Drv 2.0 Gb/s	Ext Drv 500 Mb/s	Ext Drv 750 Mb/s
Ext Drv 1.0 Gb/s	Ext Drv 1.5 Gb/s	Ext Drv 2.0 Gb/s	Rcv 500 Mb/s
Rcv 750 Mb/s	Rcv 1.0 Gb/s	Rcv 1.5 Gb/s	Rcv 2.0 Gb/s

Table 15: Rapid IO Serial masks

None	RIO Serial 1.25 Gb/s	RIO Serial 2.5 Gb/s	RIO Serial 3.125 Gb/s

Table 16: IOF masks

None	SFI/SPI-5 TA Data 2.488 Gb/s	SFI/SPI-5 TC Data 2.488 Gb/s	SFI/SPI-5 TA Clock 2.488 Gb/s
SFI/SPI-5 TC Clock 2.488 Gb/s	SFI/SPI-5 RB Data 2.488 Gb/s	SFI/SPI-5 RD Data 2.488 Gb/s	SFI/SPI-5 RB Clock 2.488 Gb/s
SFI/SPI-5 RD Clock 2.488 Gb/s	SFI/SPI-5 TA Data 3.125 Gb/s	SFI/SPI-5 TC Data 3.125 Gb/s	SFI/SPI-5 TA Clock 3.125 Gb/s
SFI/SPI-5 TC Clock 3.125 Gb/s	SFI/SPI-5 RB Data 3.125 Gb/s	SFI/SPI-5 RD Data 3.125 Gb/s	SFI/SPI-5 RB Clock 3.125 Gb/s
SFI/SPI-5 RD Clock 3.125 Gb/s	VSR OC192/STM64 1.24416 Gb/s	TFI-5 2.488 Gb/s	TFI-5 3.1104 Gb/s

Table 17: PCI-Express masks

None	PCI-Express Transm 2.5 Gb/s	PCI-Express Recv 2.5 Gb/s	

Appendix B: Supported Communication Trigger Codes and Standards

Tables 18 through 25 list all supported communication trigger standards. Note that HDB3, B3ZS, B6ZS, and B8ZS are considered to be subsets of the AMI code set.

NOTE. *The communications trigger standards available for an instrument depend on the bandwidth and/or configuration of that instrument.*

Table 18: AMI trigger standards

Custom	32Mb 32.064 Mb/s	97Mb 97.728 Mb/s	DS1 1.544 Mb/s
DS1A 2.048 Mb/s	DS1C 3.152 Mb/s	DS2 6.312 Mb/s	DS2 Rate Sym 6.312 Mb/s
DS2 Rate Coax 6.312 Mb/s	DS3 44.736 Mb/s	E1 2.048 Mb/s	E2 8.448 Mb/s
E3 34.368 Mb/s	STS-1 51.84 Mb/s		

Table 19: B3ZS trigger standards

Custom	DS3 44.736 Mb/s	STS-1 51.84 Mb/s	

Table 20: B6ZS trigger standards

Custom	DS2 6.312 Mb/s	DS2 Rate Sym 6.312 Mb/s	

Table 21: B8ZS trigger standards

Custom	DS1 1.544 Mb/s	DS1C 3.152 Mb/s	DS2 Rate Coax 6.312 Mb/s

Table 22: CMI trigger standards

Custom	DS4NA 139.26 Mb/s	E4 139.26 Mb/s
STM1E 155.52 Mb/s	STS-3 155.52 Mb/s	STM-0 CMI 51.84 Mb/s

Table 23: HDB3 trigger standards

Custom	E1 2.048 Mb/s	E2 8.448 Mb/s
E3 34.368 Mb/s	DS1A 2.048 Mb/s	STM-0 HDBx 51.84 Mb/s

Table 24: MLT3 trigger standards

Custom	100Base-TX 125 Mb/s	

Table 25: NRZ trigger standards

Custom	2.5 IBand 2.5 Gb/s	EFU 125.0 Mb/s	FC133 132.8 Mb/s
FC266 265.6 Mb/s	FC531 531.2 Mb/s	FC1063 1.0625 Gb/s	FC2125E 2.125 Gb/s
FC4250 4.25 Gb/s	FS USB 12 Mb/s	G1 ATA 1.5 Gb/s	G2 ATA 3.0 Gb/s
G3 ATA 6.0 Gb/s	GB Ethernet 1.25 Gb/s	HS USB 480 Mb/s	OC1/STM0 51.84 Mb/s
OC3/STM1 155.5 Mb/s	OC12/STM4 622.1 Mb/s	OC48/STM16 2.488 Gb/s	OC48-FEC 2.666 Gb/s
PCI-Express 2.5 Gb/s	RapidIO 500M 500 Mb/s	RapidIO 750M 750 Mb/s	RapidIO 1.0G 1.0 Gb/s
RapidIO 1.5G 1.5 Gb/s	RapidIO 2.0G 2.0 Gb/s	RIO Serial 1G 1.25 Gb/s	RIO Serial 2G 2.5 Gb/s
RIO Serial 3G 3.125 Gb/s	S400b 491.5 Mb/s	S800b 983.0 Mb/s	S1600b 1.966 Gb/s
SFI/SPI-5 2.5G 2.5 Gb/s	SFI/SPI-5 3.1G 3.1 Gb/s	TFI-5 2.5G 1.488 Gb/s	TFI-5 3.1G 3.11 Gb/s
VSR OC192 1.244 Gb/s	XAUI 3.125 Gb/s		

Appendix C: Automatic Communication Signal Measurements

Table 26 lists the automatic communication signal measurements that are part of the Serial Mask Testing features.

Table 26: Supported communications measurements and their definition

Name	Definition
Ext Ratio	The ratio of eye top to base. *Ext Ratio = $PTop_{mean}/PBase_{mean}$*
Extinction Ratio %	The ratio of eye base to top in %. *Ext Ratio % = $100*(PBase_{mean}/PTop_{mean})$*
Extinction Ratio dB	The ratio of eye top to base in dB. *Ext Ratio dB = $10*Log(PTop_{mean}/PBase_{mean})$*
Eye Height	The eye height in watts or volts. *Eye Height = $(PTop_{mean} - 3*PTop_{sigma}) - (PBase_{mean} + 3*PBase_{sigma})$*
Eye Width	The eye width in seconds. *Eye Width = $(TCross2_{mean} - 3*TCross2_{sigma}) - (TCross1_{mean} + 3*TCross1_{sigma})$*
Crossing %	The eye crossing point as a percentage of eye height. *Crossing % = $100*[(PCross1_{mean} - PBase_{mean})/(PTop_{mean} - PBase_{mean})]$*
Eye Top	The top of the eye.
Eye Base	The base of the eye.
Jitter Pk-Pk	The peak-to-peak value for the edge jitter in the current horizontal units. *Jitter PP = $TCross1_{PP}$*
Jitter RMS	The RMS value of the edge jitter in the current horizontal units. *Jitter RMS = $TCross1_{sigma}$*
Jitter 6σ	*6 x (Jitter RMS)*
Noise Pk-Pk	The peak-to-peak value of the noise of the top or base of the signal as specified by the user. *Noise Pk-Pk = $PTop_{pk-pk\ or}\ PBase_{pk-pk}$*
Noise RMS	The RMS value of the noise of the top or base of the signal as specified by the user. *Noise RMS = $PTop_{sigma\ or}\ PBase_{sigma}$*

Table 26: Supported communications measurements and their definition (Cont.)

Name	Definition
S/N Ratio	Ratio of the signal amplitude to the noise of the top or base of the signal as specified by the user. *S/N Ratio = (PTop - PBase)/($PTop_{sigma}$ or $PBase_{sigma}$)*
Duty Cycle Distortion	The peak-to-peak time variation of the 1st eye crossing measured at the MidRef as a percent of the eye period. *DCD (sec) = 100% x $TDCD_{p-p}$/($TCross2_{mean}$ - $TCross2_{mean}$)*
Quality Factor	Ratio of eye size to noise. *Quality Factor = ($PTop_{mean}$ - $PBase_{mean}$)/($PTop_{sigma}$ + $PBase_{sigma}$)*

Levels Used in Taking Eye Measurements

All eye-diagram measurements are based on the power level, the voltage level, or the time locations of edges within each acquisition.

Figure 5 shows an eye-diagram and the areas from which values are taken that are used to calculate measurements.

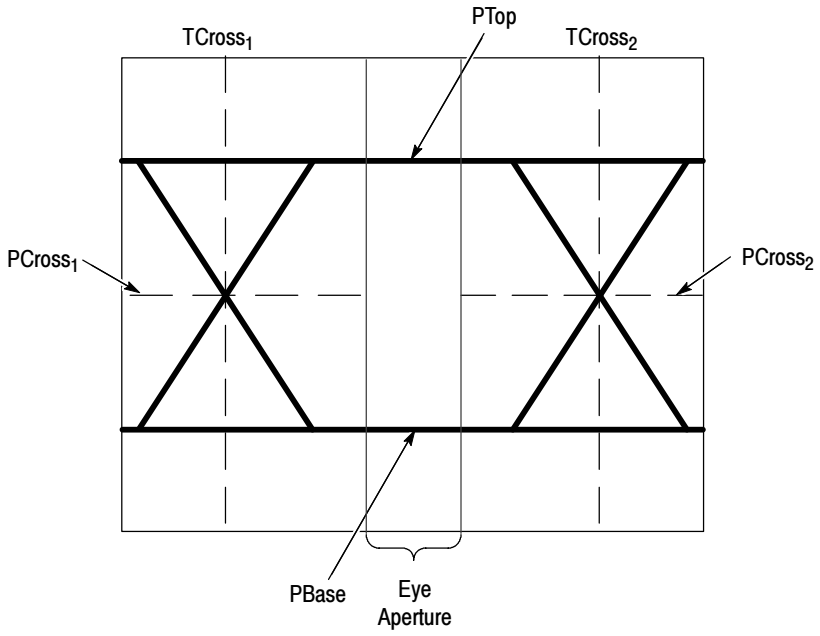


Figure 5: Eye-diagram and optical values

P Values

The P values include the mean and standard deviation of the vertical location of PTop and PBase. These areas are used with a specified sample size to statistically measure the following values:

- $PTop_{mean}$, the mean value of PTop
- $PTop_{sigma}$, the standard deviation of PTop
- $PTop_{pk\text{-}pk}$, the vertical peak-to-peak deviation of PTop
- $PBase_{mean}$, the mean value of PBase within the Eye Aperture[1]
- $PBase_{sigma}$, the standard deviation of PBase within the Eye Aperture[1]
- $PBase_{pk\text{-}pk}$, the vertical peak-to-peak deviation of PBase

[1] **The Eye Aperture defaults to the center 20% of the interval from $TCross_1$ to $TCross_2$.**

T1 Values

The T1 values are vertical and horizontal values associated with the leftmost crossing point. These areas are used to establish the following directions:

- $TCross1_{mean}$, the horizontal mean of the left crossing point at $TCross_1$
- $TCross1_{sigma}$, the horizontal standard deviation of the left crossing point at $TCross_1$
- $TCross1_{pk\text{-}pk}$, the horizontal peak-to-peak deviation of the left crossing point at $TCross_1$
- $PCross1_{mean}$, the vertical mean of the left crossing point at $PCross_1$

T2 Values

The T2 values are vertical and horizontal values associated with the rightmost crossing point. These areas are used to establish the following directions:

- $TCross2_{mean}$, the horizontal mean of the right crossing point at $TCross_2$
- $TCross2_{sigma}$, the horizontal standard deviation of the right crossing point at $TCross_2$
- $TCross2_{pk\text{-}pk}$, the horizontal peak-to-peak deviation of the right crossing point at $TCross_2$

DCD Values

The duty cycle distortion (DCD) values are horizontal values associated with the rightmost crossing point at 50% of the eye height. These areas are used to establish the $DCD_{pk\text{-}pk}$, the horizontal peak-to-peak deviation of the left crossing point at half the height of the eye.

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