User Manual

Tektronix

TDSRBS1
Rambus Channel Measurements Application

071-0761-00

This document supports software version 1.0.0 and above.

Warning
The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to all safety summaries prior to performing service.

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

Tektronix wishes to recognize and thank the Intel Folsom Desktop Products Group Analog Integrity Engineering team for their technical contributions in the design of this application.

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Table of Contents

General Safety Summary vii
Preface ix
Related Documentation ix
Conventions x
Contacting Tektronix xi

Getting Started

Product Description **1–1**
Compatibility 1–1
Requirements and Restrictions 1–1
Updates Through the Web Site 1–2
Optional Accessories 1–2
Accessories 1–2

Installation **1–3**
Installing the Application 1–3
Deskewing the Probes and Channels 1–4
Connecting to a System Under Test 1–9

Operating Basics

Basic Operations **2–1**
Application Menu Structure 2–1
  Main and Side Menus 2–1
  Common Menu Items 2–2
  Utility Menus 2–2
Using Basic Oscilloscope Functions 2–2
  Using Local Help 2–2
  Returning to the Application 2–3
Warning Messages 2–3
Configuring the Display 2–3
Rambus Terms 2–4
Understanding Measurement Points 2–4
  Write Pulse Examples 2–5
  Read Pulse Examples 2–8
Understanding Measurement Patterns 2–11
Setting Up the Application 2–12
  Measurement Selections 2–12
  Configuring the Measurement 2–13
  Plot Results Setup 2–18
  View Results Setup 2–20
Taking Measurements 2–21
  Acquiring Waveforms 2–21
  Localizing Measurements 2–22
Saving the Results and Worst Case Waveforms 2–22
  Data Log File Format 2–24
Importing a Data Log File to a Personal Computer 2–24

Viewing the Results 2–25
Statistics 2–26
Graphical Formats 2–26
Clearing Results 2–26
Saving and Recalling Setups 2–27
Saving a Setup 2–27
Recalling a Setup 2–28
Exiting the Application 2–28

Tutorial 2–29
Setting Up the Oscilloscope 2–29
Starting the Application 2–29
Loading the Reference Waveform Files 2–31
Taking Setup Time and Hold Time Measurements 2–32
Taking Measurements from Four Waveforms 2–36
Saving the Results to a Data Log File 2–38
Viewing the RESULTS.CSV File (Data Log) 2–41
Stopping the Tutorial 2–41
Returning to the Tutorial 2–41

GPIB Program Example 2–43
Guidelines 2–43
Program Example 2–43

Reference

Menu Structure 3–1

Parameters 3–3
Measure Menu 3–3
Setup Menus 3–3
Inputs Menu 3–4
Deskew Menu 3–5
Test Signal Configuration Menu 3–5
Clock Speed Menu 3–5
Limits and Limits Edit Menus 3–6
Plot Results Menus 3–7
Histogram Menu 3–7
Profiling Menu 3–7
Logging Menus 3–8
Results Logging Menu 3–8
Worst Case Wfms Logging Menu 3–8
View Results Menu 3–9
Control Menu 3–9
Utility Menus 3–9

Appendices

Appendix A: Measurement Algorithms A–1
Oscilloscope Setup Guidelines A–1
Test Methodology A–1
Waveform Analysis Phase A–2
Computation Phase A–3
Setup and Hold Time Measurement A–3
Timing Quality (Tq) Measurement A–4

Channel Error Measurement A–5
Flight Time (Data) Measurement A–5
Flight Time Clock Measurement A–6
Rise Time and Fall Time Measurements A–6

Appendix B: GPIB Command Syntax B–1

Appendix C: Error Codes C–1

Appendix D: Deskewing with a Math1 Waveform D–1

Appendix E: Quick Validation of Setup and Hold Times E–1

Waveform Display Setup E–1
Detailed Procedure E–2
Abbreviated Procedure E–6

Index

List of Figures

Figure 1–1: TDSRBS1 Rambus Channel Measurements Application 1–1

Figure 1–2: Typical signal path skew 1–5

Figure 1–3: Accessing the Deskew utility 1–6

Figure 1–4: The Deskew menu 1–6

Figure 1–5: Example of a deskew configuration 1–7

Figure 1–6: Deskewing in process 1–8

Figure 1–7: Deskew complete 1–8

Figure 1–8: Setting up a Rambus mother board 1–10

Figure 1–9: Preparing probes 1–11

Figure 1–10: Connecting probes to the oscilloscope 1–11

Figure 1–11: Clock signal contact points on RIMM connector, back of board 1–12

Figure 1–12: Clock signal contact points on the 82820 MCH in the BGA area 1–13

Figure 1–13: Probes positioned on a Rambus mother board 1–13

Figure 1–14: Overall view of the TDSRBS1 setup 1–14

Figure 1–15: Waveforms from a SUT that is set up and operating properly 1–15

Figure 2–1: Returning to the application 2–3

Figure 2–2: Write even positive pulse waveforms and measurement points 2–5

Figure 2–3: Write even negative pulse waveforms and measurement points 2–7
Figure 2–4: Read even positive pulse waveforms and measurement points 2–9
Figure 2–5: Read even negative pulse waveforms and measurement points 2–10
Figure 2–6: How to set reference voltage levels 2–15
Figure 2–7: Example of the results and display formats 2–25
Figure 2–8: Example of data in a RESULTS.CSV file viewed in a spreadsheet program 2–25
Figure 2–9: Starting the application 2–30
Figure 2–10: TDSRBS1 application initial display 2–30
Figure 2–11: Display of the Ref2 and Ref4 waveforms 2–32
Figure 2–12: Inputs menu, Ref4 2–33
Figure 2–13: Clock Speed menu 2–33
Figure 2–14: Test Signal Configuration menu, default selections 2–34
Figure 2–15: Setup Summary menu; use the GP knob to scroll the summary 2–34
Figure 2–16: Setup Time and Hold Time lesson: Result Summary readout 2–35
Figure 2–17: View Details shows the statistical values for Setup Time 2–35
Figure 2–18: View Details shows the statistical values for Hold Time 2–36
Figure 2–19: Display of Ref1, Ref2, Ref3, and Ref4 waveforms 2–37
Figure 2–20: Channel Error lesson: Result Summary readout 2–38
Figure 2–21: View Details shows the statistical values for Channel Error Falling 2–38
Figure 2–22: Logging menu 2–39
Figure 2–23: Path to the RESULTS.CSV file on the hard drive 2–40
Figure 2–24: Copying the RESULTS.CSV file to a floppy disk 2–40

Figure 3–1: Measure, Setup, Plot Results, and View Results menus structures 3–1
Figure 3–2: Logging, Control, and Utility menus structures 3–2

Figure D–1: Math1 side menu items D–1
Figure D–2: Change Math Definition side menu items D–2
Figure D–3: Deskew menu: From parameter Math1 selection D–3
Figure D–4: Channel configuration to deskew with a Math1 waveform D–3

Figure E–1: Rambus clock waveform set up properly example E–2
Figure E–2: Statistics set up properly example E–3
Figure E–3: Level Setup set up properly example E–4
Figure E–4: Statistical results on a Rambus clock signal E–5
Figure E–5: Statistical results on a Rambus data waveform (Read cycle) E–5
Figure E–6: Button abbreviations E–6

List of Tables

Table 1–1: Channel and Rambus signal mapping 1–11

Table 2–1: Common menu items 2–2
Table 2–2: Utility menus 2–2
Table 2–3: Display Options menu selections 2–4
Table 2–4: Channel or reference memory and Rambus signal assignments 2–4
Table 2–5: Write even positive pulse measurement points 2–5
Table 2–6: Write even positive pulse timing characteristics 2–6
Table 2–7: Write even negative pulse measurement points 2–6
Table 2–8: Write even negative pulse timing characteristics 2–7
Table 2–9: Read even positive pulse measurement points 2–8
Table 2–10: Read even positive pulse timing characteristics 2–9
Table 2–11: Read even negative pulse measurement points 2–10
Table 2–12: Read even negative pulse timing characteristics 2–11
Table 2–13: Measurement patterns 2–11
Table 2–14: Measure menu selections 2–12
Table 2–15: Setup menu selections 2–13
Table 2–16: Inputs menu selections and parameters 2–14
Table 2–17: Deskew menu selections 2–16
Table 2–18: Test Signal Configuration menu selections 2–16
Table 2–19: Clock Speed menu selections 2–17
Table 2–20: Limits Edit menu selections 2–17
Table 2–21: Color of Mean values when using Limits 2–18
Table 2–22: Color of PASS or FAIL when using Limits 2–18
Table 2–23: Plot Results menu selections 2–18

Table 2–24: Histogram menu selections **2–19**
Table 2–25: Profiling menu selections **2–20**
Table 2–26: View Results menu selections **2–20**
Table 2–27: Control menu selections **2–21**
Table 2–28: Logging menu selections **2–22**
Table 2–29: Results Logging menu selections **2–23**
Table 2–30: Worst Case Wfms Logging menu selections **2–23**
Table 2–31: Reference waveforms and Rambus signal types **2–31**

Table 3–1: Measure menu parameters **3–3**
Table 3–2: Inputs menu parameters **3–4**
Table 3–3: Deskew menu parameters **3–5**
Table 3–4: Test Signal Configuration menu parameters **3–5**
Table 3–5: Clock Speed menu parameters **3–5**
Table 3–6: Limits and Limits Edit menus parameters **3–6**
Table 3–7: Measurement number, key, and corresponding default limits **3–6**
Table 3–8: Plot Results menu parameters **3–7**
Table 3–9: Histogram menu parameters **3–7**
Table 3–10: Profile menu parameters **3–7**
Table 3–11: Results Logging menu parameters **3–8**
Table 3–12: Worst Case Wfms Logging menu parameters **3–8**
Table 3–13: View Results menu parameters **3–9**
Table 3–14: Control menu parameters **3–9**
Table 3–15: Utility menus and parameters **3–9**

Table B–1: VARIABLE:VALUE TDS COMMAND arguments and queries **B–2**
Table B–2: Measurement, resultFor query, and plotSource query keys **B–6**
Table B–3: Measurement results queries **B–7**

Table C–1: Error codes, descriptions and solutions **C–1**

General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of the system. Read the *General Safety Summary* in other system manuals for warnings and cautions related to operating the system.

To Avoid Fire or Personal Injury

Use Proper Power Cord. Use only the power cord specified for this product and certified for the country of use.

Connect and Disconnect Properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source.

Ground the Product. This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do Not Operate Without Covers. Do not operate this product with covers or panels removed.

Use Proper Fuse. Use only the fuse type and rating specified for this product.

Avoid Exposed Circuitry. Do not touch exposed connections and components when power is present.

Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Keep Product Surfaces Clean and Dry.

Provide Proper Ventilation. Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

Symbols and Terms

Terms in this Manual. These terms may appear in this manual:

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

CAUTION. *Caution statements identify conditions or practices that could result in damage to this product or other property.*

Preface

This manual contains operating information for the TDSRBS1 Rambus Channel Measurements Application. The manual consists of the following chapters:

- The *Getting Started* chapter briefly describes the TDSRBS1 Rambus Channel Measurements Application, lists oscilloscope compatibility, and provides installation instructions.
- The *Operating Basics* chapter covers basic operating principles of the application and includes a tutorial that teaches you how to set up the application to acquire a waveform, take measurements, and view the results.

  To show you how to operate the application using GPIB commands, this chapter includes a simple GPIB program.
- The *Reference* chapter includes a diagram of the menu structure and descriptions of parameters.
- The *Measurement Algorithms* appendix contains information on measurement guidelines and on how the application takes the measurements.
- The *GPIB Command Syntax* appendix contains a list of arguments and values that you can use with the GPIB commands and their associated parameters.
- The *Error Codes* appendix contains a list of error codes, descriptions of the errors, and possible solutions to correct the problem.
- The *Deskewing with a Math1 Waveform* appendix describes how to deskew single-ended probes relative to differential probes.
- The *Rise Time and Fall Time Analysis* appendix contains a procedure on how to set up the oscilloscope to quickly validate Rise Time and Fall Time measurements results.

Related Documentation

The user manual for your oscilloscope provides general information on how to operate the oscilloscope.

Programmer information in the online help for your TDS 694C oscilloscope provides details on how to use GPIB commands to control the oscilloscope. You can also download the tds6prog.zip file (online help) with examples from the www.Tektronix.com web site. Refer to *Updates Through the Web Site* on page 1–2 for information on how to download the file.

To help you use this application, you can also refer to the following materials:

- *Rambus® Technology Overview, Rambus, Inc., 1999*
- *Direct Rambus® Clock Generator, DL-0056, Version 1.0, Rambus, Inc.*
- *Direct RAC Data Sheet, Rambus Inc., 1998*
- *Intel® 820 Chipset: 82820 Memory Controller Hub (MCH) Datasheet, Intel Corp., 1999*

Conventions

This manual uses the following conventions:

- This manual refers to the TDSRBS1 Rambus Channel Measurements Application as the TDSRBS1 application or as the application.
- When steps require that you make a sequence of selections using front-panel controls and menu buttons, an arrow (➞) marks each transition between a front-panel button and a menu, or between menus. Names that are for a main menu or side menu item are clearly indicated: Press VERTICAL MENU ➞ Coupling (main) ➞ DC (side) ➞ Bandwidth (main) ➞ 250 MHz (side).

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: support@tektronix.com 1-800-833-9200, select option 3* 1-503-627-2400 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

Product Description

The TDSRBS1 Rambus Channel Measurements Application is a Java-based application that enhances basic capabilities of the TDS 694C oscilloscope.

The application provides Rambus channel timing measurements for the oscilloscope. Measurements can be performed on Read cycles, Write cycles, High Data pulses, Low Data pulses, Odd Data fields, and Even Data fields.

Figure 1–1 shows an example of Rambus waveforms and the Results readout.

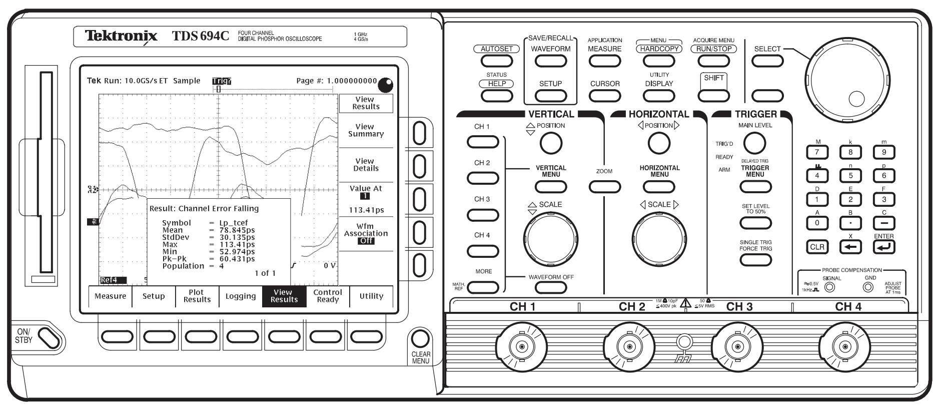


Figure 1–1: TDSRBS1 Rambus Channel Measurements Application

Compatibility

The Rambus Channel Measurements Application is compatible with the TDS694C Tektronix oscilloscope with firmware version 6.2 and above.

For information on how to get the current firmware, contact your local Tektronix distributor or sales office.

For a current list of compatible oscilloscopes, see the Software and Drivers category in the Tektronix, Inc. web site (www.tektronix.com).

Requirements and Restrictions

The TDS Run-Time Environment V1.2.0 and above must be installed on the oscilloscope to operate the TDSRBS1 application and use the GPIB commands.

Updates Through the Web Site

You can find information about this and other applications at the Tektronix Inc. web site, www.tektronix.com. Check this site for application updates and for other free applications.

To install an application update, you will need to download it from the Tektronix web site to a hard disk, copy it to a blank DOS-formatted floppy disk, and then install it on your oscilloscope.

***NOTE**. More information about changes to the application or installation is in a* Readme.txt *file on the web site. You should read it before you continue.*

To copy an application from the web site, follow these steps:

1. Access www.tek.com/Measurement/Support/scopes/software/index.html.

2. Scroll through the files to the application that you want, select the file, and download it to your hard disk drive. If necessary, unzip the file.

3. Copy the application from the hard disk to a blank, DOS-formatted floppy disk.

4. Follow the *Installing the Application* procedure on page 1–3.

Optional Accessories

To take accurate measurements, you need the following accessories:

- Two P6248 Differential Probes
- Two P6249 Active Probes
- Four surface mount device interconnects with articulated arms, such as Tektronix PPM203Bs
- Probe accessories leadset, Tektronix part number 016-1780-00

Accessories

There are no standard accessories for this product other than this manual.

Installation

This section contains information on the following tasks:

- Installing the application
- Deskewing probes and channels
- Connecting to a system under test

Installing the Application

The TDSRBS1 floppy disk contains the Rambus Channel Measurements Application. You can download updates, if any, from the Tektronix ftp site through a web browser.

***NOTE**. To operate the TDSRBS1 application, the TDS Run-Time Environment V1.2.0 or above must be installed on the TDS 694C oscilloscope, and the oscilloscope must also have firmware version 6.2 or above.*

To install the application from the floppy disk to your oscilloscope, follow these steps:

1. Power off the oscilloscope.

***NOTE**. Additional information about the application or installation is located in a* Readme.txt *file on the floppy disk. You should insert the floppy disk into a DOS-based personal computer and read the* Readme.txt *file before you continue.*

If you are updating the application, the Readme.txt *file on the Tektronix ftp site supercedes the* Readme.txt *file on the TDSRBS1 floppy disk.*

---

2. Insert the disk in the floppy disk drive, and power on the oscilloscope.

***NOTE**. To verify that the TDS Run-Time Environment V1.2.0 or above is installed, watch for the abbreviated name, RTE, and version number to appear at the top of the display when you power on the oscilloscope. If they do not appear, contact your local Tektronix sales office.*

After performing the power-on selftest, the oscilloscope automatically begins the installation procedure.

As the application loads from the disk, the oscilloscope displays a clock icon to indicate that it is busy. Also, the floppy disk drive LED is on, indicating activity. If the clock icon continues to display after the floppy disk LED has gone out, a problem has occurred with the installation. Repeat the above procedure. If the problem persists, contact your Tektronix representative.

When the installation is complete, an Installation Complete message displays.

3. Remove the floppy disk, and cycle the power to the oscilloscope.

Deskewing the Probes and Channels

To ensure accurate measurement results, it is important to first deskew the probes and oscilloscope channels before you take measurements from your Rambus system under test (SUT). Deskewing is where the oscilloscope adjusts the relative delay between signals to accurately time correlate the displayed waveforms.

CAUTION. *To prevent erroneous measurement results, retain the probe and oscilloscope channel combination after deskewing them. When you change the probe connections, the delay attributes also change. When you move a probe to another channel, you must perform the deskew procedure again.*

NOTE. *To produce good deskew results, you should connect the probes to the fastest clock signals possible, preferably ones with around a 200 pS edge rate.*

The application includes an automated deskew utility that you can use to deskew up to four probes and oscilloscope channels at once. The following procedure describes how to deskew two channels. Channel 1 (and the probe connected to it) is the reference point used to deskew channel 2. The steps to deskew the third and fourth channels are the same.

To deskew a probe and oscilloscope channel, follow these steps:

1. Follow the procedure on page 1–9 to connect similar probes to channels 1 and 2 on the oscilloscope.

2. Connect the probes to a very fast clock signal.

For optimum results, connect the probes to the output of the Direct Rambus Clock Generator (DRCG) in the SUT.

3. Set up the oscilloscope as follows:

a. Use the Horizontal Scale knob to set the oscilloscope to the fastest acquisition rate, such as 10 GS/sec.

b. Use the Vertical Scale and Position knobs to adjust the signals to fill the display (view the full amplitude) without missing any part of the signals.

c. Set the Record Length to 15,000 or 50,000 in the Horizontal menu; this minimizes the effect of trigger jitter on the resultant deskew values.

Figure 1–2 shows an example of signal path skew found in similar probes.

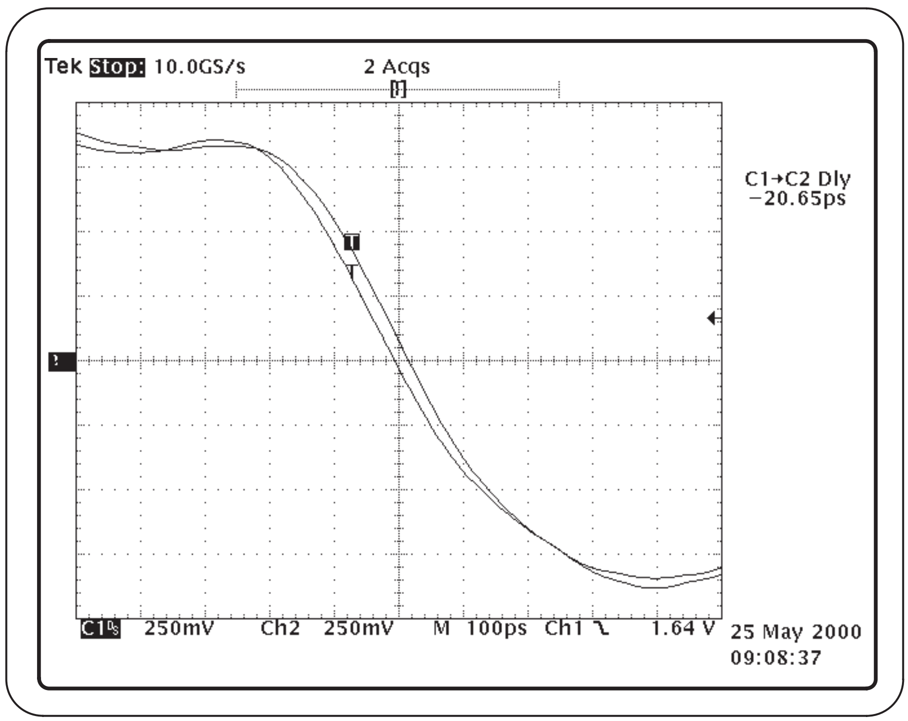


Figure 1–2: Typical signal path skew

4. Start the application as described on page 2–29.

5. Press Setup (main) → Inputs (side) → –more– 1 of 2 (side) to access the Deskew utility. Figure 1–3 shows how to access the Deskew utility.

6. Press Deskew (side). Figure 1–4 shows the Deskew menu.

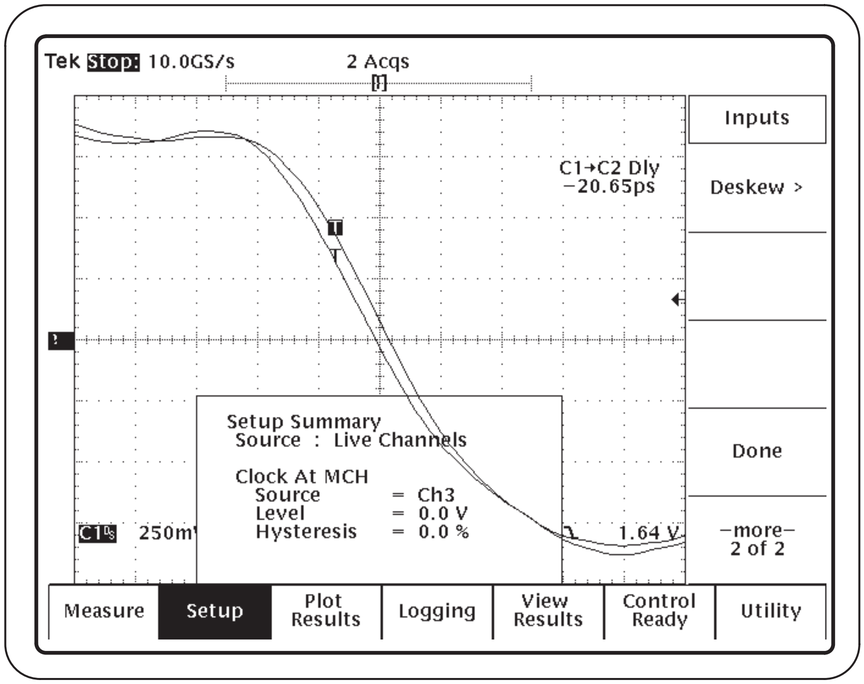


Figure 1–3: Accessing the Deskew utility

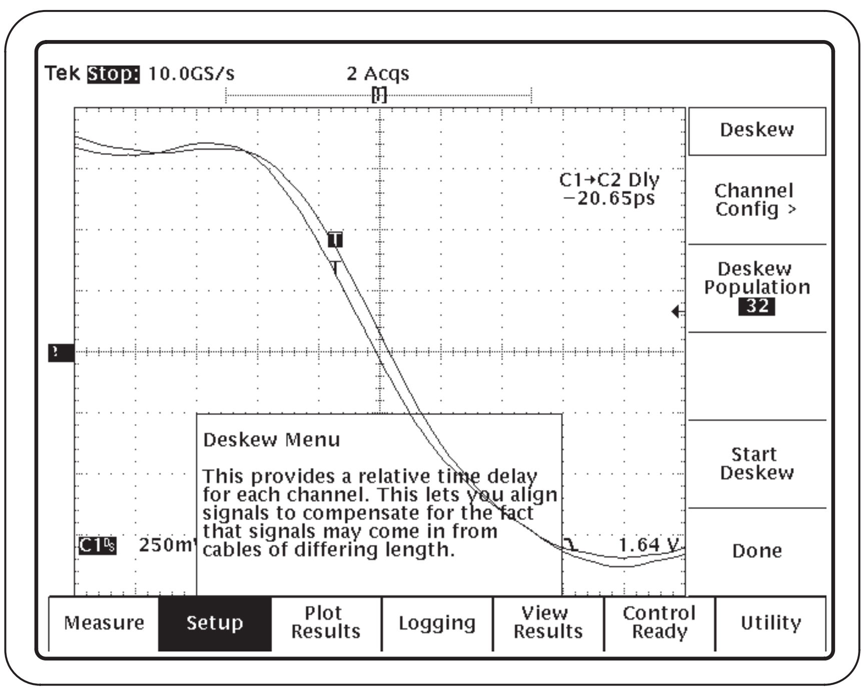


Figure 1–4: The Deskew menu

7. Press Channel Config (side) ➞ To (side) and select Ch2.

8. Press Done (side).

9. Press Slope (side) and select Falling. See Figure 1–5.

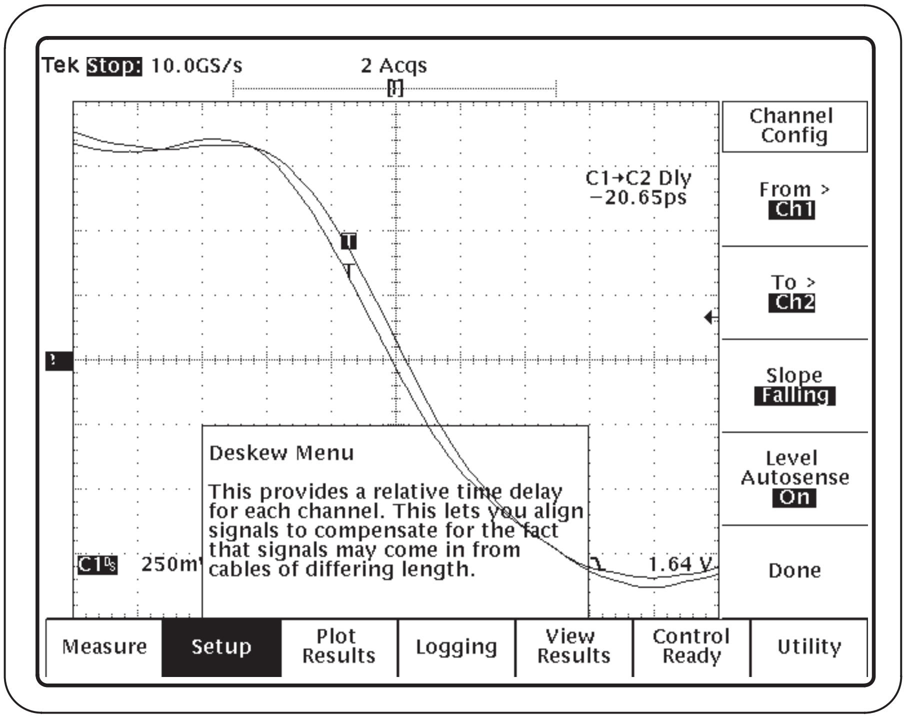


Figure 1–5: Example of a deskew configuration

10. Press Done (side).

11. To start the deskew utility, press Start Deskew (side).

The utility displays information as it deskews the channels, such as the number of samples processed and specified. Figure 1–6 shows an example of the information that displays.

Figure 1–7 shows an example of the utility when it is finished. In this example, the skew between channels 1 and 2 was reduced to 2.54 ps.

12. Press OK (side) to return to the Deskew menu.

13. Do not change the From channel and deskew channels 3 and 4.

***NOTE**. For information on one method that you can use to deskew single-ended probes relative to differential probes, refer to* Appendix D: Deskewing with a Math1 Waveform.

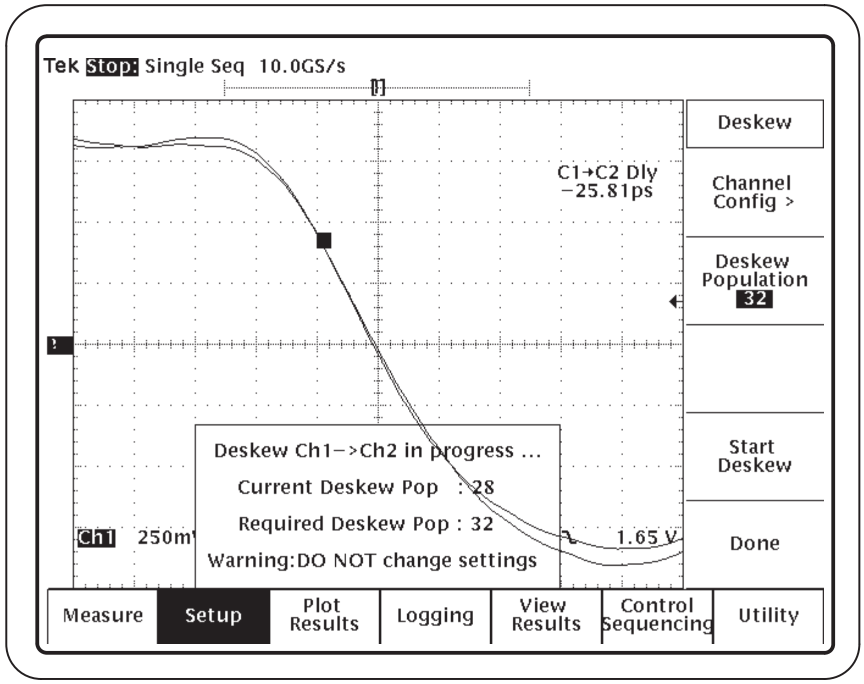


Figure 1–6: Deskewing in process

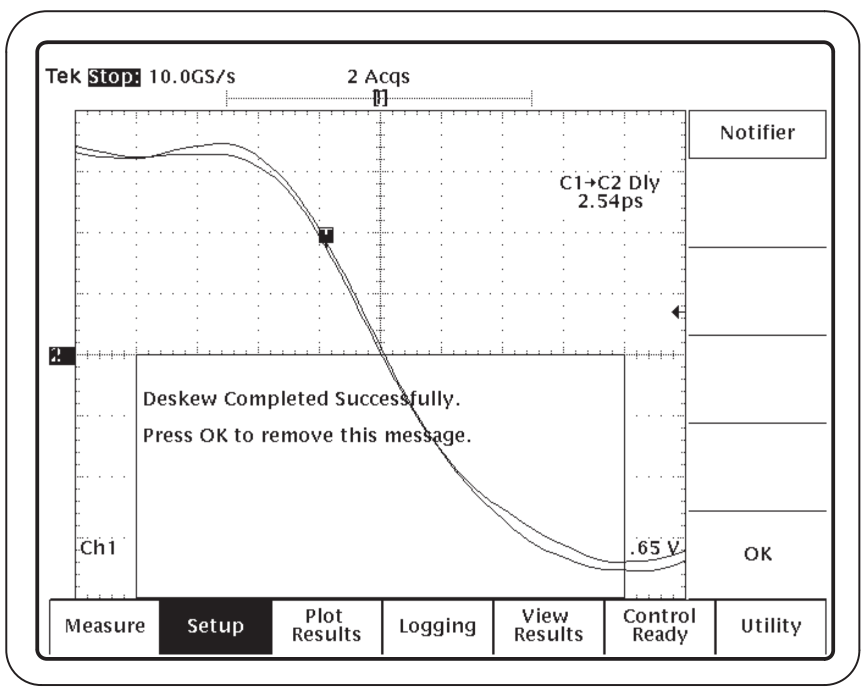


Figure 1–7: Deskew complete

14. Press Done (side) to return to the Inputs menu.

15. Press Done (side) to return to the Setup menu.

Connecting to a System Under Test

To connect the oscilloscope and TDSRBS1 application to a SUT, you will need the following items:

- Two P6248 Differential Probes
- Two P6249 Active Probes
- Four articulated arms, such as Tektronix PPM203Bs
- Probe accessories leadset, Tektronix part number 016-1780-00
- One circuit board mount frame
- Intense light source, such as a halogen lamp
- Head gear with magnifying lens

You can use other probes, but the P6248 probes and P6249 probes will provide the most accurate measurements.

To remove and set up the Rambus mother board, follow these steps:

1. Power off your SUT. It is not necessary to power off the oscilloscope.

CAUTION. *To prevent static damage, handle these components only in a static-free environment. Static discharge can damage the Rambus mother board and the probes.*

Always wear a grounding wrist strap, heel strap, or similar device while handling the Rambus mother board and the probes.

2. To discharge your stored static electricity, touch the Probe Compensation ground connector located on the front of the oscilloscope. Then, before you remove the probes from the protective bags they are shipped in, touch the bag to discharge stored static electricity from each probe.

3. Place the SUT on a horizontal static-free surface and remove the Rambus mother board.

4. Secure the mother board vertically in a circuit board mount frame on the horizontal static-free surface, as shown in Figure 1–8.

Figure 1–8: Setting up a Rambus mother board

5. Connect the power supply to the Rambus mother board.
6. Connect the hard disk drive or floppy disk drive to the mother board.
7. Connect the VGA cable to the mother board.
8. Power on the Rambus SUT, and verify that it operates properly.
9. Power off the SUT.

To connect the P6248 and P6249 probes between the SUT and oscilloscope, follow these steps:

1. Insert the solid probe tips and pogo ground probe tips from the probe accessories leadset into the end of the probes as shown in Figure 1–9.

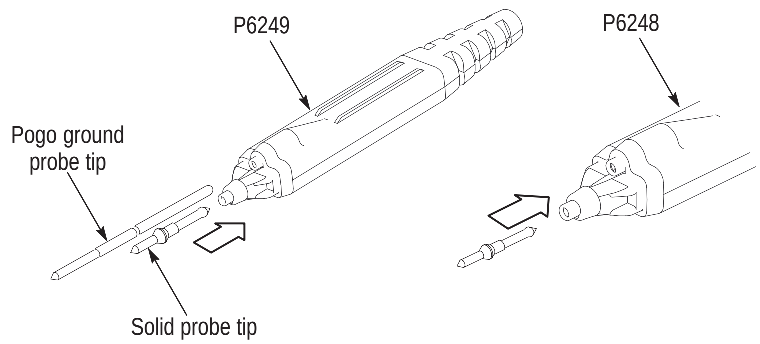


Figure 1–9: Preparing probes

2. For each probe, take a matching pair of the colored plastic clips and place the clip on each end of the probe cable.
3. Connect the probes to the oscilloscope as shown in Figure 1–10.

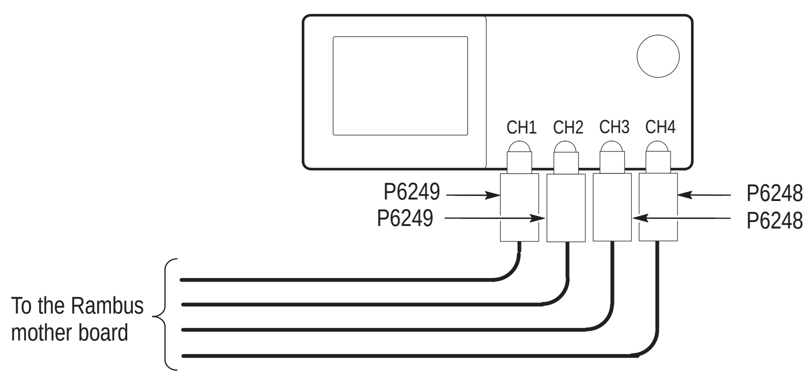


Figure 1–10: Connecting probes to the oscilloscope

4. Use an intense light source and magnifying lens to locate the points of contact to the signals on the back of the mother board. See Table 1–1.

Table 1–1: Channel and Rambus signal mapping

Channel	Rambus signal	Channel	Rambus signal
Ch 1	A data signal at the MCH	Ch 3	Clock signal at the MCH
Ch 2	Same data signal at the RIMM	Ch 4	Clock signal at the RIMM

5. Position the articulated arms, evenly spaced, around the center of the memory sockets.

6. Match the clip colors on the probe cables to the corresponding points of contact, and secure the probes in the articulated arms.

7. For Write cycle analysis, match the + and – indicators on the P6248 probe tips to the corresponding indicators on the CFM Clock signals; use the dials on the articulated arms to firmly position the probe tips on the contact points.

   Figure 1–11 shows the CFM and CTM signal contact points on the RIMM connectors on the back of a Rambus mother board.

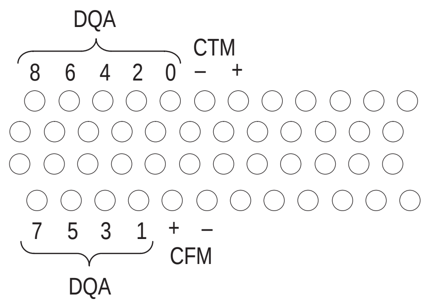


Figure 1–11: Clock signal contact points on RIMM connector, back of board

   For Read cycle analysis, remove the P6248 probe tip from the articulated arms, rotate the probe 180 degrees and match the + and – indicators on the probe tips to the corresponding indicators on the CTM Clock signals; use the dials on the articulated arms to firmly position the probe tips on the contact points.

8. To probe at the RIMM, for each P6249 probe, align the solid probe tips to the desired data signal and identify the nearest ground run that the pogo ground tip can easily reach.

CAUTION. *To prevent damage to the Rambus mother board, be careful when removing insulation from any MCH signal path run in the BGA area. Removing too much insulation can permanently damage the MCH signal paths.*

9. To probe at the 82820 MCH, use a sharp tool and gently scrape a little insulation from the signal path run in the BGA area. Figure 1–12 shows the location of the CFM clock signals (used for Write cycle analysis) and CTM clock signals (used for Read cycle analysis) of the 82820 MCH in the BGA area on the back of the Rambus mother board.

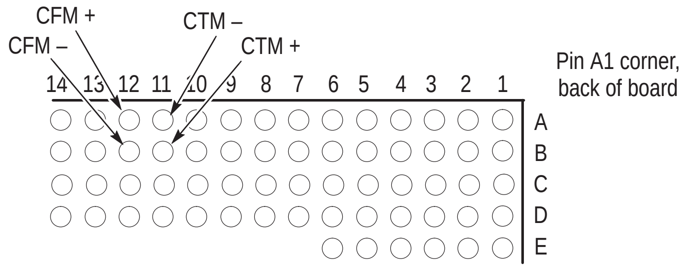


Figure 1–12: Clock signal contact points on the 82820 MCH in the BGA area

10. Realign the solid probe tip to the data signal (see step 8) and the pogo ground probe tip to the exposed signal run; use the dials on the articulated arms to firmly position the probe tips on the contact points.

Figure 1–13 shows an example of the probes positioned on a Rambus mother board.

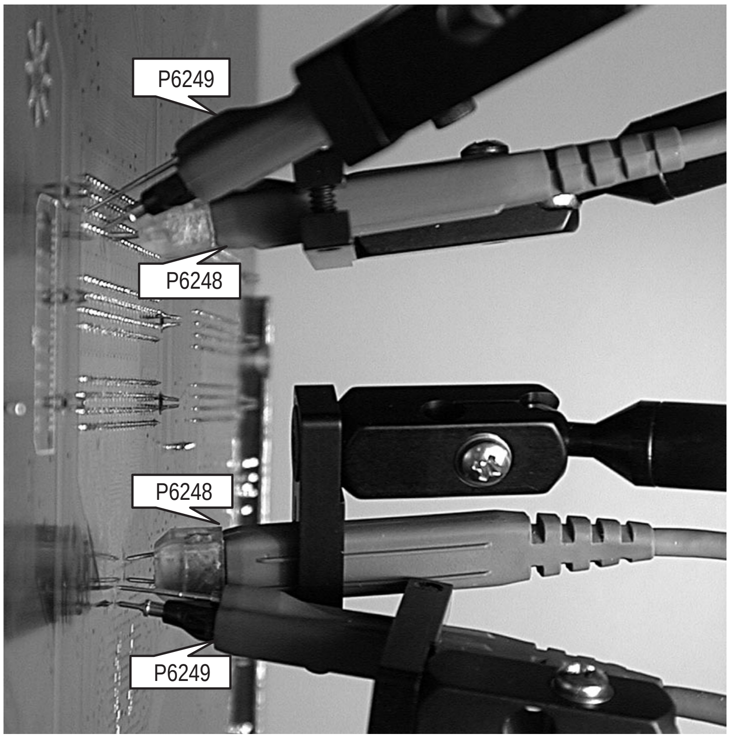


Figure 1–13: Probes positioned on a Rambus mother board

Figure 1–14 shows a view of the Rambus SUT set up for the application.

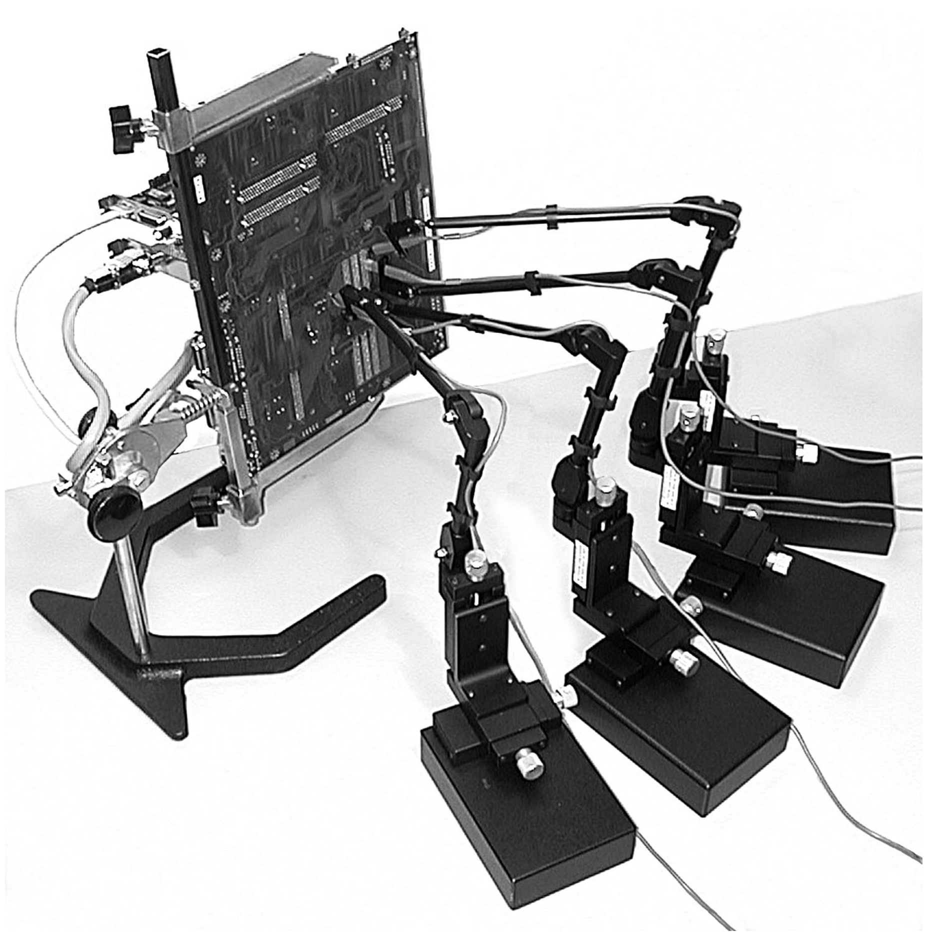


Figure 1–14: Overall view of the TDSRBS1 setup

To apply power and acquire data, follow these steps:

1. Power up the SUT.
2. Set the oscilloscope to acquire data at 10 GS/s.
3. Set the record length to 50 K or less.

***NOTE**. Do not take any TDSRBS1 measurements until you can verify that the SUT is set up and operating properly.*

4. To verify that the Rambus signals are present, select Control (main) ➞ Mode Free Run (side) and then Start (side). Figure 1–15 shows the display of waveforms from a SUT that is set up and operating properly.

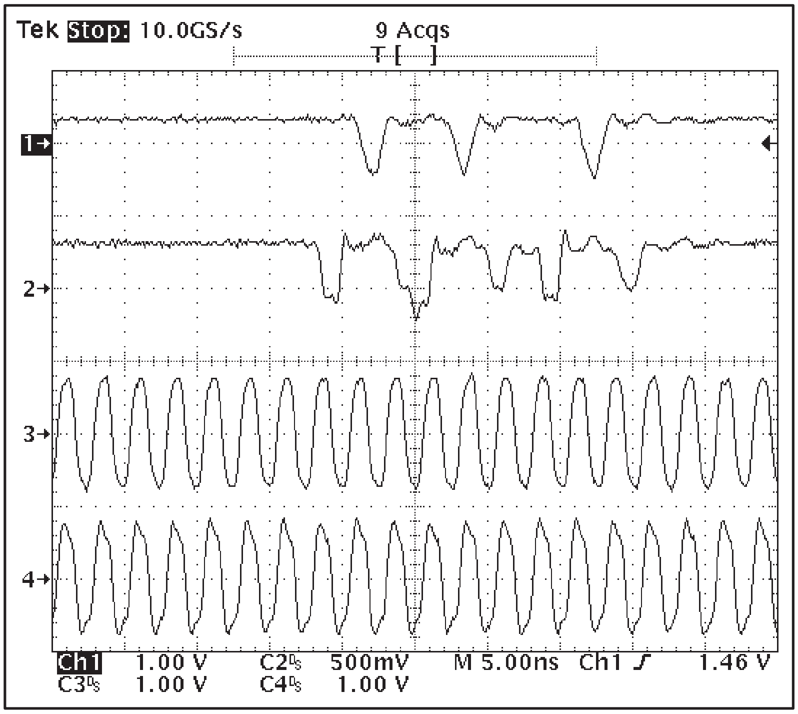


Figure 1–15: Waveforms from a SUT that is set up and operating properly

5. Press Stop (side).

If the display of Rambus waveforms on your oscilloscope does not appear similar to that shown in Figure 1–15, try the following solutions:

a. Check all the probe contacts.

b. Verify that channels 1 through 4 are visible on the oscilloscope.

c. On the oscilloscope, set the Trigger mode to AC Line and set the acquisition mode to Free Run. Gently rock each probe connector on the contact points until a signal displays.

d. Verify that the SUT is powered on, booted and is operating properly.

e. Ensure that the single-ended probes are well grounded.

After you have verified that your SUT is set up and operating properly, you should deskew the probes and oscilloscope channels as described in *Deskewing the Probes and Channels* on page 1–4, and then set up the application to take Rambus measurements.

Operating Basics

Basic Operations

This section contains information on the following topics and tasks:

- Application menu structure
- Using basic oscilloscope functions
- Warning messages
- Configuring the display
- Rambus terms
- Understanding measurement points
- Understanding measurement patterns
- Setting up the application
- Taking measurements
- Storing the results to a data log file
- Importing a data log file into a personal computer
- Viewing the results
- Saving and recalling setups
- Exiting the application

Application Menu Structure

There are two types of menus in the application menu structure: main menus and side menus. Some side menus contain common items as shown in Table 2–1.

Main and Side Menus

The main menu names appear in the bottom of the display, and the side menu names appear on the right side of the display. To see the complete application menu structure, refer to Figure 3–1 on page 3–1.

When you press the front-panel button associated with a main menu, the side menu changes. In many cases, when you press a side menu, new side menu items appear. As an example, the next figure shows you how to access the Help selections through the main Utility menu and the Help side menu.

Main menu	Side menu	Side menu item
Utility	Help	First Page Next Page Previous Page Last Page Quit Help

Common Menu Items

Table 2–1 lists common side menu items.

Table 2–1: Common menu items

Menu item	Description
Cancel	Cancels the message being displayed
Done	Indicates that you are through making changes to that set of side menus; the application returns to the previous menu
OK	Confirms an action
–more– x of y	Scrolls to another page of a menu where x is the current page and y is the total number of pages

Utility Menus

Table 2–2 lists the Utility menus.

Table 2–2: Utility menus

Utility name	Description
Help	Accesses the online help pages and displays useful information on the application
Exit	Exits the application
Display Options	Accesses other menus where you can change display settings, such as whether the dialog box is opaque or transparent
Save/Recall Setup	Accesses the save and the recall menus for application setups

Using Basic Oscilloscope Functions

You can use the Utility menu to access help information about the application. You can also use other oscilloscope functions and easily return to the application.

Using Local Help

The application includes local help information about the measurements modes, with some explanation of the individual controls.

To display the local help, follow these steps:

1. Press Utility (main) ➞ Help (side).

2. Use the side menu buttons to navigate through the help.

Returning to the Application

You can easily switch between the TDSRBS1 application and other oscilloscope functions.

To access other oscilloscope functions, press the desired front-panel control. To return to the application, push the SHIFT and then the APPLICATION front-panel menu buttons as shown in Figure 2–1.

Push the SHIFT and then the APPLICATION button to return to the application.

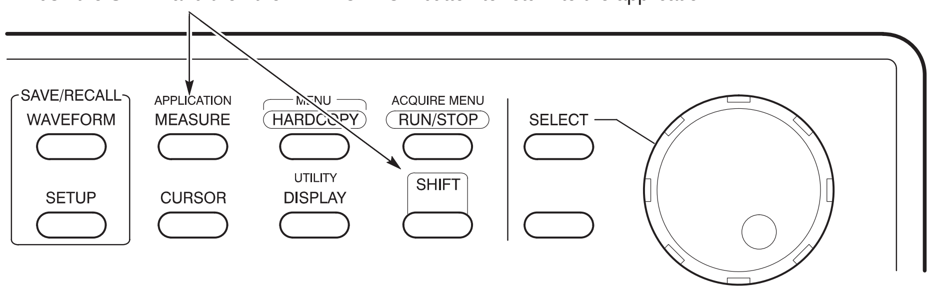


Figure 2–1: Returning to the application

Warning Messages

All timing measurements provide a warning if the input conditions do not support accurate measurements. For example, the Channel Error measurement warns you if you do not have at least a valid Clock signal and a clean 010 or 101 pulse transition.

Refer to *Appendix C: Error Codes*, for information on specific error codes and possible solutions.

Configuring the Display

You can change how dialog boxes appear on your oscilloscope, as well as the color of waveforms. The next figure shows how to access the Display Options menu, and Table 2–3 lists the options with a brief description of each.

Main menu	Side menu	Side menu item
Utility	Display Options	Dialog Box
		Box Position
		Box Style
		Color Theme
		Done

Table 2–3: Display Options menu selections

Option	Description
Dialog Box	Makes dialog boxes visible or invisible
Box Position	Positions the dialog box in the display
Box Style	Selects the style of dialog boxes to be Opaque or Transparent
Color Theme	Selects a set of colors for waveforms and dialog boxes; the application offers seven color themes

Rambus Terms

This manual contains the following Rambus system terms:

- MCH, an abbreviation for the Memory Controller Hub
- RIMM, an abbreviation for the Rambus Inline Memory Module
- Quiescent Time, the number of inactive clock cycles needed for the transmission line to be stable (no reflection) enough to take measurements
- Synthetic Clock, an imaginary clock signal whose frequency is double that of the external clock frequency. It is synchronized with the falling edge of the external clock and has a 50% duty cycle. All Rambus signals are synchronized with the falling edge of the synthetic clock.

Understanding Measurement Points

Before you set up the application, you should understand the points (relationships of the waveforms) used by the application to take measurements.

This information is provided as a courtesy by the Intel Desktop Products Group Analog Integrity Engineering team.

Table 2–4 shows the channel or reference memory to Rambus signal assignments.

Table 2–4: Channel or reference memory and Rambus signal assignments

Channel	Reference	Rambus signal
Ch 1	Ref 1	Data at the source, MCH
Ch 2	Ref 2	Data at the destination, RIMM
Ch 3	Ref 3	Clock at the MCH (CFM and CTM signals)
Ch 4	Ref 4	Clock at the RIMM (CFM and CTM signals)

Write Pulse Examples

In these examples, the Write cycle originates at the MCH and the destination is the RIMM. The application uses six points to determine various timing characteristics of a write pulse measurement.

High Write Pulse. Table 2–5 lists the measurement points and gives a description of each for a write even positive pulse measurement. The application looks for a logical data pattern of 101 for this type of measurement. Figure 2–2 shows the corresponding measurement points.

Table 2–5: Write even positive pulse measurement points

Point number	Description
T0	Rising edge of the data (1.4 V) at the source, MCH
T1	Falling edge of the clock (crossing) at the source, MCH
T2	Rising edge of the data (1.4 V) at the source, MCH
T3	Rising edge of the data (1.4 V) at the destination, RIMM
T4	Falling edge of the clock (crossing) at the destination, RIMM
T5	Falling edge of the data (1.4 V) at the destination, RIMM

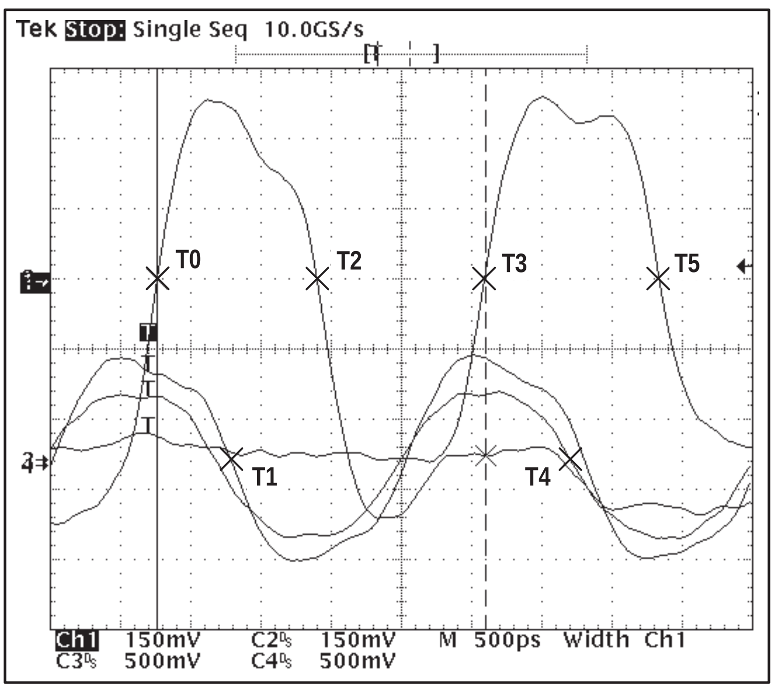


Figure 2–2: Write even positive pulse waveforms and measurement points

Table 2–6 lists the timing characteristic, the Rambus symbol for the characteristic, and the points used to take the measurement.

Table 2–6: Write even positive pulse timing characteristics

Characteristic	Symbol	Measurement points used by application
Setup time rising	Hp_tsr	T4–T3
Hold time falling	Hp_thf	T5–T4
Tq rising	Hp_tqr	625 ps – (T1–T0), where 625 ps is 1/4 of the bus clock frequency (~400 Mhz)
Tq falling	Hp_tqf	(T2 – T1) – 625 ps
Tq error	Hp_tqerr	(Hp_tqr + Hp_tqf) ÷ 2
Channel error rising	Hp_tcer	(T4 – T3) – (T1 – T0)
Channel error falling	Hp_tcef	(T5 – T4) – (T2 – T1)
Flight time rising	Hp_tfr	T3 – T0
Flight time falling	Hp_tff	T5 – T2
Flight time clock edge	Hp_tfck	T4 – T1

Low Write Pulse. Table 2–7 lists the measurement points and gives a description of each for a write even negative pulse measurement. The application looks for a logical data pattern of 010 for this type of measurement. Figure 2–3 shows the corresponding measurement points.

Table 2–7: Write even negative pulse measurement points

Point number	Description
T0	Falling edge of the data (1.4 V) at the source, MCH
T1	Falling edge of the clock (crossing) at the source, MCH
T2	Rising edge of the data (1.4 V) at the source, MCH
T3	Falling edge of the data (1.4 V) at the destination, RIMM
T4	Falling edge of the clock (crossing) at the destination, RIMM
T5	Rising edge of the data (1.4 V) at the destination, RIMM

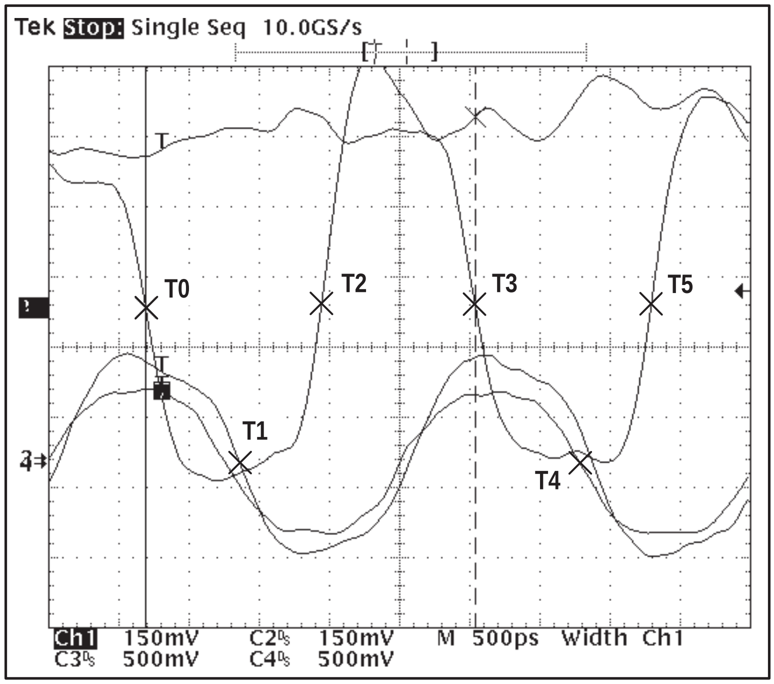


Figure 2–3: Write even negative pulse waveforms and measurement points

Table 2–8 lists the timing characteristic, the Rambus symbol for the characteristic, and the points used to take the measurement.

Table 2–8: Write even negative pulse timing characteristics

Characteristic	Symbol	Measurement points used by application
Setup time falling	Lp_tsf	T4–T3
Hold time rising	Lp_thr	T5–T4
Tq falling	Lp_tqf	625 ps – (T1–T0), where 625 ps is 1/4 of the bus clock frequency (~400 Mhz)
Tq rising	Lp_tqr	(T2 – T1) – 625 ps
Tq error	Lp_tqerr	(Lp_tqr + Lp_tqf) ÷ 2
Channel error falling	Lp_tcef	(T4 – T3) – (T1 – T0)
Channel error rising	Lp_tcer	(T5 – T4) – (T2 – T1)
Flight time falling	Lp_tff	T3 – T0
Flight time rising	Lp_tfr	T5 – T2
Flight time clock edge	Lp_tfck	T4 – T1

Read Pulse Examples

In these examples, the Read cycle originates at the RIMM and the destination is the MCH. The application uses six points to determine various timing characteristics of a read pulse measurement.

A Read cycle is like an RDRAM device write cycle except it is initiated at the mid-transmission line. Write cycles are initiated at the MCH.

A signal injected in the mid-transmission line sees two parallel 27 ohm loads: one going to the termination and the other going to the MCH. The RDRAM device views this as a 14 ohm load which causes the Read cycle signal to swing about 1.6 V instead of the 1.4V swing of a Write cycle.

In addition, it is extremely difficult to generate predictable and detectable pulse transmissions at the RDRAM devices. Because of this, effective analysis of timing at the signal source (which is needed for Read Cycle Channel Errors) is diminished.

Since it is extremely difficult to characterize the source pulse during a Read cycle, some measurements are not made available through the TDSRBS1 menu structure. However, the Tq rising, Tq falling, TQ error and Channel error measurements are still available through remote GPIB commands. Refer to the *GPIB Program Example* description on page 2–43 and to *Appendix B: GPIB Command Syntax* for more information.

High Read Pulse. Table 2–9 lists the measurement points and gives a description of each for a read even positive pulse measurement. The application looks for a logical data pattern of 101 for this type of measurement. Figure 2–4 shows the corresponding points.

Table 2–9: Read even positive pulse measurement points

Point number	Description
T0	Rising edge of the data (1.6 V) at the source, RIMM
T1	Falling edge of the clock (CFM crossing) at the source, RIMM
T2	Falling edge of the data (1.6 V) at the source, RIMM
T3	Rising edge of the data (1.4 V) at the destination, MCH
T4	Falling edge of the clock (CFM crossing) at the destination, MCH
T5	Falling edge of the data (1.4 V) at the destination, MCH

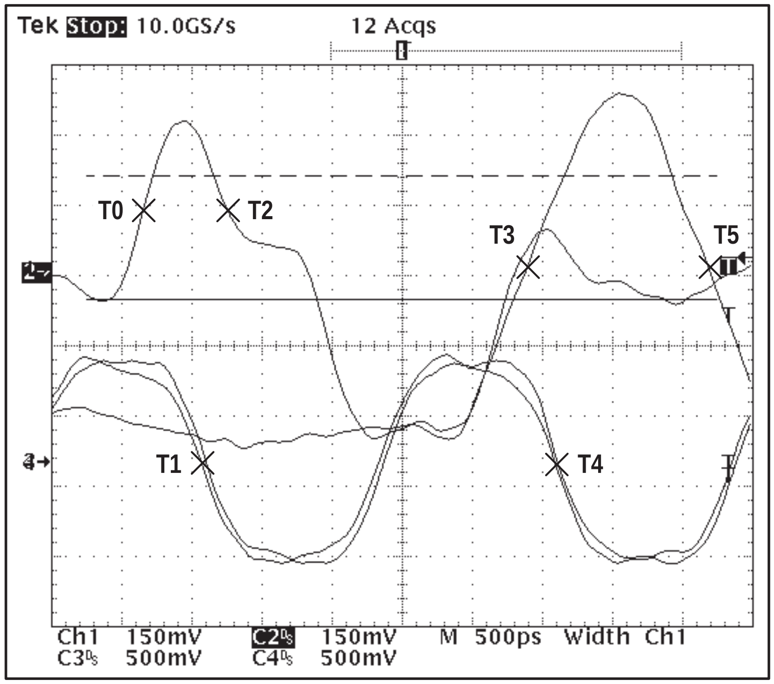


Figure 2–4: Read even positive pulse waveforms and measurement points

Table 2–10 lists the timing characteristic, the Rambus symbol for the characteristic, and the points used to take the measurement.

Table 2–10: Read even positive pulse timing characteristics

Characteristic	Symbol	Measurement points used
Setup time rising	Hp_tsr	T4–T3
Hold time falling	Hp_thf	T5–T4
Tq rising*	Hp_tqr	625 ps – (T1–T0), where 625 ps is 1/4 of the bus clock frequency (~400 Mhz)
Tq falling*	Hp_tqf	(T2 – T1) – 625 ps
Tq error*	Hp_tqerr	(Hp_tqr + Hp_tqf) ÷ 2
Channel error falling*	Hp_tcef	(T4 – T3) – (T1 – T0)
Channel error rising*	Hp_tcer	(T5 – T4) – (T2 – T1)
Flight time falling	Hp_tff	T3 – T0
Flight time rising	Hp_tfr	T5 – T2
Flight time clock edge	Hp_tfck	T4 – T1

***Only available through remote GPIB execution of the application.**

Low Read Pulse. Table 2–11 lists the measurement points and gives a description of each for a read even negative pulse measurement. The application looks for a logical data pattern of 010 for this type of measurement. Figure 2–5 shows the corresponding points.

Table 2–11: Read even negative pulse measurement points

Point number	Description
T0	Falling edge of the data (1.6 V) at the source, RIMM
T1	Falling edge of the clock (CTM crossing) at the source, RIMM
T2	Rising edge of the data (1.6 V) at the source, RIMM
T3	Falling edge of the data (1.4 V) at the destination, MCH
T4	Falling edge of the clock (CTM crossing) at the destination, MCH
T5	Rising edge of the data (1.4 V) at the destination, MCH

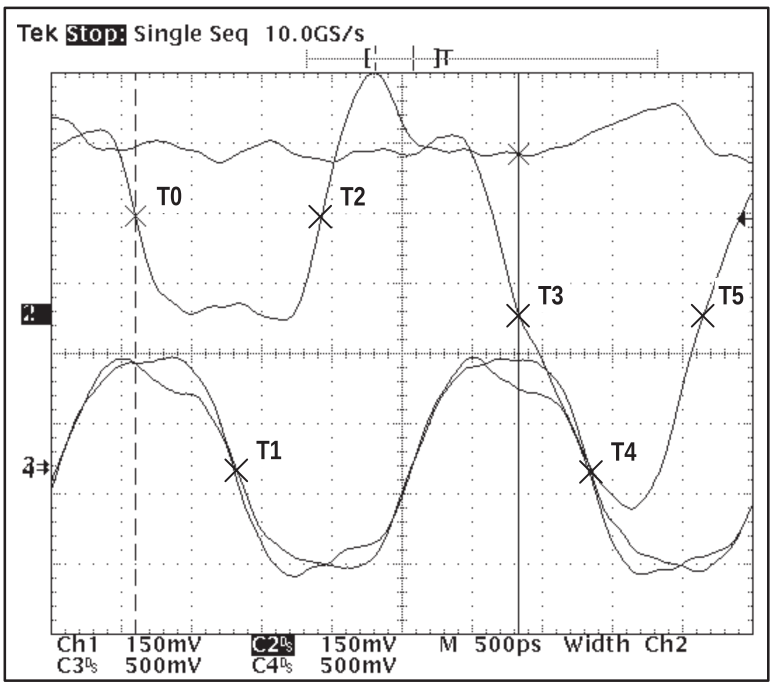


Figure 2–5: Read even negative pulse waveforms and measurement points

Table 2–12 lists the timing characteristic, the Rambus symbol for the characteristic, and the points used to take the measurement.

Table 2–12: Read even negative pulse timing characteristics

Characteristic	Symbol	Measurement points used by application
Setup time falling	Lp_tsf	T4–T3
Hold time rising	Lp_thr	T5–T4
Tq falling*	Lp_tqf	625 ps – (T1–T0), where 625 ps is 1/4 of the bus clock frequency (~400 Mhz)
Tq rising*	Lp_tqr	(T2 – T1) – 625 ps
Tq error*	Lp_tqerr	(Lp_tqr + Lp_tqf) ÷ 2
Channel error falling*	Lp_tcef	(T4 – T3) – (T1 – T0)
Channel error rising*	Lp_tcer	(T5 – T4) – (T2 – T1)
Flight time falling	Lp_tff	T3 – T0
Flight time rising	Lp_tfr	T5 – T2
Flight time clock edge	Lp_tfck	T4 – T1

***Only available through remote GPIB execution of the application.**

Understanding Measurement Patterns

The application takes measurements after it has located a specific pattern in the data. Table 2–13 lists these patterns with a brief description of each.

Table 2–13: Measurement patterns

Pattern	Description
010	Identifies a read or a write negative pulse
101	Identifies a read or a write positive pulse

Since these patterns occur in a pseudo-random fashion on a Rambus system operating normally, it can be useful to directly generate the patterns with pattern generation software. When you run a software generated pattern on the SUT and trigger the oscilloscope on the pattern, you benefit in two ways.

Triggering on a generated pattern saves time because the application does not have to wait long for a pattern to occur before taking measurements. If the pattern generation software can target specific Rambus memory devices (such as on a single RIMM socket), the application will obtain a narrower standard deviation which makes the results from the measurements more accurate and yields much finer timing characterization of individual memory components.

Setting Up the Application

You can set up the application to take timing measurements from the Rambus SUT and to display the results or save them to a data log file.

Measurement Selections

The next figure shows how to access the selections in the Measure menu, and Table 2–14 lists the measurements with a brief description of each.

Main menu | **Side menu**

Measure —
- Setup & Hold
- Rise Time
- Fall Time
- Flight Clock Edge
- Channel Error
- Flight Time
- Tq
- Tq (Error)

Table 2–14: Measure menu selections

Selection	Description
Setup and Hold	For Setup time, the elapsed time between when a data signal and its synchronizing clock signal crosses a voltage reference level followed by the synchronizing clock signal crossing its own voltage level For Hold time, the elapsed time between when the clock signal crosses a voltage reference level followed by an input signal crossing its own voltage level
Rise Time	Elapsed time from when a rising edge crosses the low reference voltage level and then the high reference voltage level
Fall Time	Elapsed time from when a falling edge crosses the high reference voltage level and then the low reference voltage level
Flight Clock Edge	Propagation delay between the source and destination
Channel Error	Difference in Flight time between the clock and data waveforms
Flight Time	Propagation delay between the source and destination of the data signal
Tq	Indicates the Timing Quality as how well the data is centered relative to the synthetic clock
Tq (Error)	Average of the TQ Rise Time and TQ Fall Time

***NOTE**. The application can take many measurements simultaneously and can display the results in various ways through the View Results menu. You can also select a specific measurement and graphically plot the results, or log the results to a file to view later on a personal computer.*

Configuring the Measurement

The next figure shows how to access the parameters in the Setup menu and Table 2–15 lists the setup parameters with a brief description of each.

Main menu **Side menu**

Setup
- Inputs
- Test Signal Configuration
- Clock Speed
- Limits
- Setup Summary

Table 2–15: Setup menu selections

Parameter	Description
Input	Sets up the waveform edge: source, level, hysteresis, VRefHigh, and VRefLow
Test Signal Configuration	Configures signal parameters: cycle, pulse, or data field
Clock Speed	Provides manual or autosense option for the frequency of the clock
Limits	Uses the default limits defined by the application or lets you edit the limits
Setup Summary	Displays complete measurement setup information in a scrollable dialog box

Inputs Menu. After you select a measurement, you must define the waveforms in the Inputs menu. The application uses these waveforms to take measurements.

***NOTE**. When you select a channel as an input, the application expects all inputs to be from channel "live"waveforms. When you select a reference memory as an input, the application expects all inputs to be from reference memory waveforms.*

The application takes Read cycle measurements from the following channel or reference memory waveforms:

- Rise Time and Fall Time measurements: Ch 1 or Ref 1
- All other measurements: Ch 2, Ch 3, Ch 4, Ref 2, Ref 3, or Ref 4

The application takes Write cycle measurements from the following channel or reference memory waveforms:

- Rise Time and Fall Time measurements: Ch 2 or Ref 2
- All other measurements: Ch 1, Ch 3, Ch 4, Ref 1, Ref 3, or Ref 4

The next figure shows how to access the parameters in the Input menu. Table 2–16 describes the selections in the Inputs menu and lists the input parameters with a brief description of each.

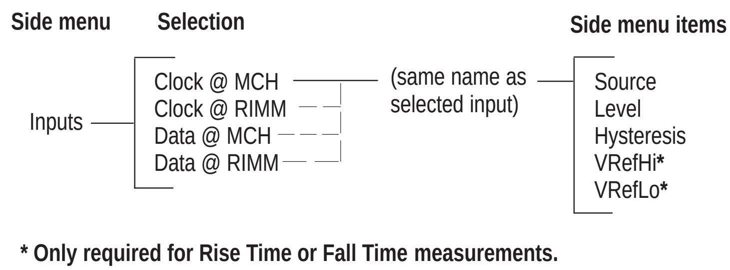


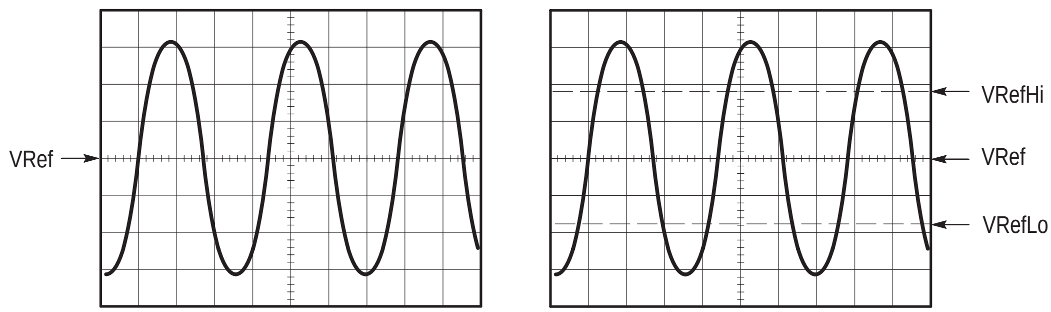
Table 2–16: Inputs menu selections and parameters

Selection	Description
Clock @ MCH	Clock waveform at the memory controller (MCH)
Clock @ RIMM	Clock waveform at the memory module (RIMM)
Data @ MCH	Data waveform at the memory controller (MCH)
Data @ RIMM	Data waveform at the memory module (RIMM)
Parameter	
Source	Selects an active waveform or a reference waveform as the data or clock source.
Level	Selects the level of the waveform on which to start the measurement.
Hysteresis	Selects the threshold margin, in percentage, relative to the reference level which the voltage must cross to be recognized as changing; the margin is the voltage reference level plus or minus half the hysteresis
VRefHi*	Specifies where on the slope, in Volts, to set the high threshold
VRefLo*	Specifies where on the slope, in Volts, to set the low threshold

*** Only required for Rise Time or Fall Time measurements; the deskew utility uses these values when Level Autosense is set to Off.**

***NOTE**. The application detects the minimum and maximum voltage levels of the waveform. If the reference voltage level plus or minus the hysteresis falls outside of 2.5% to 97.5% of the waveform peak-to-peak range, no measurement is taken, and an error message displays.*

The Setup and Hold, Flight Clock Edge, Channel Error, Flight Time, Tq, and Tq (Error) measurements require one voltage reference level to calculate the activity on the defined waveforms. The Rise Time and Fall Time measurements require two voltage reference levels. Figure 2–6 shows how to set the voltage reference levels.

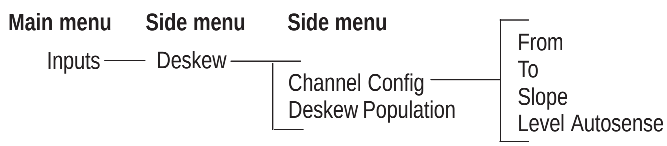


Setup and Hold, Flight Clock Edge, Channel Error, Flight Time, Tq, and Tq (Error)

Rise Time and Fall Time

Figure 2–6: How to set reference voltage levels

Deskew Menu. The next figure shows how to access parameters in the Deskew menu and Table 2–17 lists the setup parameters with a brief description of each.



***NOTE**. To deskew the probes and oscilloscope channels, refer to* Deskewing the Probes and Channels *starting on page 1–4.*

The deskew utility aligns the signal edges relative to the VRefHi and VRefLo values specified in the Inputs menu when you set Level Autosense to Off.

Table 2–17: Deskew menu selections

Parameter	Description
Deskew Population	Specifies the number of signal edges sampled by the deskew utility to determine the deskew value; more samples yield more accurate values, but also take the utility longer to process
From	Selects the reference point ("live" channels or Math1) to which the remaining channels (or the one specified) are deskewed; Math1 can be useful when deskewing single-ended probes relative to differential probes (refer to *Appendix D: Deskewing with a Math1 Waveform*)
To*	Selects the channel to deskew; includes All as a selection
Slope	Selects the edge of the signals to be deskewed; the Both selection splits the difference in the middle between the rising and falling edges and then centers the waveforms relative to each other
Level Autosense	Calculates the center point of the signals and uses that value as the voltage reference level; when set to Off, uses the VRefHi and VRefLo values

***The All selection allows you to use any channel in the From parameter; otherwise, the channel in the To parameter is excluded as a selection in the From parameter.**

Test Signal Configuration Menu. The next figure shows how to access the Test Signal Configuration selections and Table 2–18 describes each selection.

Side menu	Side menu item
Test Signal Configuration	Cycle Type Pulse Type Data Field Quiescent Time

Table 2–18: Test Signal Configuration menu selections

Selection	Description
Cycle Type	Specifies a Read or Write type of cycle
Pulse Type	Specifies a High (logic 0) or Low (logic 1) type of pulse
Data Field	Specifies an Even or Odd type of data field
Quiescent Time	Number of inactive clock cycles needed for the transmission line to be stable enough (free of reflection) to take measurements

Clock Speed Menu. The next figure shows how to access the Clock Speed selections and Table 2–19 describes each selection.

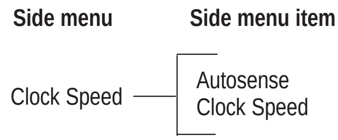
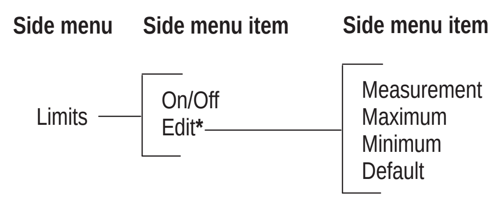


Table 2–19: Clock Speed menu selections

Selection	Description
Autosense	Application automatically senses the clock speed and uses that frequency; the application responds to a change of 10% or more in the base value of the clock frequency
Clock Speed	Specifies the frequency of the Clock signal; if you use the keypad to enter the frequency, be sure to also enter the units, such as Shift M for MHz

Limits and Limits Edit Menus. The next figure shows how to access the Limits menu and Limits Edit menu selections. Table 2–20 describes the editing selections.

When the Limits menu is enabled (set to On), the application uses the limits to alert you of a timing condition that is outside the valid limits range, either the default limits or those specified in the Limits Edit menu.



*** Limits must be set to On before you can edit the limits.**

Table 2–20: Limits Edit menu selections

Selection	Description
Measurement	Selects the measurement for which the values of the limits can be edited
Maximum	Specifies the value of the maximum limit for the Rambus Channel signals used in the selected measurement
Minimum	Specifies the value of the minimum limit for the Rambus Channel signals used in the selected measurement
Default	Sets the limits to default maximum and minimum values for the Rambus Channel signals for each TDSRBS1 measurement; see Table 3–7

When Limits is enabled (set to On), the Results Summary, accessed through View Results (main), displays Mean values that are color coded to indicate if the timing conditions were met. Table 2–21 lists the color code and describes what each color indicates.

Table 2–21: Color of Mean values when using Limits

Mean values color	Indicates
Green	Limits test is passing
Yellow	Limits test is passing but the Max or Min values are outside of the range
Red	Limits test is not passing

The Results Details, accessed through View Results (main), also displays PASS or FAIL in color next to the Mean values when Limits is enabled. Table 2–22 shows how the application uses the Mean values to determine what color to use to display PASS or FAIL.

Table 2–22: Color of PASS or FAIL when using Limits

Mean value color	Displays
Green	PASS in green
Yellow	PASS in yellow
Red	FAIL in red

Plot Results Setup

You can graphically plot the results for easier analysis. The next figure shows how to access the Plot Results menu and Table 2–23 describes each selection.

Main menu

Plot Results — Histogram / Profiling / Plot For

Table 2–23: Plot Results menu selections

Selection	Description
Histogram	A bar graph that represents the distribution of timing measurements
Profiling	A dot graph that represents consecutive values for each measurement
Plot For	Selects which measurement to plot from a list of activated measurements

NOTE. *When all four reference memory waveforms are in use, the results cannot be plotted; plots are stored in and use reference memories as display vehicles.*

The next figure shows how to access the graphical format parameters.

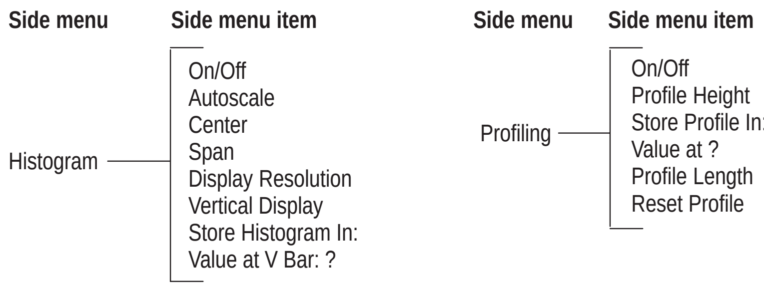


Table 2–24 lists parameters used to customize the Histogram plot graphical format with a brief description of each.

Table 2–24: Histogram menu selections

Parameter	Description
On/Off	Enables the results to be stored in a reference waveform.
Autoscale*	Determines optimum values for the Center and Span menu items.
Center	Uses the GP knob or keypad to specify a numeric value for the horizontal center position of the histogram.
Span	Uses the GP knob or keypad to specify a numeric value for the total horizontal range of the histogram.
Display resolution	Selects the resolution as defined by bins to be Low (20 bins), Medium (50 bins), or High (500 bins).
Vertical Display	Selects the vertical axis to be linear or logarithmic.
Store Histogram In	Selects a reference waveform in which to store the results.
Value at V Bar: ?	Uses vertical cursors to view vertical values.

***You must select On for Histogram and take a measurement before using Autoscale.**

Table 2–25 lists parameters used to customize the Profile plot graphical format with a brief description of each.

Table 2–25: Profiling menu selections

Parameter	Description
On/Off	Enables the results to be stored in a reference waveform
Profile Height	Selects the maximum number of vertical divisions for the Profile
Store Profile In:	Selects a reference waveform in which to store the results
Value at _ ?	Used to view vertical values by index number
Profile Length	Selects the record length of the profile in number of divisions
Reset Profile	Resets profile waveform results to zero

View Results Setup

You can view the numeric results in a variety of ways. The next figure shows how to access the View Results menu, and Table 2–26 describes each selection.

Main menu	Side menu
View Results	View Summary View Details Value At ? Wfm Association

Table 2–26: View Results menu selections

Selection	Description
View Summary	Displays a summary of the active measurements
View Details	Displays a scrollable dialog box that shows the statistical details for each of the selected measurements
Value At ?	Displays the result value at a specified point of the population used to take the measurement within the current acquisition
Wfm Association*	Displays the part of the waveform that corresponds with the Value At ?

*** Not available for Rise Time and Fall Time measurements.**

***NOTE**. When Limits is set to On, the Results Summary and Results Details display some values in color. Refer to Table 2–21 and Table 2–22 on page 2–18 for the meaning of the color.*

Taking Measurements

If you want to change trigger settings or localize the measurement, you should do so before you take any measurements. The application defaults to the reference voltage level as defined for the waveform source (refer to Table 2–16 on page 2–14).

***NOTE**. If you select a reference waveform as the source, you will need to display the waveform before a measurement can be taken. To display the waveform, press the MORE button and the appropriate main menu item.*

Remember to reset the result values (Control (main) → Reset Results (side) if you change the Vertical or the Horizontal time settings between measurements.

Acquiring Waveforms

To acquire waveforms, follow these steps:

1. Press Control (main). Table 2–27 lists selections in the Control menu.

Table 2–27: Control menu selections

Selection	Description
Mode	
Single	Searches for valid data patterns (up to ten times); when a valid pattern is found, performs the measurements on that acquisition and stops
Free Run	Repeatedly acquires and searches for a valid data pattern; when a valid pattern is found, performs the measurements, searches for another valid pattern, performs the measurements and continues until you press Pause or Stop
Start	The application starts to take measurements from the waveform(s)
Continue	When paused, the application continues taking measurements
Pause	The application pauses and resumes when you press Continue or stops when you press Stop
Stop	The application stops taking measurements
Reset Results	Resets all result values to zero

2. Press Mode (side) to select Single or Free Run acquisition mode.
3. Press Start (side).

***NOTE**. Do not change oscilloscope settings while a measurement is being taken. Doing so can cause an invalid measurement.*

Localizing Measurements

You can control the amount of data to measure by adjusting the Record Length, or the Trigger Position. By specifying the Trigger Position, the starting point, and the total length of the measurement, you can effectively size the area of interest.

***NOTE**. If an error message displays because there are not enough cycles from which to take a measurement, you should increase the Record Length.*

Saving the Results and Worst Case Waveforms

You can save the measurement results in a data log file. You can also save the worst case waveforms to a reference memory or in a file. The next figure shows the selections in the Logging menus, and Table 2–28 describes each selection.

Main menu **Side menu**

Logging
- Results
- Worst Case Wfms

Table 2–28: Logging menu selections

Selection	Description
Results	Saves the statistical results and the individual result points for all activated measurements to a data log file
Worst Case Wfms	Saves the acquired waveforms where the worst case (Min/Max) occurs; you can save worst case waveforms to a set of reference memories or to a set of files

The next figure shows how to access the Logging menus and associated parameters.

Side menu **Side menu item**

Results
- On/Off
- Store Results In:
- Clear Log File
- Select Drive

Side menu **Side menu item**

Worst Case Wfms
- On/Off
- Store Worst Case For
- Max/Min
- Store In
- Ref Base
- Filename

Table 2–29 lists the parameters in the Results Logging menu with a brief description of each.

Table 2–29: Results Logging menu selections

Parameter	Description
On/Off	Enables or disables the data log file; when enabled, stores the measurement results in a “comma separated variable” formatted file (.CSV file) that you can view on a personal computer
Store Results In:	Allows you to enter a name for the .CSV file
Clear Log File	Clears the data log file; you must disable the log file before you can clear its contents
Select Drive	Selects the drive on which the .CSV file will be stored; if you select the hard disk drive, the file will be stored in the hd0:/APP/TDSRBS1/TEMP directory

***NOTE**. If the disk is full or not present, the application displays an error message and stops taking measurements.*

Table 2–30 lists the parameters in the Worst Case Wfms Logging menu with a brief description of each.

Table 2–30: Worst Case Wfms Logging menu selections

Parameter	Description
On/Off	Enables the saving of worst case waveforms; see Table 2–28 for definition
Store Worst Case For	Selects the measurement from a list of activated measurements to store the worst case waveform for
Max/Min	Selects the type of worst case to save: maximum or minimum
Store In	Selects where to store the file: a reference memory, the floppy disk drive, or the hard disk drive
Ref Base*	Specifies the reference memory where the application will start to save the worst case waveforms; for example, if Ref2 is selected here and the selected measurement requires two waveforms, such as Setup and Hold, the worst case waveforms will be saved to Ref2 and Ref3
Filename**	Allows you to enter up to 3-characters for the .wfm file name; if you enter a name with more than 3 characters, it will be truncated because the application appends other information to the file name that relates to the Max/Min selection and input; if you select the hard disk drive, the file will be stored in the hd0:/APP/TDSRBS1/TEMP directory

*** Only available when Ref is selected in the Store In menu item.**

**** Only available when fd0 or hd0 is selected in the Store In menu item.**

***NOTE**. The longest record length that can be saved to a reference memory is 50K.*

Data Log File Format

The data log file contains three parts: a header row, statistical results, and individual result points. Figure 2–8 on page 2–25 shows an example.

The header row of the log file contains the application name, the version number of the application, and the date and time on which the file was created. For statistical results, the application updates the rows for all of the active measurements. For individual result points, the application appends rows of results to each active measurement.

***NOTE**. If you are using a GPIB program to execute the application, you can add your own annotation through the logAnnotate GPIB command. You can add information consisting of up to 20 characters; the custom information is added to the end of each result record.*

Importing a Data Log File to a Personal Computer

You can import the .CSV data log file (comma separated variable format) into a spreadsheet, database, or data analysis program on your personal computer for further analysis.

If you saved the data log file on the hard disk drive, you need to copy it to a floppy disk. To do so, follow these steps:

1. Insert a blank, DOS-formatted floppy disk into the floppy disk drive of the oscilloscope.
2. Copy the .CSV file from the hard disk drive to the floppy disk. For details on how to do this, refer to step 5 on page 2–39 in the *Tutorial* section.

To import a data log file to a personal computer, follow these steps:

1. Insert the floppy disk into the floppy disk drive on your personal computer.
2. Copy the .CSV file.
3. Open the file using a spreadsheet, database, or data analysis program.

Figure 2–8 shows an example of the .CSV file viewed in a spreadsheet program.

Viewing the Results

The application provides information on the variation of timing measurements as numerical values in a readout, or graphically in a Histogram or a Profiling format.

***NOTE**. Stop the acquisition before viewing the results in a graphical format if you are operating the oscilloscope in the Free Run acquisition mode.*

Figure 2–7 shows an example of the various results display formats.

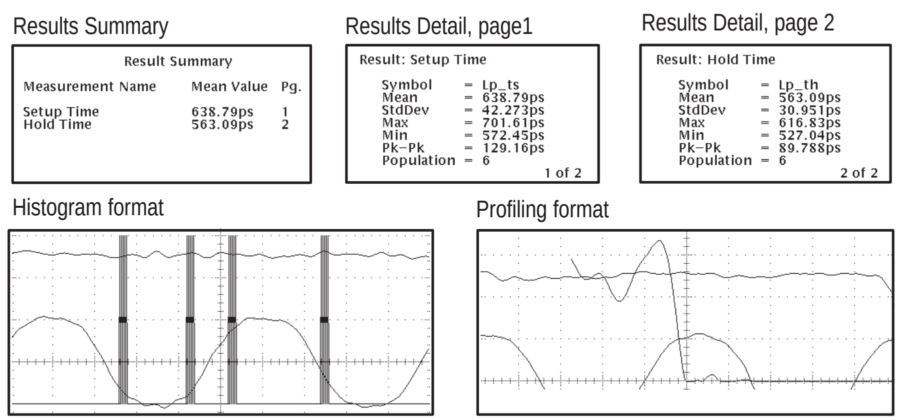


Figure 2–7: Example of the results and display formats

You can also log the data to a RESULTS.CSV file for viewing with a spreadsheet, database, or data analysis program on a personal computer. Figure 2–8 shows an example of how the RESULTS.CSV file might look in a spreadsheet.

TDSRBS1	Version 0.3	2000-02-29 "20:35:05"											
Result Type	Setup Time	Hold Time	Tq Rising	Tq Falling	Tq Error	Channel Error Rising	Channel Error Falling	Flight Time Rising	Flight Time Falling	Fall Time Data	Rise Time Data	Flight Time of Clock	
Mean	19.670ns	30.396ns	-1.2358ns	10.095ns	5.6656ns	-2.0900ns	-1.4844ns	121.81ns	125.39ns	3.6459ns	4.4729ns	123.90ns	
Std Dev	6.3299ns	12.708ns	3.6413ns	5.0416ns	4.3208ns	12.680ns	1.7047ns	12.863ns	957.76ps	1.0826ns	1.2975ns	953.17ps	
Maximum	30.016ns	38.266ns	4.0614ns	14.530ns	9.9970ns	3.3516ns	2.0175ns	128.35ns	128.14ns	8.9687ns	9.0312ns	126.33ns	
Minimum	12.839ns	-28.984ns	-5.4743ns	2.6133ns	-706.96ps	-56.545ns	-5.2415ns	69.788ns	123.57ns	1.0313ns	1.3229ns	122.33ns	
Peak Peak	17.177ns	67.250ns	9.5357ns	11.917ns	10.704ns	59.897ns	7.2590ns	58.563ns	4.5678ns	7.9375ns	7.7083ns	4.0000ns	
Population	212	212	212	212	212	212	212	212	212	1.4580k	1.6480k	212	
Serial No	Setup Time	Hold Time	Tq Rising	Tq Falling	Tq Error	Channel Error Rising	Channel Error Falling	Flight Time Rising	Flight Time Falling	Fall Time Data	Rise Time Data	Flight Time of Clock	Annotation
1	28.016ns	29.672ns	3.7466ns	2.9859ns	-380.34ps	2.1685ns	-248.44ps	127.37ns	125.45ns	4.4922ns	3.9896ns	125.20ns	setup1
2										3.0000ns	4.0000ns		setup1
3										3.1641ns	4.0078ns		setup1
4										3.0000ns	4.0000ns		setup1
5										4.0000ns	5.6563ns		setup1
6										4.4922ns	8.0104ns		setup1
7											5.0000ns		setup1

Figure 2–8: Example of data in a RESULTS.CSV file viewed in a spreadsheet program

Statistics

By default, the measurement displays the results as statistics. The statistics contains values for the mean, the standard deviation (StdDev), the peak-to-peak (Pk-Pk), the maximum (Max) and minimum (Min) values, and the population (the number of cycles used to calculate the values).

To view parts of the waveform that are obscured by the statistics, push the CLEAR MENU button. To return to the application, push the SHIFT then the APPLICATION front-panel menu buttons

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***NOTE**. To view the waveform and the results, you can adjust the placement of the statistics in the display through the Display Options side menu.*

The next figure shows how to make the statistics visible or invisible.

Main menu	Side menu	Side menu item
Utility	Display Options	Dialog Box: On/Off

Graphical Formats

There are two graphical formats available: Histogram or Profile.

Histogram To view the results in the Histogram format, press MORE → Ref# (main). Ref# is the reference waveform that you selected in the Store Histogram In menu item.

The horizontal axis (center and span) represents the measurement values and the vertical axis represents the number of times that the value occurred.

***NOTE**. Use the HORIZONTAL SCALE knob to adjust the horizontal scale of the waveform to fit the screen for proper viewing.*

Use the Autoscale function to set the optimum Center and Span values. You can use Autoscale only after taking measurements with Histogram On.

Profile. To view the results in the Profile format, press MORE → Ref# (main). Ref# is the reference waveform that you selected in the Target menu item.

The vertical axis represents the measurement value and the horizontal axis represents the index number of the measurement. This can be useful for observing the variation of a measurement.

Clearing Results

To reset the results to zero, press Control (main) → Reset Results (side). You do not have to wait for a measurement to complete to clear the results.

Saving and Recalling Setups

You can use the Save/Recall Setup menu to save and recall setups for both the application and the oscilloscope. The TDSRBS1 application Save/Recall function is totally independent of the primary oscilloscope Save/Recall function stored in nonvolatile RAM.

Oscilloscope setup files have a .set extension. Application setup files have a .ini extension, and the associated limits file has a .lim extension.

The next figure shows how to access the Save/Recall Setup menu.

Main menu	Side menu	Side menu item
Utility	Save/Recall Setup	Recall Setup Recall from File: Save Setup Save to File: Done

---

***NOTE**. Press Utility (main) → Save/Recall Setup (side) to access the menu items that you can use to save and to recall setup files.*

Saving a Setup

To save the application setup to the file displayed in the Save to File: menu item, press Save Setup (side).

To create a new file in which to save the application setup, follow these steps:

1. Press Save to File: (side).
2. Use the direction arrows and Delete Char (side) to clear the existing file name or part of the file name.
3. Use the General Purpose (GP) knob to select each character in the file name. Press Enter Char (side) after selecting each character.

   The file name can be up to eight characters long excluding the extension. The application automatically appends a .ini extension to the name.
4. Press OK Accept (side) to save the file name.
5. Press Save Setup (side) to store the application setup in the file just created.
6. Press Done (side).

Application setups are always saved in the APPS/TDSRBS1/TEMP directory (accessed through the File Utilities menu) on the oscilloscope. Once you have saved a setup, you must recall it to use it again.

Recalling a Setup

To recall the application settings from the Default setup file or from a saved setup file, follow these steps:

1. Press Recall from File: (side) until the desired setup file name displays.

NOTE. *The application starts with all parameters set to default values regardless of which setup file was last used.*

2. Press Recall Setup (side).
3. Press Done (side).

Exiting the Application

To exit the application, press Utility (main) ➞ Exit (side). To confirm, press OK (side).

Tutorial

This tutorial teaches you how to set up, take two types of measurements, and view the results in the various formats. Further operating information is located in the *Operating Basics* section.

Before you begin the tutorial, you must do the following tasks:

- Set up the oscilloscope
- Start the application
- Load the reference waveforms

Setting Up the Oscilloscope

To set up the oscilloscope, follow these steps:

1. Press SETUP → Recall Factory Setup (main) → OK Confirm Factory Init (side) to set the oscilloscope to the default factory settings.
2. Press the WAVEFORM OFF button as often as necessary to remove active waveforms.

Starting the Application

To perform these lessons, the TDSRBS1 application must be installed on the oscilloscope. See *Installation* on page 1–3.

To start the application, refer to Figure 2–9, and follow these steps:

1. Press SETUP → Select Application (main).
2. Use the general purpose (GP) knob to select hd0: and press SELECT.
3. Use the GP knob to select the TDSRBS1.APP file and press Activate Application (side).

The application starts up and displays as shown in Figure 2–10.

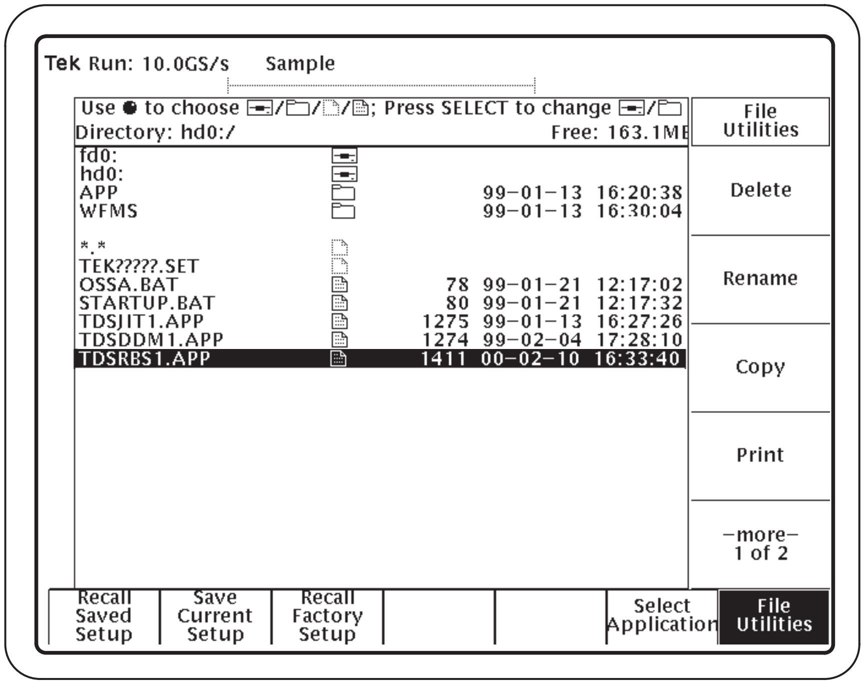

Figure 2–9: Starting the application

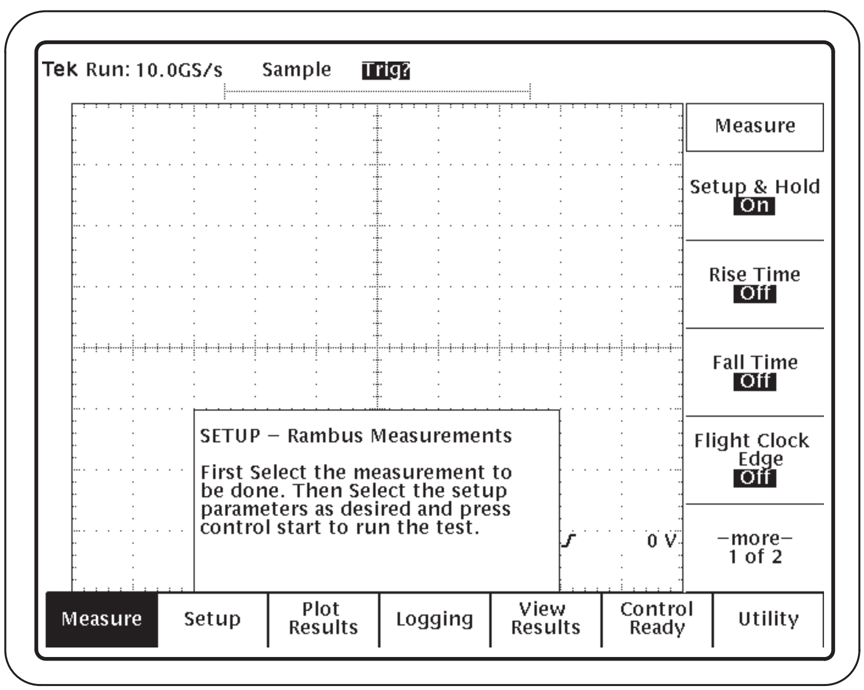

Figure 2–10: TDSRBS1 application initial display

Loading the Reference Waveform Files

The application includes four reference waveform files for use with this tutorial. Table 2–31 shows the types of signals that these waveforms represent.

Table 2–31: Reference waveforms and Rambus signal types

Reference	Waveform name	Signal type
Ref1	RBRef1.wfm	Data signal at the MCH
Ref2	RBRef2.wfm	Corresponding data signal at the RIMM
Ref3	RBRef3.wfm	Clock signal at the MCH
Ref4	RBRef4.wfm	Clock signal at the RIMM

NOTE*. You do no need to load Ref1 and Ref3 until the second tutorial lesson.*

To load Ref2 and Ref4, follow these steps:

1. Press WAVEFORM ➞ Recall Wfm to Ref (main) ➞ Recall from file (side).
2. Use the general purpose (GP) knob to select hd0: and press SELECT.
3. Use the GP knob to select WFMS and press SELECT.
4. Use the GP knob to select RBREF2.WFM; press To Ref 2 active/empty (side).
5. Press Recall from file (side).
6. Use the GP knob to select RBREF4.WFM; press To Ref 4 active/empty (side).
7. Press Recall from file (side).
8. Press MORE ➞ Ref2 (main) to display the RBREF2 waveform, a data signal at the RIMM.
9. Use the Shift/Horizontal Position knob to quickly move the waveform horizontally and locate the first falling edge. Then, use the Vertical Position knob to move the waveform vertically in the display as shown in Figure 2–11.
10. Press Ref4 (main) to display the RBREF4 waveform, a clock signal at the RIMM.

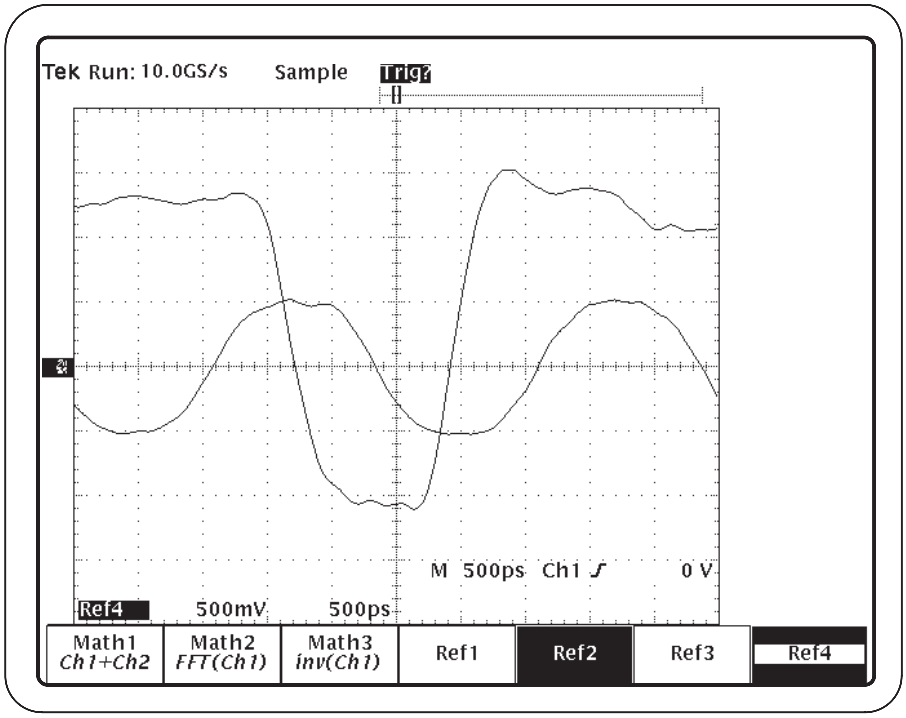

Figure 2–11: Display of the Ref2 and Ref4 waveforms

11. Press the SHIFT, and then the APPLICATION front-panel menu button to return to the application.

Taking Setup Time and Hold Time Measurements

In this example, you will learn how to use the application to calculate the delay between two sources as defined by two individual reference voltage levels.

To become familiar with the Setup and Hold measurement, follow these steps:

1. Press Measure (main) ➞ Setup & Hold (side) to select On.
2. Press Setup (main) ➞ Inputs (side).
3. Press Clock @ RIMM (side) and select Ref4 as the Source. See Figure 2–12.

***NOTE**. When you select a reference memory as an input, the application changes all the inputs to the appropriate reference memory waveforms.*

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4. Press Done (side).

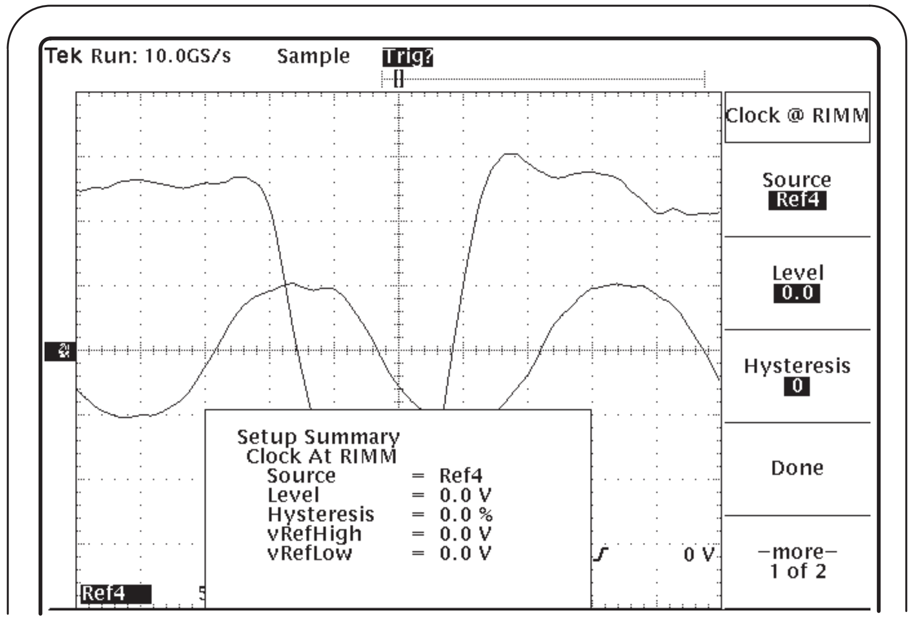

Figure 2–12: Inputs menu, Ref4

5. Press Clock Speed (side) ➞ Autosense (side) to select Off. See Figure 2–13.
6. Press Done (side).

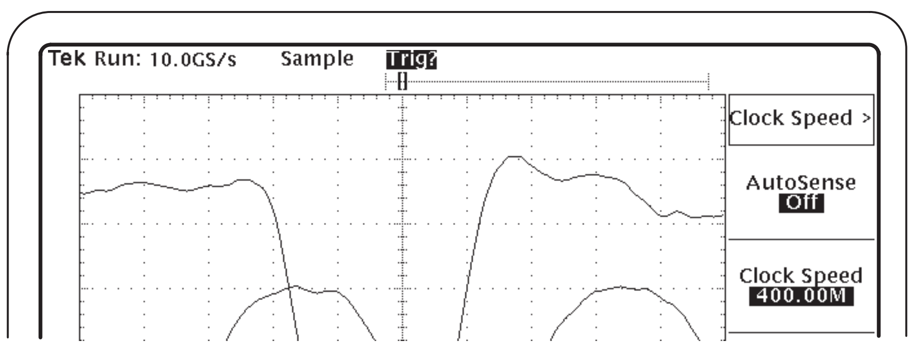

Figure 2–13: Clock Speed menu

7. Press Test Signal Configuration (side). This lesson uses the default selections as shown in Figure 2–14. Press Done (side).

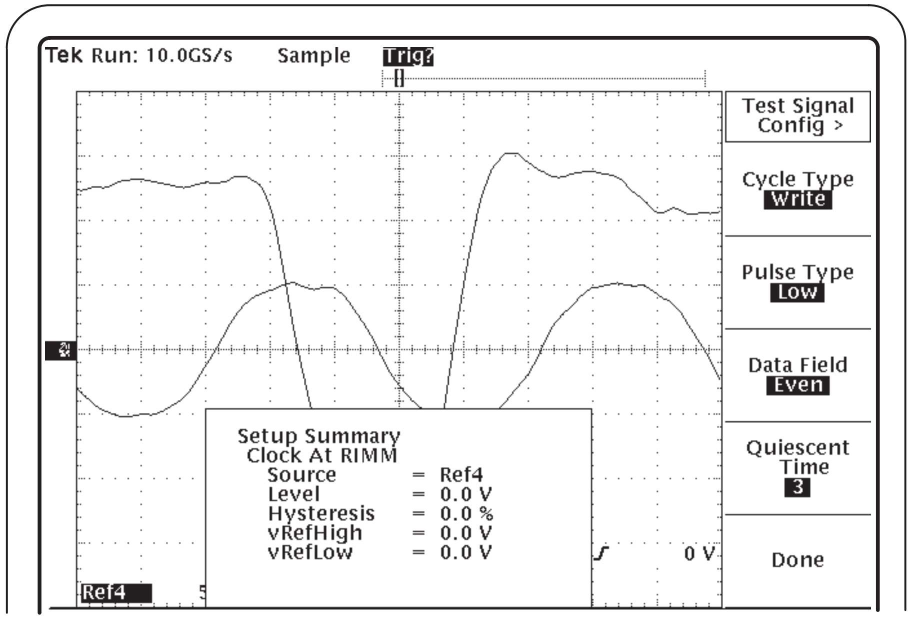

Figure 2–14: Test Signal Configuration menu, default selections

8. To view a summary of the setup, press Setup Summary (side). Figure 2–15 shows part of the Setup Summary for the Setup and Hold measurement. You can use the GP knob to scroll through the entire summary.

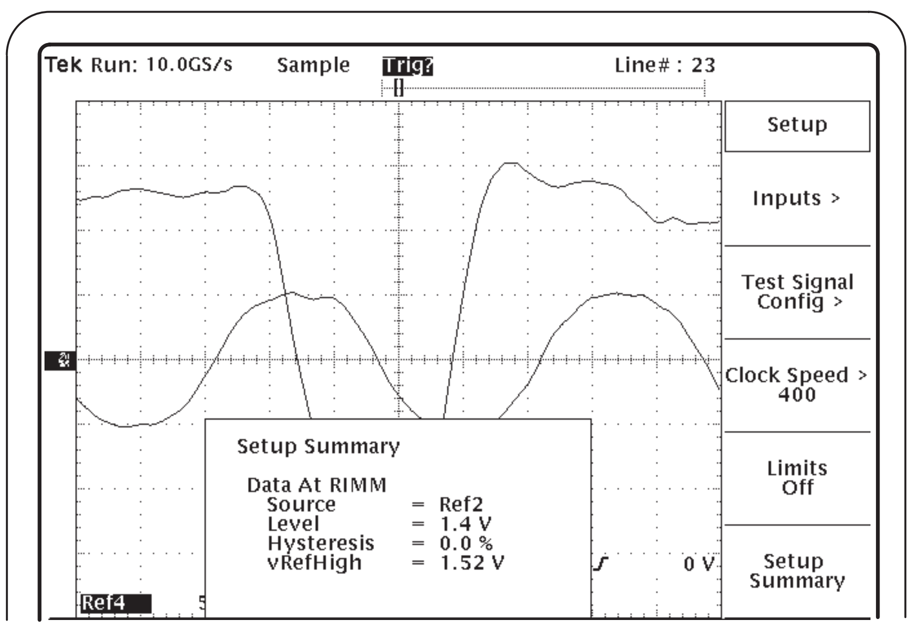

Figure 2–15: Setup Summary menu; use the GP knob to scroll the summary

9. To take the measurement, press Control (main) ➞ Start (side).

NOTE*. When the input is a reference waveform, the measurement performs a single measurement cycle regardless of the acquisition mode.*

The Control menu (main) displays Control Sequencing while the application is executing. When the Control menu displays Control Ready, the application has completed the calculations.

10. Wait for the calculations to complete. Figure 2–16 shows the results.

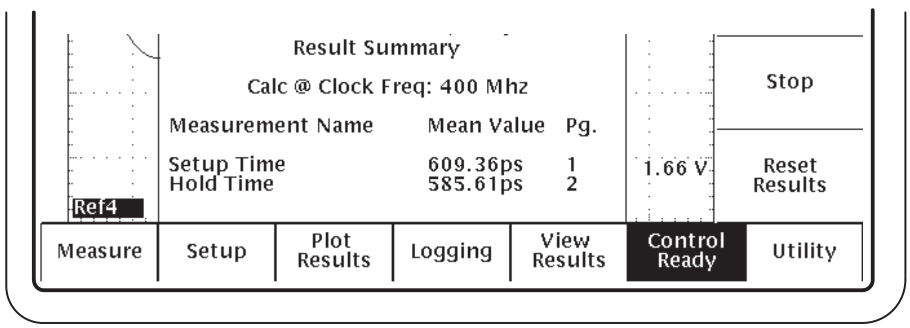

Figure 2–16: Setup Time and Hold Time lesson: Result Summary readout

11. Press View Results (main) ➞ View Details (side).

Figure 2–17 shows the Results Details for Setup Time. Use the GP knob to scroll to the next page to see the Hold Time details (shown in Figure 2–18).

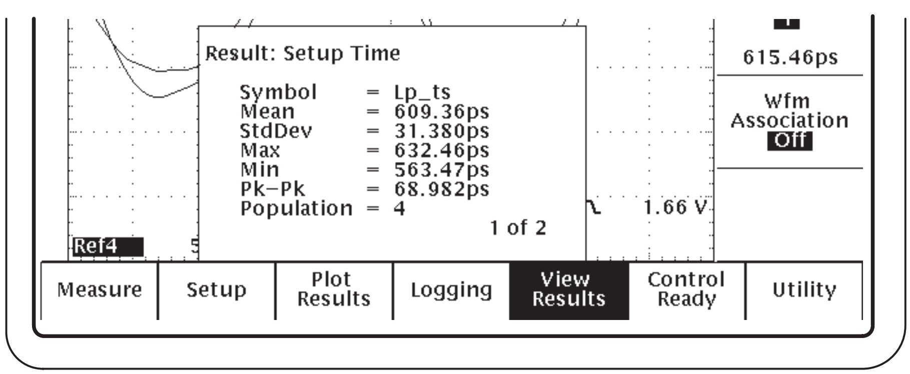

Figure 2–17: View Details shows the statistical values for Setup Time

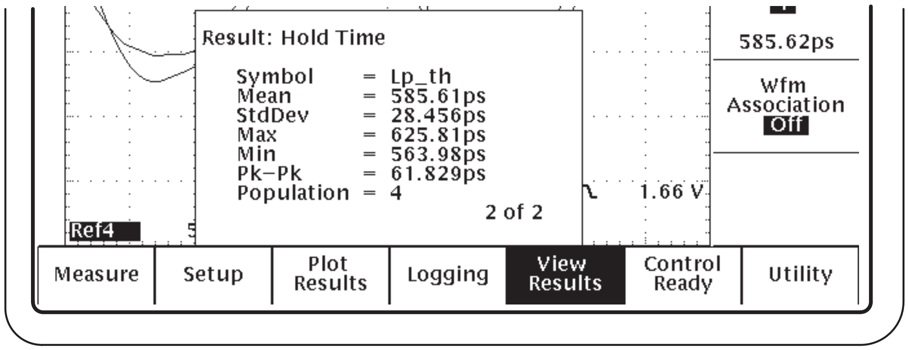

Figure 2–18: View Details shows the statistical values for Hold Time

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NOTE*. When the application uses reference memory waveforms to take measurements, the results cannot be plotted as a Histogram or as a Profile.*

Taking Measurements from Four Waveforms

In this example, you will learn how to use the application to calculate the Channel Error on Rambus signals. You will use four reference memory waveforms, two from the previous lesson (Ref2 andf Ref4) and two more. To load Ref1 and Ref3, follow these steps:

1. Press WAVEFORM ➞ Recall Wfm to Ref (main) ➞ Recall from file (side).
2. Use the general purpose (GP) knob to select hd0: and press SELECT.
3. Use the GP knob to select WFMS and press SELECT.
4. Use the GP knob to select RBREF1.WFM; press To Ref 1 active/empty (side).
5. Press Recall from file (side).
6. Use the GP knob to select RBREF3.WFM; press To Ref 3 active/empty (side).
7. Press Recall from file (side).
8. Press MORE ➞ Ref1 (main) to display the RBREF1 waveform, a data signal at the MCH.
9. Press Ref3 (main) to display the RBREF3 waveform, a clock signal at the MCH.

Figure 2–19 shows the display of the Ref1, Ref2, Ref3, and Ref4 waveforms.

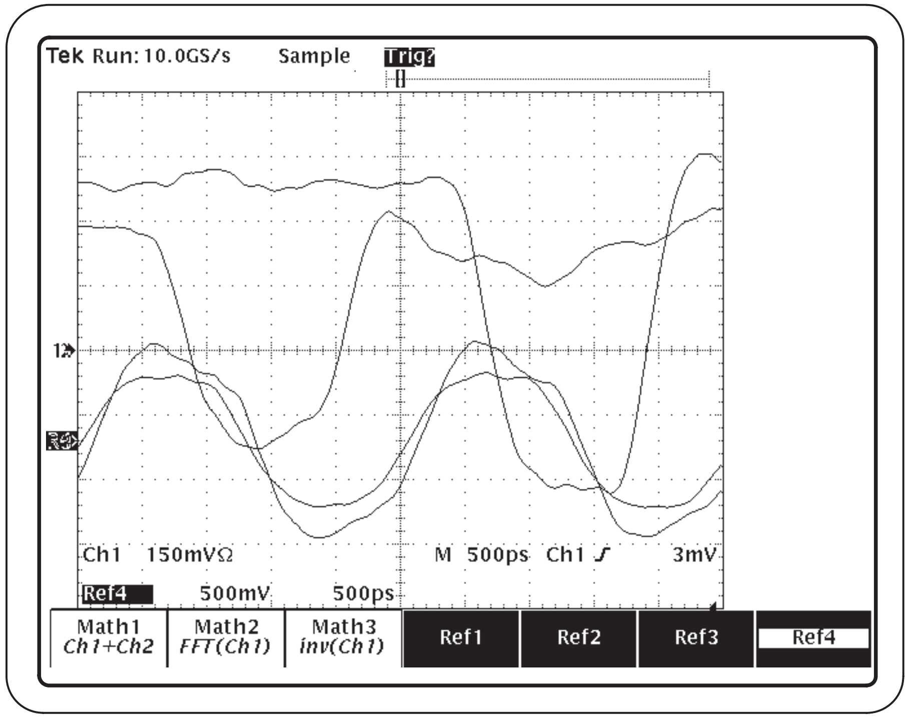


Figure 2–19: Display of Ref1, Ref2, Ref3, and Ref4 waveforms

10. Press the SHIFT, and then the APPLICATION front-panel menu button to return to the application.

To become familiar with the Channel Error measurement, follow these steps:

1. Press Measure (main) ➞ Setup & Hold (side) and select Off.

2. Press –more– 1 of 2 (side) ➞ Channel Error (side) and select Falling.

3. Press Setup (main) ➞ Inputs (side).

4. Press Clock @ MCH (side) and select Ref3.

***NOTE**. When you select a reference memory as an input, the application changes all the inputs to the appropriate reference memory waveforms.*

---

5. Press Done (side).

6. To take the measurement, press Control (main) ➞ Start (side).
7. Wait for the calculations to complete. Figure 2–20 shows the Result Summary readout.

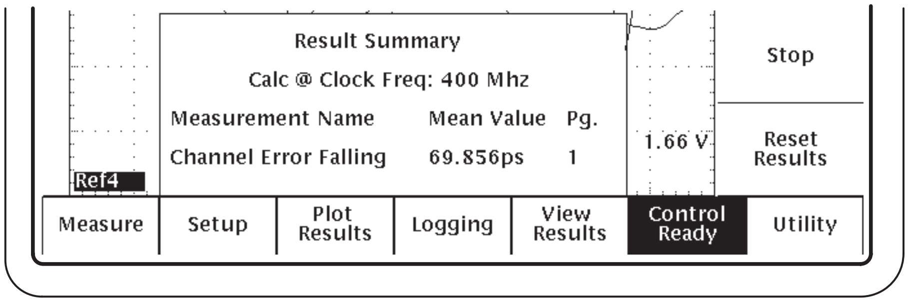


Figure 2–20: Channel Error lesson: Result Summary readout

8. Press View Results (main) ➞ View Details (side). Figure 2–21 shows the View Details readout.

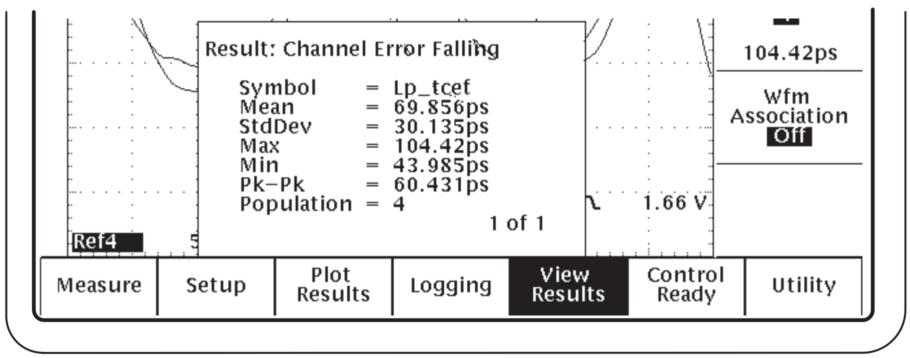


Figure 2–21: View Details shows the statistical values for Channel Error Falling

***NOTE**. When the application uses reference memory waveforms to take measurements, the results cannot be plotted as a Histogram or as a Profile.*

Saving the Results to a Data Log File

To save the measurement results to a data log file, follow these steps:

1. Press Logging (main) ➞ Results (side) and select On.

2. Press Select Drive (side) and select hd0. Figure 2–22 shows the Logging Results menu.

***NOTE**. It is faster to save data to a log file on the hard disk drive than to a floppy disk.*

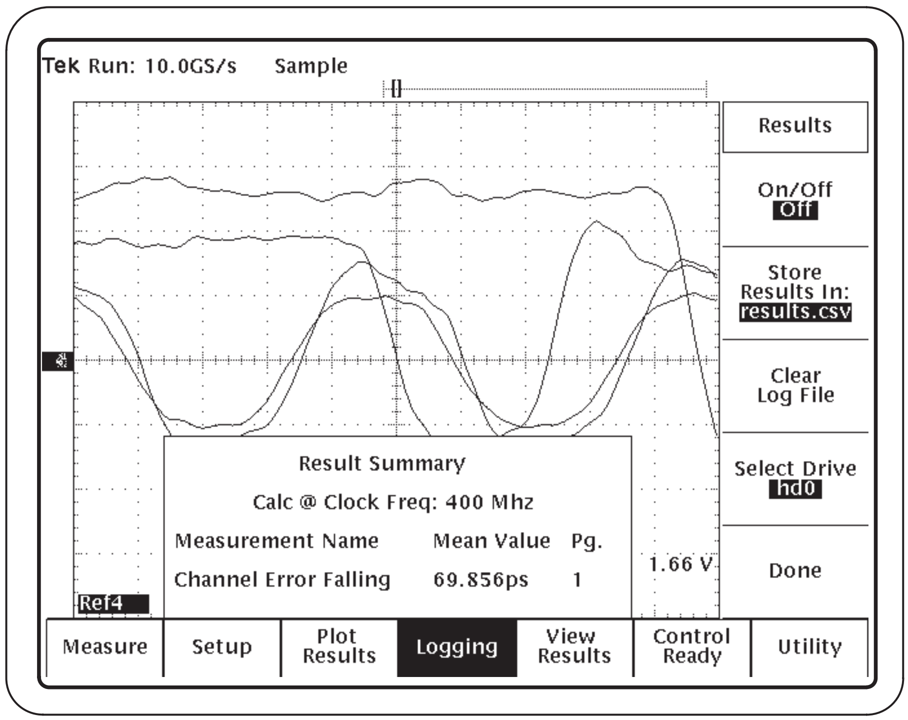


Figure 2–22: Logging menu

3. To log the results to a .CSV file, press Control (main) ➞ Start (side).

   The “comma separated variable” file format (.CSV) is compatible with many spreadsheet, database, and data analysis programs on a personal computer.

4. After the measurement completes, press Control (main) ➞ Start (side) to log more data to the RESULTS.CSV file.

5. To copy the RESULTS.CSV file to a floppy disk to view on a personal computer, follow these steps:

   a. Insert a blank, DOS-formatted floppy disk into the floppy disk drive on the oscilloscope.

   b. Press SAVE/RECALL SETUP ➞ File Utilities (main).

c. Use the GP knob to highlight hd0:, and press SELECT.

d. Use the GP knob to highlight APP, and press SELECT.

e. Use the GP knob to highlight TDSRBS1, and press SELECT.

f. Use the GP knob to highlight TEMP, and press SELECT.

Figure 2–23 shows the RESULTS.CSV file and the path to it.

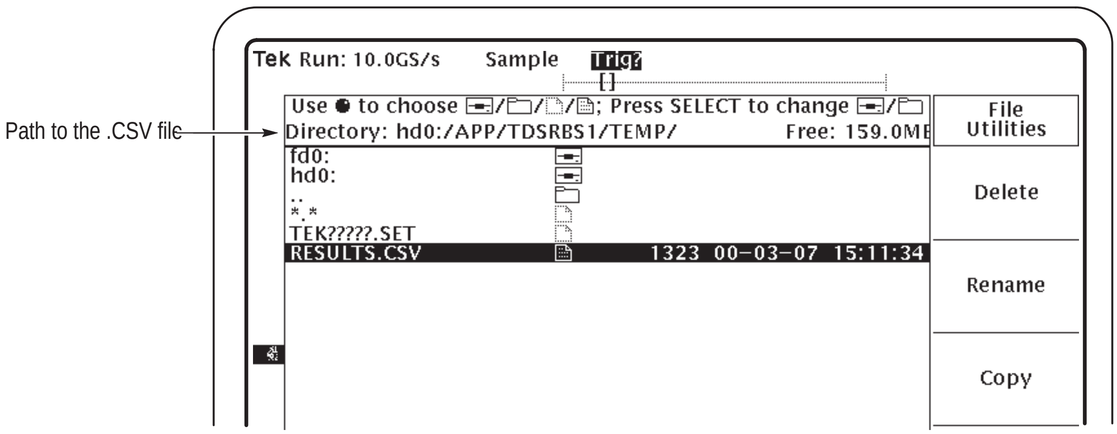


Figure 2–23: Path to the RESULTS.CSV file on the hard drive

g. Use the GP knob to highlight RESULTS.CSV, and press Copy (side).

h. Use the GP knob to highlight fd0:, and press Copy RESULTS.CSV to selected directory (side). Figure 2–24 shows this side menu item.

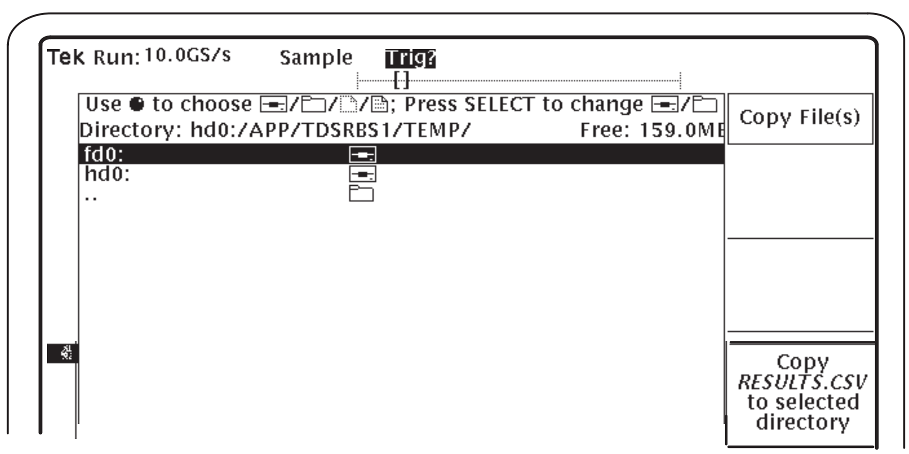


Figure 2–24: Copying the RESULTS.CSV file to a floppy disk

6. To return to the application, push the SHIFT and then the APPLICATION front-panel menu buttons.

7. Eject and remove the floppy disk from the floppy disk drive.

Viewing the RESULTS.CSV File (Data Log)

You can import the RESULTS.CSV file to a DOS-based personal computer and then view the data log file with a spreadsheet, database, or data analysis program. Figure 2–8 on page 2–25 shows an example of how the RESULTS.CSV file might look in a spreadsheet program on a personal computer.

Stopping the Tutorial

If you need more than one session to complete the tutorial lessons, you can stop the tutorial and return to it another time. To do so, you will need to save the oscilloscope setup and then the application setup.

To save the oscilloscope setup, refer to the user manual for your oscilloscope. The application setup is always saved in the APPS/TDSRBS1/TEMP directory on the oscilloscope.

To save the application setup and stop your session, refer to *Saving a Setup* on page 2–27 and to *Exiting the Application* on page 2–28.

Returning to the Tutorial

To return to the tutorial setup, you can recall the saved oscilloscope setup from the hard disk, and then restart the application.

To recall the oscilloscope setup, refer to the user manual for your oscilloscope. The procedure varies between models.

To recall the application setup, refer to *Recalling a Setup* on page 2–28.

GPIB Program Example

This section contains an example of a GPIB program that can execute the TDSRBS1 application. The application floppy disk may contain a more current program in the the rbsctrl.c file.

Guidelines

Your GPIB program should comply with the following guidelines:

- Turn on the GPIB response leaders with the "HEADER OFF" command; refer to the programmer information (in online help) for your oscilloscope.
- The application startup must complete before sending additional GPIB commands to the application (see example).
- The measurements cycle must complete before data is queried (see example).
- The error variable should be checked to ensure that an error has not occurred because of a measurement command problem.

Program Example

The example shows how a GPIB program might execute the application to do the following tasks:

- Start the application
- Select a measurement
- Select an input
- Define a waveform
- Enable the logger
- Take a measurement
- Check for an error
- Exit the application

Refer to *Appendix B: GPIB Command Syntax* for a complete list of the GPIB command syntax with the arguments, variables, and variable values.

```
/* TDSRBS Validate
 * This is a reference program to illustrate how to communicate to the TDSRBS1 Application
 * using remote GPIB facilities on a regular PC. This file can be found on the TDSRBS1 product
 * floppy disk as the rbsctrl.c file. Included are additonal files for IEEE488.2 interface
 * required by the user, which are generally installed when you load the National Instruments
 * GPIB services. Refer to TDSRBS1 users manual (Part# 071–0761–XX) Appendix B, Table B–1.

            Overview of TDSRBS remotely accessible measurments:

                                        Table 1
                  MEASUREMENT NAME        Measurement–KEY    Result(Stats)–KEY
                  Setup and Hold Time          SHT           HT=Hold Time Statistics
                                                             and ST=Setup Time Statistics.
                  Rise time of Data            RTD           RTD
                  Fall time of Data            FTD           FTD
                  Flight time of Clock         FTCF          FTCF
                  Flight time of data rising   FTDR          FTDR
                  Flight time of data falling  FTDF          FTDF
                  Tq Rising                    TQR           TQR
                  Tq Falling                   TQF           TQF
                  Tq Error                     TQE           TQE
                  Channel error rising         CER           CER
                  Channel error falling        CEF           CEF
 */

/* ======================================================================
 * Note: In order to build the .exe correctly, copy gpib–32.obj and decl–32.h
 * from ”C:\Program Files\National Instruments\GPIB\NI488\LangInt\C\” to
 * the local workspace.
 */

#include <string.h>
#include <stdio.h>
#include <sys/timeb.h>
#include <windows.h>
#include ”./decl–32.h” /* This comes with the NI–488.2 distribution */
#include ”C:\Program Files\National Instruments\NI–488.2\Languages\DLL Direct Entry\decl–32.h”

/* Local definitions */
#define VERBOSE 1
#define QUIET     0

/* Measurement result statistics structure*/
typedef struct {
     char * Measurement;
     int          options;
     double       Mean;
     double       StdDev;
     double       Max;
     double       Min;
     double       PkPk;
     int          Population;
     char *       Error;
} Result_Struct;

Result_Struct Results;
```

```
/* Forward declartions */
int        start_application( int scope);
int        do_single_test( int scope);
void setupAndExecuteTest(char * Standard, char * Rate, char * Test, int loggerOn,int Scope);
int        get_results(int scope,Result_Struct *Results, char * measurment, int options);
double     querry_stats( int scope,char * statistic,int options);
void setupAndExecuteTest(int scope, char * Test, int loggerOn, int histogramOn, int profileOn);

/*
 * Simple test program to excercise all the different TDSRBS1 measurments.
 */
void main (void)
{

     char  read_buffer        [100] = ””;
     char  write_buffer       [100] = ””;
     char  MeasurementResult  [100] = ””;
     int        scope,awg;
     int        status;
     int        iCounter = 0;
     int        Input;

     /*
      * Open session to TDS Scope with for IBIC
      */
     scope = ibfind (”DEV1”);
     status = ibtmo (scope, T10s);

     if (start_application(scope)){

        /*
         * Select the input source
         */
          sprintf (write_buffer, ”%s”, ”Variable:value \”sourceType\”,\”Ref\””);
          status = ibwrt (scope, write_buffer, strlen (write_buffer));

          printf (”cycle counter = %d\n”,iCounter++);

               //Setup and execute a Rise time of Data test.
               if (setupAndExecuteTest(scope, ”RTD”,0,0,0))
                    get_results(scope,&Results,”RTD”,VERBOSE);

               //Deactivate this measurment, or accumulate a running list of active tests.
               deactivateTest(scope,”RTD”);

               //Setup and execute a Tq Error test.
               if (setupAndExecuteTest(scope, ”TQE”,0,0,0))
                    get_results(scope,&Results,”TQE”,VERBOSE);

               //Deactivate this measurment, or accumulate a running list of active tests.
               deactivateTest(scope,”TQE”);

               //Setup and execute a Tq Rising test.
               if (setupAndExecuteTest(scope, ”TQR”,0,0,0))
                    get_results(scope,&Results,”TQR”,VERBOSE);
```

```
                //Deactivate this measurment, or accumulate a running list of active tests.
                deactivateTest(scope,”TQR”);

                //Setup and execute a Flight time of data rising test.
                if (setupAndExecuteTest(scope, ”FTDR”,0,0,0))
                     get_results(scope,&Results,”FTDR”,VERBOSE);

                //Deactivate this measurment, or accumulate a running list of active tests.
                deactivateTest(scope,”FTDR”);

                //Setup and execute a Flight time of data falling test.
                if (setupAndExecuteTest(scope, ”FTDF”,0,0,0))
                     get_results(scope,&Results,”FTDF”,VERBOSE);

                //Deactivate this measurment, or accumulate a running list of active tests.
                deactivateTest(scope,”FTDF”);

                //Setup and execute a Channel error rising test.
                if (setupAndExecuteTest(scope, ”CER”,0,0,0))
                     get_results(scope,&Results,”CER”,VERBOSE);

                //Deactivate this measurment, or accumulate a running list of active tests.
                deactivateTest(scope,”CER”);

                //Setup and execute a Channel error falling test.
                if (setupAndExecuteTest(scope, ”CEF”,0,0,0))
                     get_results(scope,&Results,”CEF”,VERBOSE);

                //Deactivate this measurment, or accumulate a running list of active tests.
                deactivateTest(scope,”CEF”);

                //Setup and execute a Setup & Holt time measurment.
                //Note there are TWO result’s fields to be querried by this test.
                if (setupAndExecuteTest(scope, ”SHT”,0,0,0)) {
                     get_results(scope,&Results,”ST”,VERBOSE);
                     get_results(scope,&Results,”HT”,VERBOSE);
           }

                //Deactivate this measurment, or accumulate a running list of active tests.
                deactivateTest(scope,”SHT”);
     }
}

/*
 * For each test, there are 7 results, ranging from the population to the various statistics.
 * This routine pulls the values from the instrument, and loads them into a Results structure.
 */
void get_results(int scope,Result_Struct *results , char * measurement, int options)
{
     char read_buffer        [100] = ””;
     char write_buffer       [100] = ””;
     int        status;

     /*
      * Query test result
      */
```

```
        sprintf (write_buffer, ”%s%s%s”, ”Variable:value \”resultFor\”,\””,measurement,”\””);
        printf (”Outgoing request: %s\n”, write_buffer);

        status = ibwrt (scope, write_buffer, strlen (write_buffer));

        /* Allow .5 seconds for the instrument to post results following the ”resultFor” request.
         */
     Sleep(500);

        /* Pull out the indivdual statistics
         */
        results–>Mean = querry_stats(scope,”mean”,options);
        results–>StdDev = querry_stats(scope,”stdDev”,options);
        results–>Min = querry_stats(scope,”min”,options);
        results–>Max = querry_stats(scope,”max”,options);
        results–>PkPk = querry_stats(scope,”pkpk”,options);
 }


/*
 * This routine deactivates a selected test.
 */
void deactivateTest(int scope, char * Test)
{
        int     status;
        char write_buffer  [100] = ””;

        /*
         * De–Select a Test
         */
        sprintf (write_buffer, ”%s%s%s”, ”Variable:value \””,Test,”\”,\”Off\””);
        status = ibwrt (scope, write_buffer, strlen (write_buffer));
}


/*
 * This routine pulls the specified result out of the instrument, and does the
 * required string to double conversions, as well as stripping of the quotes.
 */
double querry_stats( int scope, char * statistic,int options)
{
        char read_buffer   [100] = ””;
        char write_buffer  [100] = ””;
        int     status;
        float statistics_val;

        /* Request the appropriate measurment result (as several may be selected)
         * to be returned with the statistics querry command. Options are.
         */
        sprintf (write_buffer, ”%s%s%s”, ”Variable:value? \””,statistic,”\””);
        status = ibwrt (scope, write_buffer, strlen (write_buffer));
        status = ibrd (scope, read_buffer, sizeof (read_buffer));

        /* Note we recieve the result string from GPIB with quotes around it,
         * We strip them off with this sscanf expression.
         */
```

```
    sscanf (read_buffer,"\"%e\"", &statistics_val );

    if (options == VERBOSE){
        printf ("Statistics Querry for %s: = %e\n",statistic,statistics_val);
        printf ("Statistics Querry string = %s\n",read_buffer);
    }

    return ((double) statistics_val);
}


int setupAndExecuteTest(int scope, char * Test, int loggerOn, int histogramOn, int profileOn)
{
    char read_buffer     [100] = "";
    char write_buffer    [100] = "";
    int     retVal,status;

    /*
     * For this program to work correctly, the instrument should be in "Header Off" state
     */
    sprintf (write_buffer, "%s", "Header Off");
    status = ibwrt (scope, write_buffer, strlen (write_buffer));

    if (loggerOn == TRUE){
    /*
     * Turn on the logger
     */
        sprintf (write_buffer, "%s", "Variable:value \"loggerState\",\"On\"");
        status = ibwrt (scope, write_buffer, strlen (write_buffer));
    }
    else{
    /*
     * Turn off the logger
     */
    sprintf (write_buffer, "%s", "Variable:value \"loggerState\",\"Off\"");
    status = ibwrt (scope, write_buffer, strlen (write_buffer));
    }

    /*
     * Select a Test
     */
    sprintf (write_buffer, "%s%s%s", "Variable:value \"",Test,"\",\"On\"");
    status = ibwrt (scope, write_buffer, strlen (write_buffer));

    /*
     * Do a single test
     */
    retVal = do_single_test(scope);

    return (retVal);
}
```

```
/*-------------------------------------------------------------------------------
 * Function: start_application
 * Argument: scope
 * Return: 1 if success, 0 otherwise
 *
 * This function starts the application and comfirms the complition of startup
 */
int start_application(/* in */ int scope)
{
      char  read_buffer        [100];
      char  write_buffer       [100];
      char  app_name[30]       = ”\”TDSRBS1\”\n”;
      int        status;
      int        timer = 0;
      int        i = 0;

   /*
      * Has application already been started?
      */
      sprintf (write_buffer, ”%s”, ”Variable:value? \”application\””);
      status = ibwrt (scope, write_buffer, strlen (write_buffer));
      status = ibrd (scope, read_buffer, sizeof (read_buffer));
      read_buffer [ibcnt] = 0;/* Get rid of extra characters */


      if (strcmp(app_name, read_buffer) == 0){
            printf (”Application %s is already running\n”,app_name);
            return 1;               /* Application is running, don’t need to do anything */
      }

      /*
       * If application is not started up, start it and wait for application to completely
       * start up
       */
      sprintf (write_buffer, ”%s”, ”Application:activate \”hd0:/tdsrbs1.app\””);
      status = ibwrt (scope, write_buffer, strlen (write_buffer));
   printf (”Starting application, please wait...\n”);
      while (strcmp(app_name, read_buffer) != 0){
            timer += 1;
            if (timer > 60) {       /* The application normally take 24 seconds to start up */
                  printf (”***Application start up time out***\n”);
                  return 0;         /* Something is wrong if application does start up in 30s */
         }
            sprintf (write_buffer, ”%s”, ”Variable:value? \”application\””);
            status = ibwrt (scope, write_buffer, strlen (write_buffer));
            status = ibrd (scope, read_buffer, sizeof (read_buffer));
            read_buffer [ibcnt] = 0;/* Get rid of extra characters */

            Sleep(1000);
      }
      /* Application start up! */

      return 1;
}
```

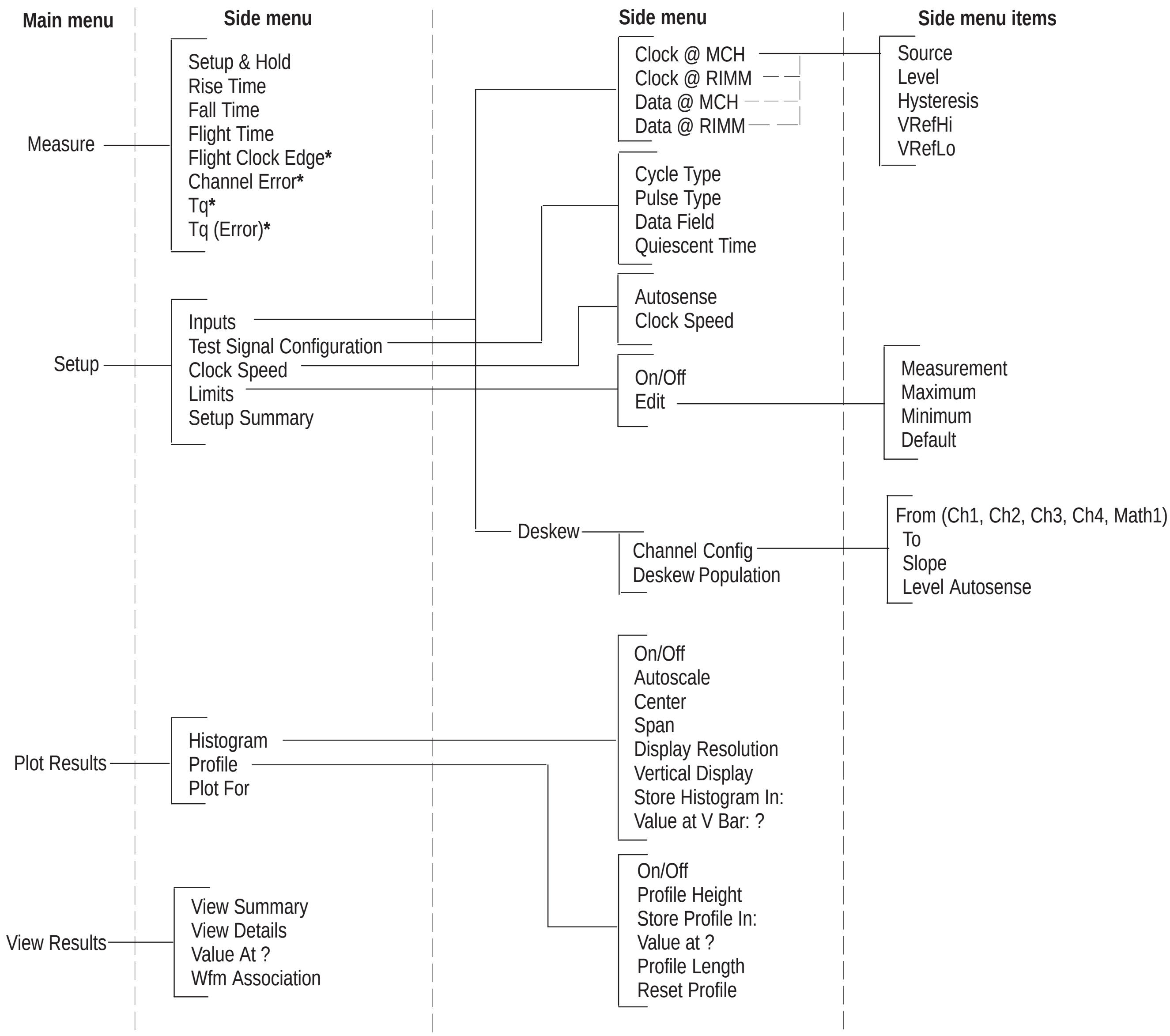
```
/*-------------------------------------------------------------------------------
  * Function: exit_application
 * Argument: scope
 * Return: 1 if success, 0 otherwise
 *
 * This function terminates ANY currently running application.
 */
int exit_application(int scope)
{
     char write_buffer      [100];
     int        status;

     printf (”Exit application!\n”);
     sprintf (write_buffer, ”%s”, ”Variable:value \”application\”,\”exit\””);
     status = ibwrt (scope, write_buffer, strlen (write_buffer));
     /* Application terminated! */

     return 1;
}


/*----------------------------------------------------------------
 * Function: do_single_test
 * Argument: scope
 * Return: 1 if success, 0 otherwise
 *
 * This function does a single measurement and checks error status
 */
int do_single_test(/* in */ int scope)
{
     char read_buffer       [100];
     char write_buffer      [100];
     char state[10]         = ”\”Ready\”\n”;
     int        status;
     int        timer = 0;
     int        i = 0;

     /*
      * Start measurement
      */
   printf (”Do a single test...\n”);
     sprintf (write_buffer, ”%s”, ”Variable:value \”sequencerState\”,\”Sequencing\””);
     status = ibwrt (scope, write_buffer, strlen (write_buffer));

     // Let measurment get rolling before checking for completion status.
     Sleep(1000);

   do{
          timer += 1;
          if (timer > 90) {  /* Assuming a single test takes less than 60 seconds */
               printf (”***Test time out***\n”);
               return 0;       /* Something is wrong if sequencerState does not come back
                                * to Ready */
                                */
          }
          sprintf (write_buffer, ”%s”, ”Variable:value? \”sequencerState\””);
```

```
            status = ibwrt (scope, write_buffer, strlen (write_buffer));
            status = ibrd (scope, read_buffer, sizeof (read_buffer));


            read_buffer [ibcnt] = 0;/* Get rid of extra characters */

            //printf (”Sequencer State = %s\n”,read_buffer);
            Sleep(1000);
      }while (strcmp(state, read_buffer) != 0);


      /*
       * Though sequencerState Back to Ready, need to check the error variable
       * to make no error occur during measurement
       */
      sprintf (write_buffer, ”%s”, ”Variable:value? \”error\””);
      status = ibwrt (scope, write_buffer, strlen (write_buffer));
      status = ibrd (scope, read_buffer, sizeof (read_buffer));
      if (ibcnt != 4){              /* error string is not empty */
         read_buffer [ibcnt] = 0;/* Get rid of extra characters */
         printf (”*** Error: %s ***\n”, read_buffer);
         return 0;
      }

      printf (”Sequencer returned to ready state\n”);

      return 1;
}
```

Reference

Menu Structure

Figure 3–1 shows the relationship of the application-specific menus.



*** Only available for Write cycle analysis.**

Figure 3–1: Measure, Setup, Plot Results, and View Results menus structures

Figure 3–2 shows the structure of the Control and Utility menus.

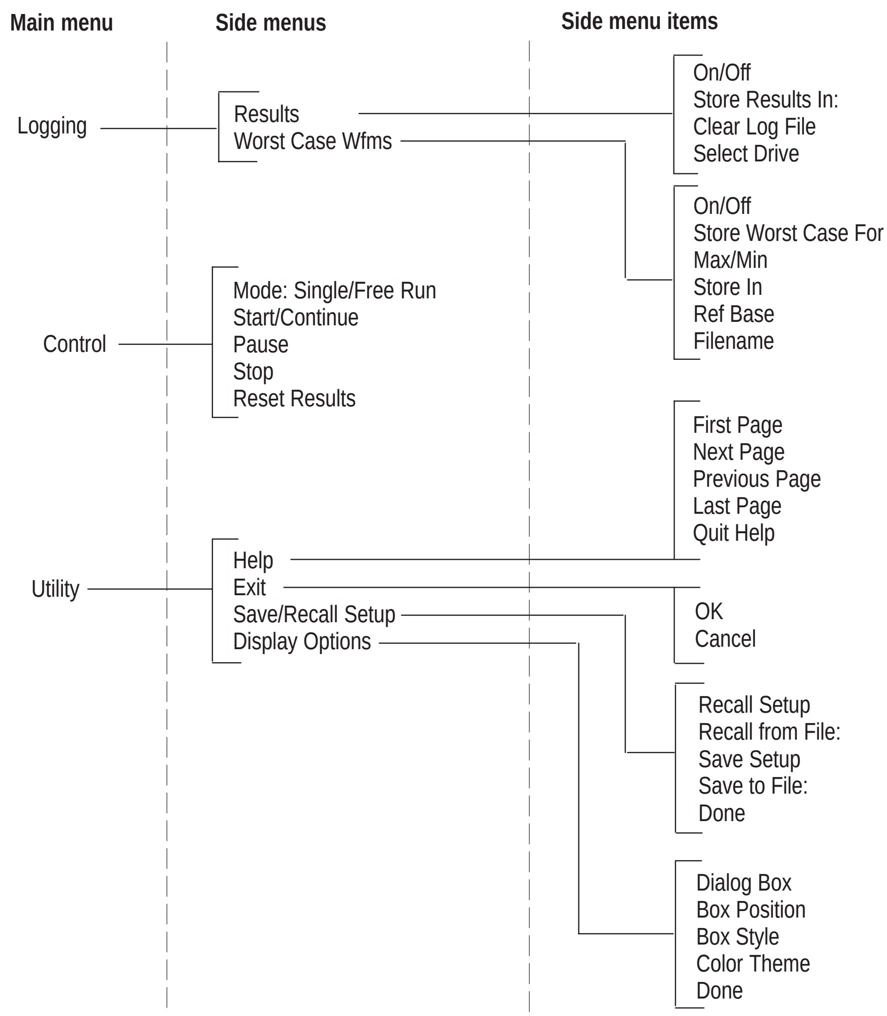


Figure 3–2: Logging, Control, and Utility menus structures

Parameters

This section describes the TDSRBS1 application parameters. You should refer to the user manual for your oscilloscope for operating details for each front-panel menu button.

Refer to *Appendix B: GPIB Command Syntax* for a complete list of the GPIB command syntax with the arguments, variables, and variable values that correspond to the TDSRBS1 parameters.

Measure Menu

Table 3–1 lists the parameters for the Measure menu and the selections or range of values available for each.

Table 3–1: Measure menu parameters

Parameter	Selections	Default setting
Setup & Hold	Off, On	On
Rise Time	Off, On	Off
Fall Time	Off, On	Off
Flight Clock Edge	Off, On	Off
Channel Error	Falling, Rising, Both, Off	Off
Flight Time	Falling, Rising, Both, Off	Off
Tq	Falling, Rising, Both, Off	Off
Tq (Error)	Off, On	Off

Setup Menus

The Setup menu has the following selections:

- Inputs (includes Deskew)
- Test Signal Configuration
- Clock Speed
- Limits
- Setup Summary

Inputs Menu

Table 3–2 lists the parameters for the Inputs menu and the selections or range of values available for each.

Table 3–2: Inputs menu parameters

Input	Parameter	Selections	Default setting
Clock @ MCH	Source	Ch3, Ref3	Ch3
	Level	2.0 V to –2.0 V in .01 V	0.0
	VrefHi	2.0 V to –2.0 V in .01 V	0.0
	VrefLow	2.0 V to –2.0 V in .01 V	0.0
Clock @ RIMM	Source	Ch4, Ref4	Ch4
	Level	2.0 V to –2.0 V in .01 V	0.0
	VrefHi	2.0 V to –2.0 V in .01 V	0.0
	VrefLow	2.0 V to –2.0 V in .01 V	0.0
Data @ RIMM	Source	Ch1, Ref1	Ch1
	Level	2.0 V to –2.0 V in .01 V	1.4
	VrefHi	2.0 V to –2.0 V in .01 V	1.52
	VrefLow	2.0 V to –2.0 V in .01 V	1.28
Data @ MCH	Source	Ch2, Ref2	Ch2
	Level	2.0 V to –2.0 V in .01 V	1.4
	VrefHi	2.0 V to –2.0 V in .01 V	1.52
	VrefLow	2.0 V to –2.0 V in .01 V	1.28
All of the above	Hysteresis	0 to 100% in 1% increments of the entire vertical screen	1%

***NOTE**. When you select a channel as an input, the application expects all inputs to be from "live" channel waveforms. When you select a reference memory as an input, the application expects all inputs to be from reference memory waveforms.*

Deskew Menu

Table 3–3 lists the parameters for the Deskew menu and the selections or range of values available for each.

Table 3–3: Deskew menu parameters

Parameter	Selections	Default setting
Deskew Population	1 to 1000 edges in 1 edge units	32
From	Ch1, Ch2, Ch3, Ch4, Math1	Ch1
To*	Ch1, Ch2, Ch3, Ch4, All	All
Slope	Falling, Rising, Both	Falling
Level Autosense	On, Off	On

***The All selection allows you to use any channel in the From parameter; otherwise, the channel in the To parameter is excluded as a selection in the From parameter.**

Test Signal Configuration Menu

Table 3–4 lists the parameters for the Test Signal Configuration menu and the selections or range of values available for each.

Table 3–4: Test Signal Configuration menu parameters

Parameter	Selections	Default setting
Cycle Type	Write, Read	Write
Pulse Type	Low, High	Low
Data Field	Even, Odd	Even
Quiescent Time	1 to 100 cycles in 1 cycle units	3

Clock Speed Menu

Table 3–5 lists the parameters for the Clock Speed menu and the selections or range of values available for each.

Table 3–5: Clock Speed menu parameters

Parameter	Selections	Default setting
Autosense	On, Off	On
Clock Speed	1 MHz to 700 MHz in 1 MHz units	400

Limits and Limits Edit Menus

Table 3–5 lists the parameters for the Limits and the Limits Edit menus and the selections or range of values available for each.

Table 3–6: Limits and Limits Edit menus parameters

Parameter	Selections	Default setting
Limits	On, Off	Off
Edit*		
Measurement	1 to 14; see Table 3–7	1
Maximum**	–.999 to 1 sec in 1 ps units	650
Minimum**	–1 to .999 sec in 1 ps units	200
Default	See Table 3–7	See Table 3–7

*** Limit Edit menu only available when the Limits selection is On.**

**** Application ensures that the maximum value is at least 0.1% greater than the minimum.**

Table 3–7 shows the measurement number, key, and default limit values.

Table 3–7: Measurement number, key, and corresponding default limits

Number	Measurement key	Maximum default	Minimum default
1	RTD (rise time of the data)	650.00 ps	200.00 ps
2	FTD (fall time of the data)	650.00 ps	200.00 ps
3	ST (setup time)	800.00 ps	500.00 ps
4	HT (hold time)	800.00 ps	500.00 ps
5	TQR (TQ rise time)	200.00 ps	–200.00 ps
6	TQF (TQ fall time)	200.00 ps	–200.00 ps
7	TQE (TQ error)	200.00 ps	–200.00 ps
8	CER (channel error rise time)	80.00 ps	–80.00 ps
9	CEF (channel error fall time)	80.00 ps	–80.00 ps
10	FTDR (flight time data rise time)	500.00 ps	200.00 ps
11	FTDF (flight time data fall time)	500.00 ps	200.00 ps
12	FTCF (flight time clock fall time)	500.00 ps	200.00 ps

Plot Results Menus

Table 3–8 lists the parameters for the Plot Results menu and the selections or range of values available for each.

Table 3–8: Plot Results menu parameters

Parameter	Selections	Default setting
Histogram	Off, On	Off
Profiling	Off, On	Off
Plot For	0 to the number of active measurements	1

Histogram Menu

Table 3–9 lists the parameters for the Histogram plot and the selections or range of values available for each.

Table 3–9: Histogram menu parameters

Parameter	Selections	Default setting
On/Off	On, Off	Off
Autoscale	None	
Center	–500 to 500 ms in 5 ps units	0 ps
Span	–1 s to 1 s in 5 ps units	1.0000 s
Display resolution	High, Medium, Low	Medium
Vertical Display	Linear, Log (logarithmic)	Linear
Store Histogram In	Ref1, Ref2, Ref3, Ref4	Ref2
Value at V Bar: ?	None	

Profiling Menu

Table 3–10 lists the parameters for the Profiling plot and the selections or range of values available for each.

Table 3–10: Profile menu parameters

Parameter	Selections	Default setting
On/Off	On, Off	Off
Profile Height	0.5 to 8.0 divisions in 0.5 division units	4 divisions
Store Profile In:	Ref1, Ref2, Ref3, Ref4	Ref1
Value at _?	None	

Table 3–10: Profile menu parameters (Cont.)

Parameter	Selections	Default setting
Profile Length	500, 1000, 2500, 5000, 15000	500
Reset Profile	None	

Logging Menus

The selections for the Logging menu are as follows:

- Results
- Worst Case Wfms

Results Logging Menu

Table 3–11 lists the parameters for the Results Logging menu and the selections or range of values available for each.

Table 3–11: Results Logging menu parameters

Parameter	Selections	Default setting
On/Off	On, Off	Off
Store Results In:	RESULTS.CSV, or new file name	RESULTS
Clear Log File	None	
Select Drive	fd0, hd0	fd0

Worst Case Wfms Logging Menu

Table 3–12 lists the parameters for the Worst Case Wfms Logging menu and the selections or range of values available for each.

Table 3–12: Worst Case Wfms Logging menu parameters

Parameter	Selections	Default setting
On/Off	On, Off	Off
Store Worst Case For	0 to the number of active measurements	1
Max/Min	Max, Min	Max
Store In	Ref, hd0, fd0	Ref
Ref Base	Ref1, Ref2, Ref3, Ref4	Ref1
Filename	fil.wfm, or new file name	fil.wfm

View Results Menu

Table 3–13 lists the parameters for the View Results menu and the selections or range of values available for each.

Table 3–13: View Results menu parameters

Parameter	Selections	Default setting
View Summary	None	
View Details	None	
Value At	varies	
Wfm Association	Off, On	Off

The application can display the results from one to six measurements in the Statistics readout.

Control Menu

Table 3–14 lists the parameters for the Control menu and the selections available.

Table 3–14: Control menu parameters

Parameter	Selections	Default setting
Mode	Single, Free Run	Single
Start (or Continue)	None	
Pause	None	
Stop	None	
Reset Results	None	

Utility Menus

Table 3–15 lists each utility menu, the parameters, the selections available, and default settings.

Table 3–15: Utility menus and parameters

Utility menu	Parameter	Selections	Default setting
Help	Refer to page 2–2	None	
Exit	Refer to page 2–28	None	

Table 3–15: Utility menus and parameters (Cont.)

Utility menu	Parameter	Selections	Default setting
Display Options	Dialog Box	On, Off	On
	Box Position	Left, Middle, Right	Right
	Box Style	Opaque, Transparent	Opaque
	Color Theme	Based on the TDS oscilloscope color selections	TDS Default
Save/Recall Setup	Recall Setup	None	
	Recall from File:	Default, or saved setup files	Default
	Save Setup	None	
	Save to File:	setup1.ini, or new file name	setup1.ini

Appendices

Appendix A: Measurement Algorithms

The TDSRBS1 application can take the following measurements on Rambus signals: Setup Time, Hold Time, Rise Time, Fall Time, Flight Time, Channel Error, and Timing Signal Quality.

The TDSRBS1 application takes measurements in two phases: Waveform Analysis Phase and Computation Phase. The application can also take multiple measurements.

Oscilloscope Setup Guidelines

For all measurements, use the following guidelines to set up the oscilloscope:

1. The signal is any channel or reference waveform.

2. The vertical scale for the waveform must be set so that the waveform does not exceed the vertical range of the TDS oscilloscope.

3. The time per division must be set small enough to capture sufficient waveform detail and avoid aliasing.

4. If you set the record length to more than 50 K, the application will reset it to 50 K.

Test Methodology

The application performs the measurement according to the following steps:

1. Imports the appropriate set of waveforms depending on the measurements selected.

2. Checks that the reference voltage level plus or minus half the hysteresis are within the 2.5% to 97.5% range of the peak-to-peak waveform values.

3. Checks that there are a minimum of two edges in the waveform to calculate the measurement.

4. Calculates the T0–T5 measurement point values as described in the *Operating Basics* section.

5. Computes the results based on the T0–T5 values.

6. Uses the results in the Statistics readout, or saves the results formatted graphically in a reference waveform.

Waveform Analysis Phase

During the Waveform Analysis Phase, the application analyzes the waveforms to find a predefined data pattern and to calculate the values for the T0–T5 measurement points. The pattern is based on the following criteria:

- Quiescent time, the number of cycles for which the data channel must be dormant before a logic transition occurs; this helps in observing clean data transitions
- High/Low Pulse, the specific pulse type of interest
- Even/Odd data field

The next pattern is a high pulse with quiescent time of 3 cycles. The three 1s before the 0 (which is the data of interest) represent minimum quiescent time. The 1 following the data of interest ensures a clean even /odd pulse.

```
.....11101....
```

The next pattern is a low pulse with quiescent time of 5 cycles. The five 0s before the 1 (which is the data of interest) represent minimum quiescent time. The 0 following the data of interest ensures a clean even/odd pulse.

```
.....0000010....
```

The next pattern is an invalid pattern, a low pulse with quiescent time of 5 cycles. The five 0s before the 1 (which is the data of interest) represent minimum quiescent time. This signal is invalid because it is a combination of odd and even pulses.

```
.....0000011....
```

The next pattern is another invalid pattern, a low pulse with quiescent time of 5 cycles. The three 0s before the 1 (which is the data of interest) represent minimum quiescent time. This is invalid since it does not provide for the specified quiescent time.

```
.....100010....
```

***NOTE**. In Single acquisition mode, the TDSRBS1 application looks for a pattern until it finds one, or it stops after 10 attempts. In Free Run mode, the above behavior repeats until the acquisition is stopped.*

After the application recognizes a pattern, it then identifies the test points based on the following definitions:

- T0, the first valid data edge at the source
- T1, the clock edge at the source associated with T0
- T2, the data edge at the source immediately following T0 (if T0 is a falling edge, then T2 is a rising edge, and vice versa)
- T3, the valid data edge at the destination that corresponds to T0 at the source
- T4, the clock edge at the destination associated with T3
- T5, the data edge at the destination immediately following T3 (if T3 is a falling edge, then T5 is a rising edge, and vice versa)

***NOTE**. The difference between T0 and T2 is expected to be less than half of the Rambus clock period.*

At the end of this phase, the application saves a set of T0–T5 values and passes the values to the Computation phase where the measurement is completed.

Computation Phase

During the Computation Phase, the application computes the measurements based on the T0–T5 measurement point values calculated in the first phase. Most of the following measurements also use a synthetic clock, which is an Imaginary Clock that has twice the frequency of the external Rambus Clock. The Imaginary Clock is synchronized with the falling edge of the external Rambus clock and has a 50% duty cycle.

Setup and Hold Time Measurement

The Setup and Hold time measurements are performed at the destination. Setup time is defined as the time from the input data signal crossing its VREF to the falling edge of synthetic clock.

The application calculates this measurement using the following equation:

$$ts = T4 - T3$$

Where: *ts* is the setup time.

Hold time is defined as the time from the falling edge of a synthetic clock to the input data signal crossing its VREF.

The application calculates this measurement using the following equation:

$$t_h = T5 - T4$$

Where: *th* is the hold time.

Timing Quality (Tq) Measurement

Timing Quality Measurements (Tq) indicate how well the data is centered relative to the synthetic clock. Data is expected at the mid point of every synthetic clock. This measurement is done at the source.

This measurement checks the difference of the actual signal crossing edge to the calculated mid point. Zero is the ideal result.

Tq Rising. This is a Tq measurement for the rising edge of data. The application calculates this measurement using the following equation:

$t_{qr} = 625\ ps - (T1 - T0)$ high pulse of data

$t_{qr} = (T2 - T1) - 625\ ps$ low pulse of data

Where: *tqr* is the TQ rising time.

Tq Falling. This is a Tq measurement for the falling edge of data. The application calculates this measurement using the following equation:

$t_{qf} = (T2 - T1) - 625\ ps$ high pulse of data

$t_{qf} = 625\ ps - (T1 - T0)$ low pulse of data

Where: *tqf* is the TQ falling time.

Tq Error. This is an average of Tq Rising and Tq Falling. The application calculates this measurement using the following equation:

$$t_{qerr} = \frac{(t_{qf} + t_{qr})}{2}$$

Where: *tqerr* is the average of TQ rising and falling time measurements.

Channel Error Measurement

Channel Error Measurements (TCE) are the differences in propagation delay between Clock and Data Channels. Data is associated (measured in time units) with a clock edge and, due to the propagation delay in a system, this association may vary. When the application measures the association (in time units) at the source and at the destination, there will be slight variation due to the propagation delay effect. Zero is the ideal result.

Channel Error Rising. This is the Channel Error measurement for the rising edge of data. The application calculates this measurement using the following equation:

$t_{cer} = (T4 – T3) – (T1 – T0))$ high pulse of data

$t_{cer} = (T5 – T4) – (T2 – T1)$ low pulse of data

Where: *tqr* is the Channel Error rising time.

Channel Error Falling. This is the Channel Error measurement for the falling edge of data. The application calculates this measurement using the following equation:

$t_{cef} = (T5 – T4) – (T2 – T1)$ high pulse of data

$t_{cef} = (T4 – T3) – (T1 – T0)$ low pulse of data

Where: *tqf* is the Channel Error falling time.

Flight Time (Data) Measurement

Flight Time (Data) Measurements are similar to propagation delay. The difference in the rising edge of the data when it is measured at the source and at the destination is known as Flight Time of Data (Rising). When it is measured with respect to the falling edge, it is known as Flight time of Data (Falling).

Flight Time of Data Rising. This is the Flight Time measurement for the rising edge of data. The application calculates this measurement using the following equation:

$t_{fr} = T3 - T0$	high pulse of data
$t_{fr} = T5 - T2$	low pulse of data

Where: *tfr* is the flight time of the data rising.

Flight Time of Data Falling. This is the Flight Time measurement for the falling edge of data. The application calculates this measurement using the following equation:

$t_{ff} = T5 - T2$	high pulse of data
$t_{ff} = T3 - T0$	low pulse of data

Where: *tff* is the flight time of the data falling.

Flight Time Clock Measurement

Flight Time Clock Measurements are similar to Flight Time Data except the clock is the reference. Since all RSL transactions are synchronized with the Clock Falling edge, flight time of the clock is measured relative to the falling clock edge. The application calculates this measurement using the following equation:

$$t_{fck} = T4 - T1$$

Where: *tfck* is the flight time of the clock.

Rise Time and Fall Time Measurements

The Rise Time and Fall Time measurements require VRefHigh and VRefLow reference voltage levels. The TDSRBS1 supports rise time and fall time measurements for data pulses destination.

Rise Time. The Rise Time measurement is the time difference between VRefHigh and VRefLow reference levels on a rising edge of the waveform. The application calculates this measurement using the following equation:

$$t_{rd} = t_{RefHigh} - t_{RefLow}$$

Where: *trd* is the rise time
tRefHigh is the VRefHigh crossing on the rising edge
tRefLow is the VRefLow crossing on the rising edge

For High Pulse, rise time is calculated at the edge where T3 occurs and for Low Pulse at T5.

Fall Time. The Fall Time measurement is the time difference between VRefLow and VRefHigh reference levels on a falling edge of the waveform. The application calculates this measurement using the following equation:

$$t_{fd} = t_{RefLow} - t_{RefHigh}$$

Where: *tfd* is the fall time
tRefHigh is the VRefHigh crossing on the falling edge
tRefLow is the VRefLow crossing on the falling edge

For High Pulse, fall time is calculated at the edge where T5 occurs and for Low pulse at T3.

Appendix B: GPIB Command Syntax

This appendix describes the GPIB command syntax that you can use in your GPIB program to do the following tasks:

- Start the TDSRBS1 application
- Recognize an active application with GPIB protocol
- Program and read application setup parameters
- Sequence measurements
- Synchronously read measurement results

To use GPIB commands with your oscilloscope, you can use the following reference materials:

- the rbsctrl.c file on the application floppy disk for an example of a GPIB program that can execute the application
- the *GPIB Program Example* section for guidelines to use while designing a GPIB program
- the *Parameters Reference* section for incremental units and default values of TDSRBS1 parameters
- the programmer information in the online help of your oscilloscope

Description. Gives the function of the command, conditions of its use, and its interactions with other commands.

Syntax. Gives the valid select and query command forms. The required arguments are listed in their proper order.

For example, in the syntax definition

```
PATH= <Ad><Ars>
```

```
the arguments <Ad> and <Ars> are required in the order indicated.
```

Arguments. The arguments to a command are defined along with their range of values.

Returns. Defines the data returned in response to a command query.

VARIABLE:VALUE TDS COMMAND

Description

VARIABLE:VALUE TDS COMMAND accepts string arguments for a control or data variable and a value to which to set the argument.

Syntax

VARIABLE:VALUE

```
VARIABLE:VALUE "<variable name>","<variable value>"
```

```
the arguments <variable name> and <variable value> are required
in the order indicated.
```

Arguments and Returns

Table B–1 lists the arguments, their function, and the query returns.

Table B–1: VARIABLE:VALUE TDS COMMAND arguments and queries

Variable name	Variable value	Function	Query form
application	exit	Terminates the active application	Returns a string that corresponds to the name of the active application
Display Options			
boxBackground	{Transparent, Opaque}	Sets the message box background	Returns the message box back-ground
boxPosition	{Left, Middle, Right}	Sets the position of the message box on the display	Returns the position of the message box
boxVisibility	{On, Off}	Sets the visibility of the message box	Returns the visibility of the mes-sage box
colorTheme	{TDS Default, Black, Green, Mild, Purple, Steel, Tek Blue}	Sets the TDS oscilloscope color scheme	Returns the TDS oscilloscope color scheme
Measurements			
CEF	{On, Off}	Sets the Channel Error Falling measurement	Returns the Channel Error Falling measurement; see Table B–3
CER	{On, Off}	Sets the Channel Error Rising measurement	Returns the Channel Error Rising measurement; see Table B–3
FTCF	{On, Off}	Sets the Flight Time of the Falling Clock edge measurement	Returns the Flight Time of the Falling Clock edge measurement; see Table B–3
FTD	{On, Off}	Sets the Fall Time measurement	Returns the Fall Time measurement; see Table B–3
FTDF	{On, Off}	Sets the Flight Time of the Falling Data edge measurement	Returns the Flight Time of the Falling Data edge measurement; see Table B–3

Table B–1: VARIABLE:VALUE TDS COMMAND arguments and queries (Cont.)

Variable name	Variable value	Function	Query form
FTDR	{On, Off}	Sets the Flight Time of the Rising Data edge measurement	Returns the Flight Time of the Rising Data edge measurement ; see Table B–3
RTD	{On, Off}	Sets the Rise Time measurement	Returns the Rise Time measurement ; see Table B–3
SHT	{On, Off}	Sets the Setup and Hold Time measurement	Returns the Setup and Hold Time measurement; see Table B–3
TQE	{On, Off}	Sets the TQ Error measurement	Returns the TQ Error measurement; see Table B–3
TQF	{On, Off}	Sets the TQ Time Falling measurement	Returns the TQ Time Falling measurement; see Table B–3
TQR	{On, Off}	Sets the TQ Time Rising measurement	Returns the TQ Time Rising measurement; see Table B–3
Setup			
clockAutosense	{On, Off}	Sets the automatic sensing of the clock	Returns the automatic sensing of the clock
clockSpeed	{10000 to 700000000}	Sets the speed of the clock	Returns the speed of the clock
cycleType	{Read, Write}	Sets the type of cycle	Returns the type of cycle
dataField	{Even, Odd}	Sets the type of data field	Returns the type of data field
pulseType	{Low, High}	Sets the type of pulse	Returns the type of pulse
qTime	{1 to 100}	Sets the quiescent time in cycles	Returns the quiescent time
hysteresisOfCMCH	{0 to 100}	Sets the hysteresis in percentage for the clock of the MCH	Returns the hysteresis of the clock of the MCH
hysteresisOfCRIMM	{0 to 100}	Sets the hysteresis in percentage for the clock of the RIMM	Returns the hysteresis of the clock of the RIMM
hysteresisOfDMCH	{0 to 100}	Sets the hysteresis in percentage for the data of the MCH	Returns the hysteresis of the data of the MCH
hysteresisOfDRIMM	{0 to 100}	Sets the hysteresis in percentage for the data of the RIMM	Returns the hysteresis of the data of the RIMM
levelOfCMCH	{2.0 to –2.0}	Sets the level of the MCH clock	Returns the level of the MCH clock
levelOfCRIMM	{2.0 to –2.0}	Sets the level of the RIMM clock	Returns the level of the RIMM clock
levelOfDMCH	{2.0 to –2.0}	Sets the level of the MCH data	Returns the level of the MCH data
levelOfDRIMM	{2.0 to –2.0}	Sets the level of the RIMM data	Returns the level of the RIMM data
sourceType	{Ref, Live}	Sets the type of source	Returns the type of source
vRefHighCMCH	{2.0 to –2.0}	Sets the high voltage reference level of the MCH clock	Returns the high voltage reference level of the MCH clock

Table B–1: VARIABLE:VALUE TDS COMMAND arguments and queries (Cont.)

Variable name	Variable value	Function	Query form
vRefHighCRIMM	{2.0 to –2.0}	Sets the high voltage reference level of the RIMM clock	Returns the high voltage reference level of the RIMM clock
vRefHighDMCH	{2.0 to –2.0}	Sets the high voltage reference level of the MCH data	Returns the high voltage reference level of the MCH data
vRefHighDRIMM	{2.0 to –2.0}	Sets the high voltage reference level of the RIMM data	Returns the high voltage reference level of the RIMM data
vRefLowCMCH	{2.0 to –2.0}	Sets the low voltage reference level of the MCH clock	Returns the low voltage reference level of the MCH clock
vRefLowCRIMM	{2.0 to –2.0}	Sets the low voltage reference level of the RIMM clock	Returns the low voltage reference level of the RIMM clock
vRefLowDMCH	{2.0 to –2.0}	Sets the low voltage reference level of the MCH data	Returns the low voltage reference level of the MCH data
vRefLowDRIMM	{2.0 to –2.0}	Sets the low voltage reference level of the RIMM data	Returns the low voltage reference level of the RIMM data
Histogram			
histogram	{Reset}	Resets the histogram data	No query form
histogramAutoscale	{On}	Uses the previous results to automatically scale if there is a population of at least three	No query form
histogramCenter	{–.5s to .5s}	Sets the center point of the Histogram plot	Returns the center point of the Histogram plot
histogramDestination	{Ref1, Ref2, Ref3, Ref4}	Sets the destination reference memory of the Histogram plot	Returns the destination reference memory of the Histogram plot
histogramResolution	{High, Medium,Low}	Sets the resolution of the Histogram plot	Returns the resolution of the Histogram plot
histogramSpan	{–1s to 1s}	Sets the span (range) of the Histogram plot	Returns the span (range) of the Histogram plot
histogramState	{On, Off}	Sets the state of the Histogram plot	Returns the state of the Histogram plot
histogramVAxis	{Linear, Log}	Sets the type of vertical axis for the Histogram plot	Returns the type of vertical axis for the Histogram plot
Profiler			
profiler	{Reset}	Resets the profiler data	No query form
profilerState	{On, Off}	Sets the state of the Profiler plot	Returns the state of the Profiler plot
profilerDestination	{Ref1, Ref2, Ref3, Ref4}	Sets the destination reference memory of the Profiler plot	Returns the destination reference memory of the Profiler plot
profilerLength	{500, 1000, 2500, 5000, 15000}	Sets the length of the Profiler plot in record points	Returns the length of the Profiler plot

Table B–1: VARIABLE:VALUE TDS COMMAND arguments and queries (Cont.)

Variable name	Variable value	Function	Query form
Logging Results			
logger	{Reset}	Clears the current data log file	Returns the reset of the data log
logAnnotate*	Any string from 1 to 20 characters from A to Z and/or zero to nine	Provides custom annotation to the data log file	No query form
loggerDestination	Any string from 1 to 8 characters from A to Z and/or zero to nine	Sets the data log file name	Returns the data log file name
logDrive	{fd0, hd0}	Sets the drive used for logging	Returns the drive used for logging
loggerState	{On, Off}	Sets the state of the data log	Returns the state of the data log
Worse Case Waveform Results			
filename	Any string from 1 to 3 characters from A to Z and/or zero to nine	Sets the worse case waveform file name	Returns the worse case waveform file name
maxMin	{Max, Min}	Sets the type of worst case to save	Returns the type of worst case to save
refBase	{Ref1, Ref2, Ref3, Ref4}	Sets the reference memory where the application will start to save the worst cases; see Table 2–30	Returns the reference memory where the application will start to save the worst cases
storeFor	{CEF, CER, FTCF, FTD, FTDF, FTDR, RTD, SHT, ST, HT, TQE, TQF, TQR}	Sets the source of the measurement results; see Table B–2	See Table B–3
storeIn	{Ref, hd0, fd0}	Sets the destination of the waveform as a reference memory, or to the hard disk or floppy disk drive	Returns the destination of the waveform as a reference memory, or to the hard disk or floppy disk drive
worstCaseState	{On, Off}	Sets the state of the worse case data log or file	Returns the state of the worse case data log or file
Results Analysis			
plotSource	{CEF, CER, FTCF, FTD, FTDF, FTDR, RTD, SHT, ST, HT, TQE, TQF, TQR}	Sets the source of the measurement results for the Histogram or Profiler plots; see Table B–2	See Table B–3
limits	{On, Off}	Sets the limits evaluation for the measurement results	Returns the limits evaluation for the measurement results
wfmAssociationState	{On, Off}	Sets the state of the waveform association for the measurement results	Returns the state of the waveform association for the measurement results
Result Variables			
resultFor	{CEF, CER, FTCF, FTD, FTDF, FTDR, RTD, SHT, ST, HT, TQE, TQF, TQR}	Sets the measurement for which results are requested; see Table B–2	See Table B–3

Table B–1: VARIABLE:VALUE TDS COMMAND arguments and queries (Cont.)

Variable name	Variable value	Function	Query form
Save/Recall			
recallName	Any string that uses one to eight characters from A to Z and/or zero to nine	Sets the recalled setup file name	Returns the saved setup file name
saveName	Any string from one to eight characters from A to Z and/or zero to nine	Sets setup file name	Returns the setup file name
setup	{Default, Recall, Save}	Sets the Save/Recall/Default action	No query form
Sequencer			
sequencerMode	{FreeRun, Single}	Sets the sequencer mode	Returns the sequencer mode
sequencerState	{Ready, Paused, Sequencing}	Sets the state of the sequencer	Returns the state of the sequencer

*** Custom annotation in the data log file is only available through GPIB execution of the application.**

Table B–2 lists the measurement keys for the resultFor and plotSource querries.

Table B–2: Measurement, resultFor query, and plotSource query keys

Measurement name	Measurement key	resultFor and plotSource query keys
Channel error fall time	CEF	CEF
Channel error rise time	CER	CER
Fall time of data	FTD	FTD
Flight time data fall time	FTDF	FTDF
Flight time data rise time	FTDR	FTDR
Flight time clock fall time	FTCF	FTCF
Rise time of data	RTD	RTD
Setup and Hold time	SHT	ST
		HT
TQ error	TQE	TQE
TQ fall time	TQF	TQF
TQ rise time	TQR	TQR

Table B–3 lists the measurement results queries.

Table B–3: Measurement results queries

Variable name	Function
error	Returns the error code; see *Apprndix C: Error Codes*
max	Returns the maximum value of the result of the measurement selected in the resultFor variable
mean	Returns the mean value of the result of the measurement selected in the resultFor variable
min	Returns the minimum value of the result of the measurement selected in the resultFor variable
pkpk	Returns the peak-to-peak value of the result of the measurement selected in the resultFor variable
stdDev	Returns the standard deviation value of the result of the measurement selected in the resultFor variable
population	Returns the population for the result of the measurement selected in the resultFor variable

Appendix C: Error Codes

This appendix describes the error codes that display when there is a problem with operating the application. Table C–1 lists the codes with a brief description of each and a possible solution.

***NOTE**. Be sure to deskew the probes and oscilloscope channels before taking Rambus measurements. (Refer to* Deskewing the Probes and Channels *on page 1–4.) You may encounter problems that cause the application to display error codes because the probes and channels are not deskewed.*

Table C–1: Error codes, descriptions and solutions

Number	Description	Solution
E001	No measurement selected	Select a measurement in the Measure menu and acquire data
E002	No valid edge found at the data source	If using Single mode, reacquire data; if the application still cannot find a valid edge, change to Free Run mode and acquire data
E003	No valid edge found at the data destination	Same solution as E002
E004	Association of edges failed	Unable to associate the data signals with the clock signals; this may indicate a Rambus system problem with time synchronization between the signals; also try solution for E002
E005	Search for edges terminated; waveform segment is too short	The application requires a minimum waveform length of two records; if the length of the acquired waveform is less than two, increase the record length and acquire data
E006	Too many edges; sampling frequency is too low	The application cannot accurately reconstruct the waveform; use the HORIZONTAL SCALE knob to decrease the horizontal scale and acquire data
E007	The waveform is above the hysteresis because the level is too low; the waveform does not cross the hysteresis and remains above it	Increase the level of the waveform; select Setup (main) → Inputs (side) → (a waveform)(side) → Level (side) and turn the GP knob towards the right
E008	The waveform is below the hysteresis because the level is too high; the waveform does not cross the hysteresis and remains below it	Decrease the level of the waveform; select Setup (main) → Inputs (side) → (a waveform)(side) → Level (side) and turn the GP knob towards the left
E009	The level is too high and the waveform does not cut into the upper boundary of the hysteresis	Increase the hysteresis of the waveform; select Setup (main) → Inputs (side) → (a waveform)(side) → Hysteresis (side) and turn the GP knob towards the right or try the same solution as E008.
E010	The level is too low and the waveform does not cut into the lower boundary of the hysteresis	Decrease the hysteresis of the waveform; select Setup (main) → Inputs (side) → (a waveform)(side) → Hysteresis (side) and turn the GP knob towards the left or try the same solution as E007.
E011	Hysteresis band is not within the central 95% peak-to-peak	Decrease the hysteresis of the waveform; select Setup (main) → Inputs (side) → (a waveform)(side) → Hysteresis (side) and turn the GP knob towards the left

Table C–1: Error codes, descriptions and solutions (Cont.)

Number	Description	Solution
E012	VRefHi value is not appropriate	Check the VRefHi value; it should be more than the VRefLo value and the Level (VRefMid) value
E013	VRefLo value is not appropriate	Check the VRefLo value; it should be less than the VRefHi value and the Level (VRefMid) value
E014	Failed to import a waveform and sequencing stopped	The application did not acquire the waveform; check the connection of the live signal to the channel or check the reference memory to be sure that it contains the appropriate waveform
E015	No data association found between the source and the destination	Unable to associate the data at the source with the destination signals; this may indicate a Rambus system problem with time synchronization between the signals; also try solution for E002
E016	No edge of the data at the source corresponds to the clock at the source	Unable to associate the data at the source with the clock at the source; this may indicate a Rambus system problem with time synchronization between the signals; also try solution for E002
E017	No edge of the data at the destination corresponds to the clock at the destination	Unable to associate the data at the destination with the clock at the destination; this may indicate a Rambus system problem with time synchronization between the signals; also try solution for E002
E018	No valid edges found in the waveform	Waveform does not contain an edge as defined in the Deskew Channel Config menu and deskew was not performed; increase the HORIZONTAL SCALE and increase the record length (HORIZONTAL MENU ➞ Record Length (main) ➞ and select larger value)
E019	Not enough edges found to perform deskew	Increase the HORIZONTAL SCALE and/or increase the record length (HORIZONTAL MENU ➞ Record Length (main) ➞ select larger value)
E101	Clock signal may not be present	Check the connection of the Clock signals to Ch3 and Ch4 or check the Ref3 and Ref4 reference memories for the appropriate Clock waveform
E102	Clock frequency at the source and destination do not match	If AutoSense is set to On (Setup ➞ ClockSpeed ➞ AutoSense), the application measures the frequency of the Clock at the source and at the destination. If the difference in frequency is 10 MHz, error E102 displays. Check that the oscilloscope to Rambus system connections for the CFM +, CFM–, CTM+, and CTM– signals are correct.
E103	Failed to acquire a signal, not able to trigger	Check that the signal is present and the Level is set properly; to do this, select Setup (main) ➞ Inputs (side) ➞ (a waveform)(side) ➞ Level (side). Also check that the quiescent time is set properly and the signal actually contains that much quiescent time; to change the quiescent time, select Setup (main) ➞ Test Signal Configuration (side) ➞ Quiescent Time(side) and change the number
E104	Reference voltage level is not between VRefHi and VRefLo, or VRefLo is a higher value than VRefHi	Check that the reference voltage levels are set properly; to do this, select Setup (main) ➞ Inputs (side) ➞ (a waveform)(side) ➞ VRefHi/VRefLo (side)
E105	Failed to power on source	There is a problem with the oscilloscope and the application is not able to turn on the input channels
E106	Present signal does not contain valid T0–T5 measurement points	Check that the measurement is taken on an appropriate waveform; to do this, check the connection between the Rambus signal and the oscilloscope or check the reference memory waveform

Table C–1: Error codes, descriptions and solutions (Cont.)

Number	Description	Solution
E201	Waveform import error in Worst Case	The application is not able to write to the reference memory; check if there is another reference memory available
E202	Waveform export error in Worst Case	Change the Record Length to 50 K or less; 50 K is the maximum that can be saved to a reference memory
E203	Worst Case file operation error	The oscilloscope cannot write to a file because the disk is full, the disk is write-protected, or the disk is bad.
E301	Cannot find the base point for the At-position number	Check the valueAt number; to do this, select Plot Results (main) → Plot For (side) → Value At? (side) and change the number
E302	No results found; population is unknown	Retake the measurement by pressing Control (main) → Mode Free Run (side) → Start (side).
E303	Exceeded maximum result limit	The number of results exceed the maximum allowed; decrease the HORIZONTAL SCALE to decrease the number of edges acquired.
E401	Error in file operation	The oscilloscope cannot write to a file because the disk is full, the disk is write-protected, or the disk is bad.
E402	Source conflict in result profiler destination	The application is not able to write to the reference memory; check if there is another reference memory available
E403	No reference memories available for the Profiler format	Same solution as E402
E404	No reference memories available for the Histogram format	Same solution as E402
E405	Conflict in the destination for the Histogram	Same solution as E402
E406	No measurement selected	Set the Plot Source to a nonzero value in the Plot Results (main) → Plot For (side) parameter; select a measurement in the Measure menu and acquire data
E501	Conflict found in Worst Case resource	Turn off Histogram or Profiler; select Setup(main) → Inputs(side) → ClockAtMCH(side) → Source(side) → Ch1(side)
E502	Conflict found in resource	Same solution as E501
E601	Confllict found in resource	Same solution as E501

Appendix D: Deskewing with a Math1 Waveform

This appendix describes how to deskew single-ended probes relative to differential probes using the Math1 waveform.

In *Deskewing the Probes and Channels*, the procedure states that it is for deskewing similar probes. The procedure also recommends that you connect the probes to the output of the Direct Rambus Clock Generator (DRCG) in the SUT. Clocks in a Rambus SUT have two legs with different polarities: positive (+) and negative (–). Each leg is a connection to a common polarity signal.

To deskew the single-ended probes on channels 1 and 2 against the differential probes attached to channels 3 and 4, follow these steps:

1. Connect the single-ended probes from channel 1 and channel 2 on the oscilloscope to the + leg of the DRCG in the SUT.
2. Deskew the probes. The procedure starts on page 1–4.
3. When done, detach the channel 2 probe from the + leg of the DRCG and attach it to the – leg of the DRCG.
4. On the oscilloscope, press the MATH. REF button. Figure D–1 shows the default Math1 side menu items.

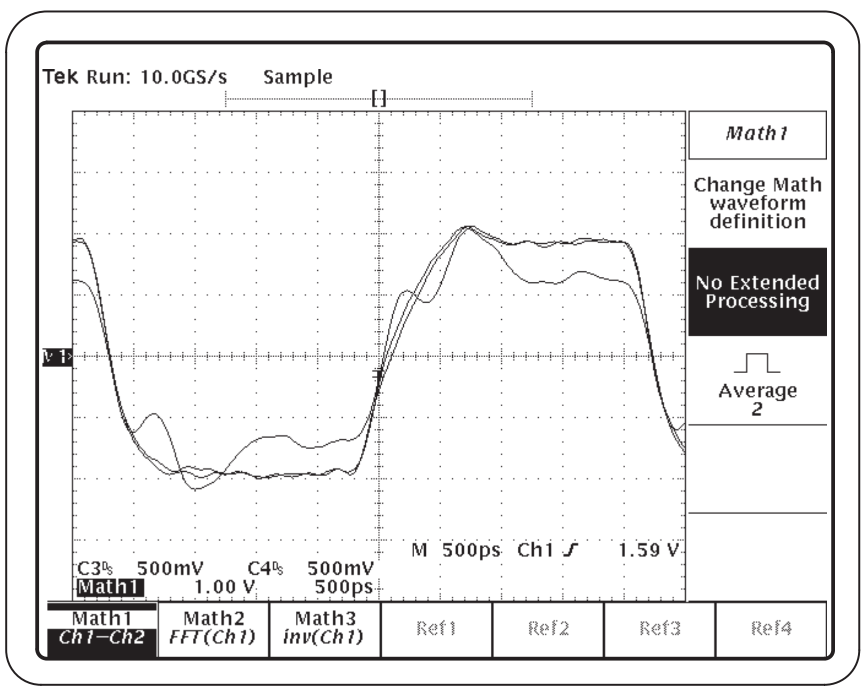


Figure D–1: Math1 side menu items

5. Press Change Math Waveform definition (side) ➞ Dual Wfm Math (main). Figure D–2 shows the Change Math Definition side menu items.

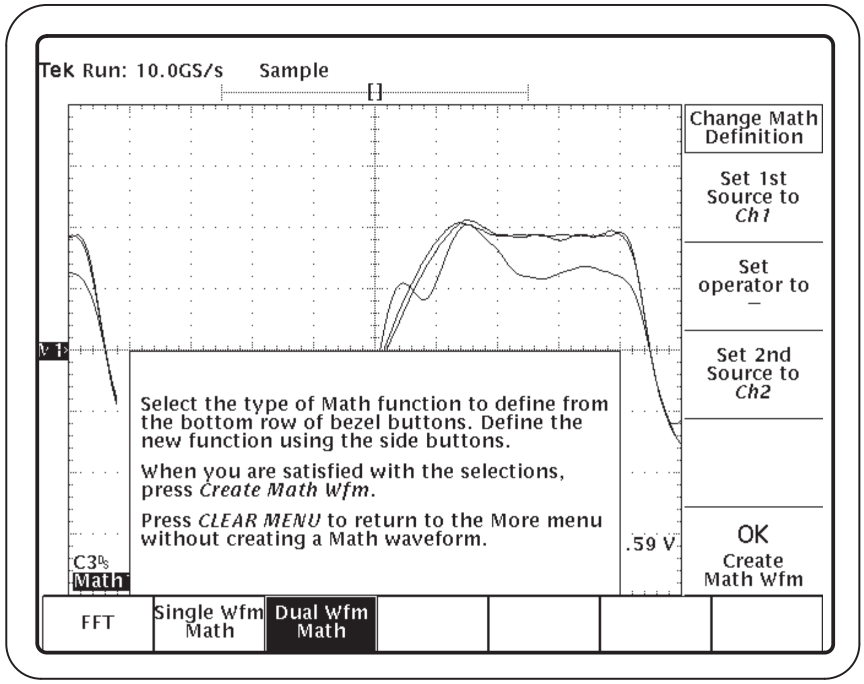


Figure D–2: Change Math Definition side menu items

6. Press Set operator to (side) and select – (subtract).

7. Press OK Create Math Wfm (side) to create a new Math1 waveform which is the result of the CH1 – CH2 math operation.

***NOTE**. The Math1 waveform resembles the displayed DRCG signal when it is attached to a differential probe.*

---

8. To return to the application, push the SHIFT and then the APPLICATION front-panel menu buttons.

9. Press Channel Config (side) ➞ From (side) ➞ Math1 (side). Figure D–3 shows the From parameter with Math1 selected.

10. Press Done (side).

11. Press To (side) and select All. When you select All and the Math1 waveform is the deskew reference point (From), the application knows to only deskew channels 3 and 4. Figure D–4 shows the Channel Config setup to deskew differential probes with a Math1 waveform.

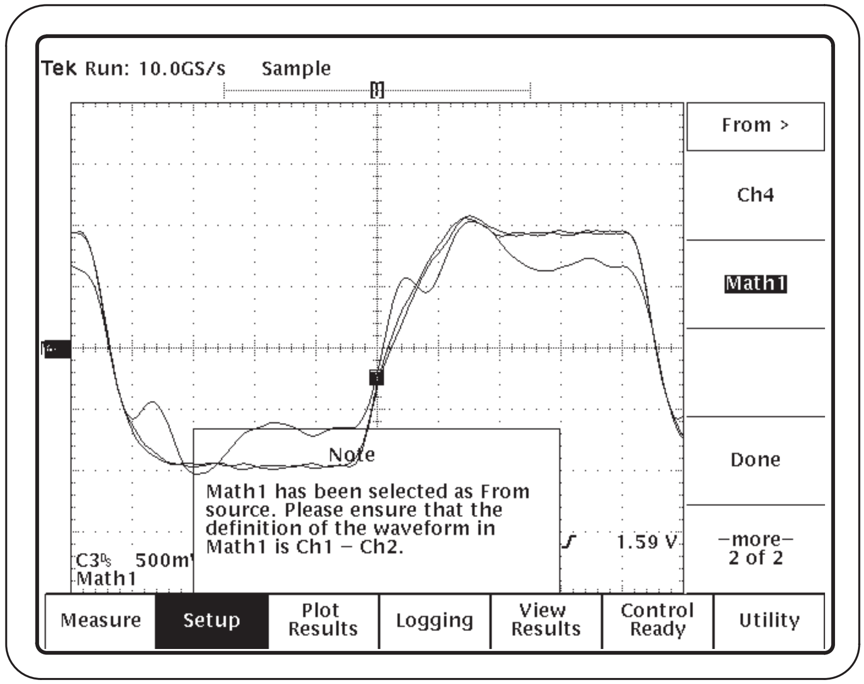


Figure D–3: Deskew menu: From parameter Math1 selection

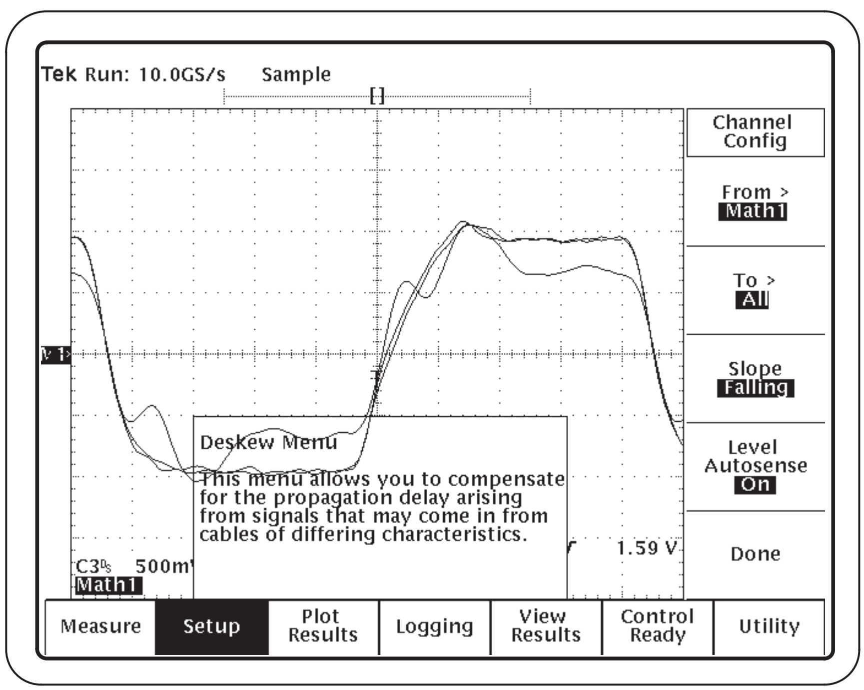


Figure D–4: Channel configuration to deskew with a Math1 waveform

12. To start the deskew utility, press Start Deskew (side).

The utility displays information as it deskews the channels, such as the number of samples processed and specified.

13. When the utility is finished, press OK (side) to return to the Deskew menu.

14. Press Done (side) to return to the Inputs menu.

15. Press Done (side) to return to the Setup menu.

Refer to the *Basic Operations* section for information on setting up the application to take Rambus measurements and on understanding the measurement points and patterns.

Appendix E: Rise Time and Fall Time Analysis

This appendix contains a procedure on how to set up the oscilloscope to quickly validate Rise Time and Fall Time measurements. You can use this technique on the rising or the falling edges of any signal.

This technique is described in two ways. One procedure is detailed with the proper names of each oscilloscope control used. The other procedure is abbreviated with a sequence of numbered bezel buttons to press.

You will need the following equipment:

- Calibrated TDS694C oscilloscope
- P6249 single-ended probes for clock and data signals

Follow the procedure starting on page 1–9 to connect the oscilloscope to the Rambus system under test (SUT).

Waveform Display Setup

To set up the display of the waveform from the clock or data signal, follow these steps:

1. Obtain the signal to be measured and set the trigger accordingly.
2. Press Autoset (main) if needed.
3. Use the Horizontal Scale knob to set the timebase to 10 GS/s.
4. Press Trigger Menu (main) → Source (main) and select the appropriate side menu item for the channel that is connected to the signal to be measured.
5. Press Slope (side) and select the rising or falling edge for the edge of the channel that is to be measured.
6. Use the Vertical Position and Horizontal Position knobs to center the waveform on the display.
7. Use the Vertical Scale knob to make the edge of the waveform completely fill the display vertically without clipping off any of the waveform.

   Figure E–1 shows an example of a clock waveform set up properly.

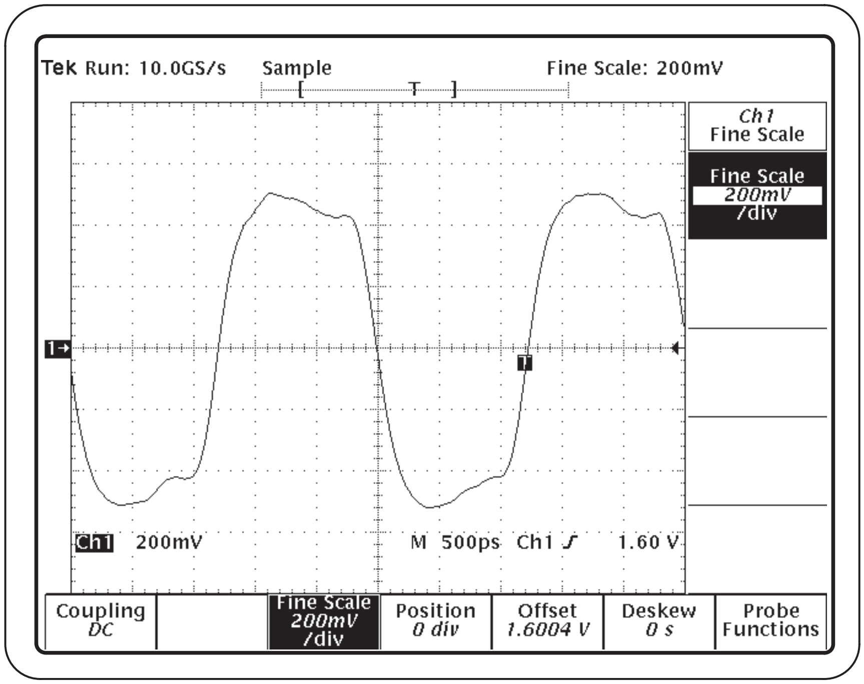


Figure E–1: Rambus clock waveform set up properly example

Detailed Procedure

To set up the oscilloscope to take Rise Time or Fall Time measurements, follow these steps:

1. Press Measure (main) and select the Measure mode.
2. Press Select Measrment (main) and select the channel that is set up in the display.
3. Press Statistics (main) → Statistics Mean/StdDev (side).
4. Press Statistics Weights (side) and enter 20.

   Figure E–2 shows an example of Statistics set up properly.

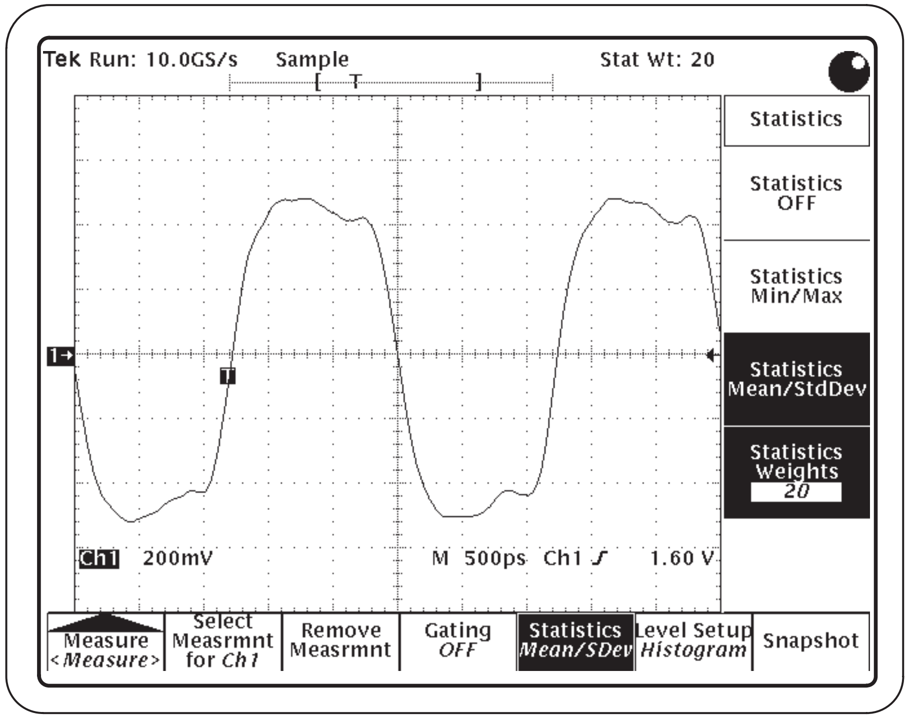


Figure E–2: Statistics set up properly example

5. Press Level Setup Histogram (main) ➞ Histogram (best for pulses).
6. Press Set Levels in % units (side).
7. Press – more – 1 of 2 (side) ➞ High Ref (side) and select 80%.
8. Press Low Ref (side) and select 20%.
9. Press Select Measrmnt ➞ –more– x of 8 until the Rise Time and Fall Time side menu items appear.
10. Select the corresponding side menu item for the appropriate measurement, Rise Time or Fall Time.

    Figure E–3 shows the Level Setup set up properly.

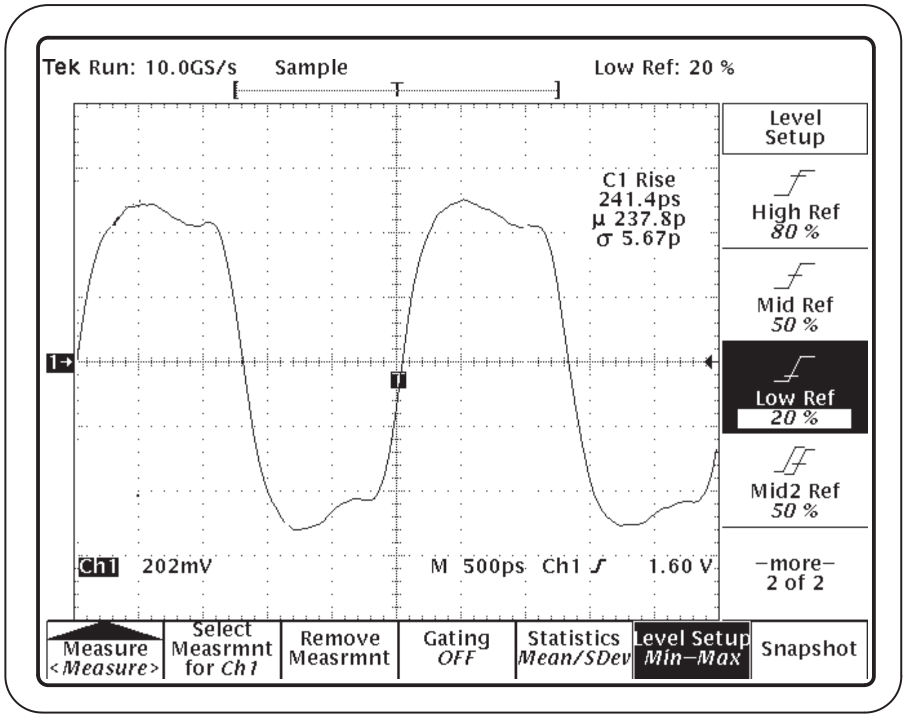


Figure E–3: Level Setup set up properly example

***NOTE**. Rambus Rise Time and Fall Time measurements are calculated at 20% and 80% Min/Max voltage levels.*

---

11. To measure a Rambus clock signal, take the measurement in Free Run acquisition mode.

Figure E–4 shows the statistical Rise Time measurement on a Rambus clock signal. Figure E–5 shows the statistical Rise Time measurement on a Rambus data signal.

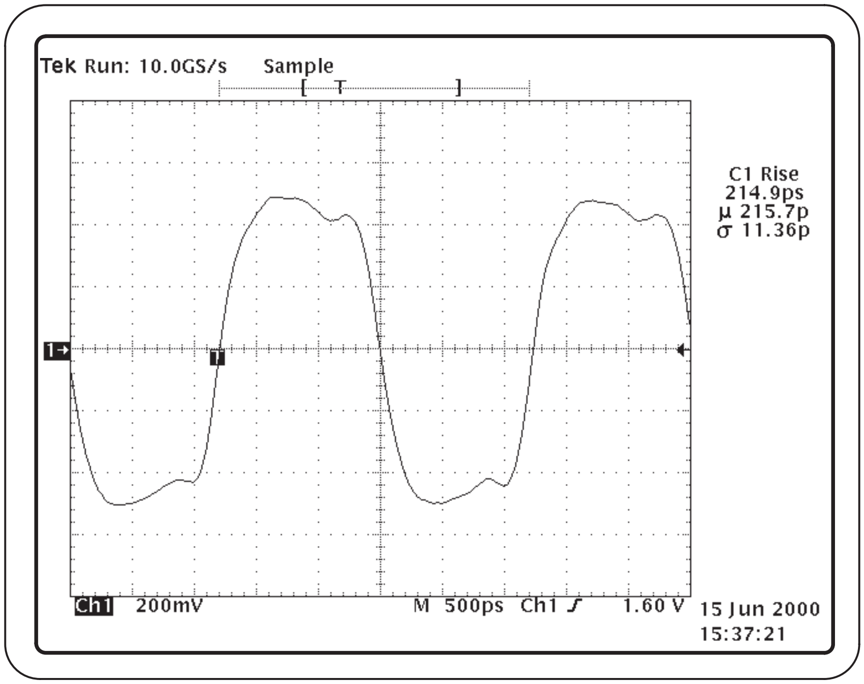


Figure E–4: Statistical results on a Rambus clock signal

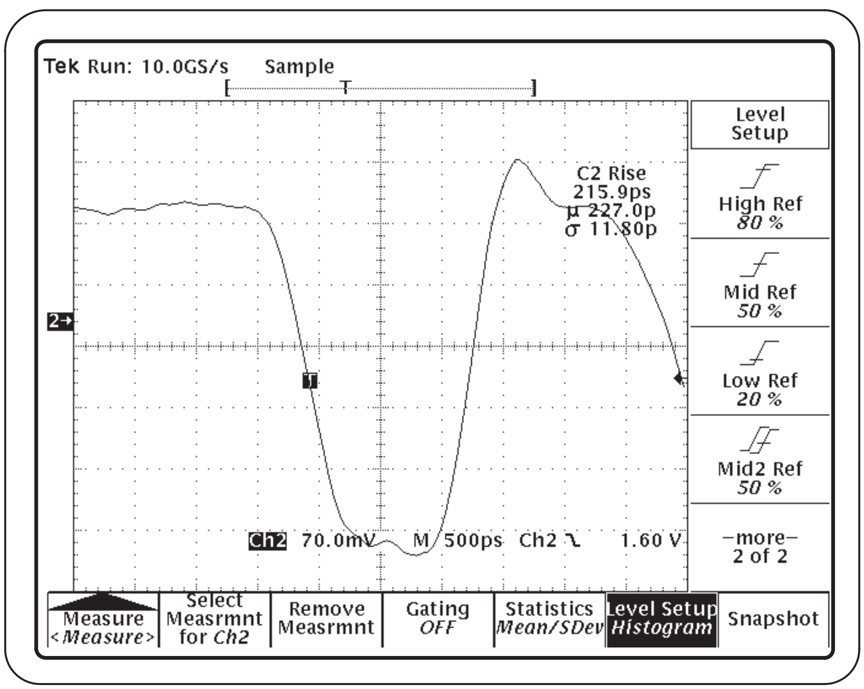


Figure E–5: Statistical results on a Rambus data waveform (Read cycle)

12. To measure a Rambus data signal, be sure to use a data pattern generator that is set up to produce a consistent and repetitive data pattern for the edge of interest.

Abbreviated Procedure

In this procedure, the bottom buttons are abbreviated as BB and the side buttons are abbreviated as SB. Figure E–6 shows the abbreviations.

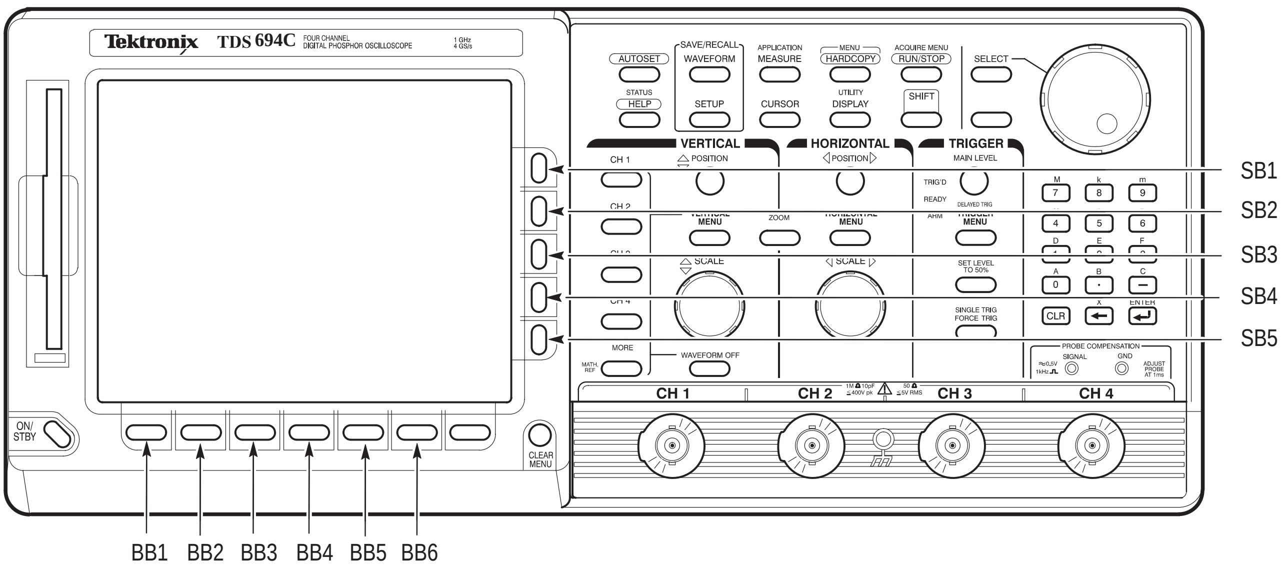


Figure E–6: Button abbreviations

To quickly perform the detailed procedure, follow these steps:

1. Press the Measure front-panel button.

2. Press **BB1** and select the Measure mode.

3. Press **BB2** and select the channel that is set up in the display.

4. Press **BB5**, Statistics.

5. Press **SB3**, Statistics Mean/StdDev.

6. Press **SB4**, Statistics Weights, key in 20, and press ENTER.

7. Press **BB6**, Level Setup Histogram.

8. Press **SB2**, Histogram (best for pulses).

9. Press **SB4**, and select %.

10. Press **SB5**, –more– 1 of 2.
11. Press **SB1** and use the GP knob to select 80% for High Ref.
12. Press **SB3** and use the GP knob to select 20% for Low Ref.
13. Press **BB2**, and press –more– x of 8 until the Rise Time and Fall Time side menu items appear.
14. Press **SB1** or **SB2** depending on the measurement you want to take.
15. To take the measurement, use the Free Run acquisition mode.

***NOTE**. To measure a Rambus data signal, be sure to use a data pattern generator that is set up to produce a consistent and repetitive data pattern for the edge of interest.*

Index

Index

Symbols

.CSV file
  copying, 2–40
  custom annotation with GPIB command, 2–24
  definition, 2–39
  example, 2–25
  format, 2–24
  importing, 2–24
  path on the oscilloscope, 2–40
  saving, 2–23
  viewing on a personal computer, 2–41

A

accessories
  optional, 1–2
  standard, 1–2
Address, Tektronix, xi
application
  basic functions with an oscilloscope, 2–2
  description, 1–1
  deskewing probes and channels, 1–4
  exiting, 2–28
  GPIB program example, 2–44
  installing, 1–3
  menu structure, 2–1, 3–1
  returning to, 2–3
  setting up, 2–12
    to plot results, 2–18
    to save results, 2–22
    to save worst case waveforms, 2–22
    to take measurements, 2–13
    to view results, 2–20
  starting, 2–29
  test methodology, A–1
  updates, 1–2
  waveform points used, 2–4

C

Cancel, 2–2
CFM contact points
  MCH, 1–12
  RIMM, 1–12
changing settings during a measurement, 2–22
Channel Error measurement, application equation, A–5
channels, deskewing, 1–4, D–1
CLEAR MENU button, 2–26
Clock Speed menu
  descriptions, 2–16
  parameters, 3–5
codes, error, C–1
color code
  for Mean values when using Limits, 2–18
  for PASS or FAIL when using Limits, 2–18
command syntax, GBIP protocol, B–1
common menu items, 2–2
configuring the display, 2–3
connecting to a system under test, 1–9
Contacting Tektronix, xi
Control menu, 2–21
  parameters, 3–9
conventions, x
CTM contact points
  MCH, 1–12
  RIMM, 1–12

D

data log file
  custom annotation with GPIB command, 2–24
  example, 2–25
  format, 2–24
  importing, 2–24
  saving, 2–23
  saving the results tutorial lesson, 2–38
Default Setup, 2–28
Deskew menu
  descriptions, 2–15
  parameters, 3–5
  setup items, 2–16
deskewing probes and channels, 1–4
  with a Math1 waveform, D–1
dialog boxes, changing the appearance, 2–4
disk
  full message, 2–23
  not present message, 2–23
Display Options menu, 2–4
Done, 2–2

E

error codes, C–1
exiting the application, 2–28

F

FAIL, color code when using Limits, 2–18
Fall Time measurement
  application equation, A–6
  Histogram statistics, E–1
firmware version for the oscilloscope, 1–1
Flight Time Clock measurement, application equation, A–6
Flight Time Data measurement, application equation, A–5
Free Run acquisition mode, 2–21

G

GPIB protocol
  command syntax, B–1
  custom annotation for the data log file, 2–24
  guidelines, 2–43
  oscilloscope operation, ix
  program example, 2–44
graphical formats, 2–26
  Histogram menu parameters, 3–7
  Profiling menu parameters, 3–7

H

Help, online, 2–2
High Read pulse example, 2–8
High Write pulse example, 2–5
Histogram format
  Autoscale, 2–26
  definition, 2–26
  description, 2–18
  scaling, 2–26
Histogram measurement, E–1
Histogram menu
  parameters, 3–7
  setup items, 2–19
Hold Time, tutorial lesson, 2–32
Hold Time measurement, application equation, A–4

I

inputs
  for Read cycles, 2–13
  for Write cycles, 2–14
Inputs menu, 2–13
  descriptions, 2–14
  parameters, 3–4
installation
  application, 1–3
  downloading updates, 1–2

L

leaving the application, 2–28
lessons. *See* tutorial lessons
Limits Edit menu
  descriptions, 2–17
  parameters, 3–6
Limits menu
  color code of Mean values, 2–18
  color code of PASS and FAIL, 2–18
  default values, 3–6
  descriptions, 2–17
  parameters, 3–6
loading, reference waveforms, 2–31
localizing measurements, 2–22
log file, example, 2–25
Logging menu
  descriptions, 2–22
  Results, description, 2–23
  Results parameters, 3–8
  Worst Case Wfms, description, 2–23
  Worst Case Wfms parameters, 3–8
Low Read pulse example, 2–10
Low Write pulse example, 2–6

M

main menus, 2–1
Math1 waveform to deskew, D–1
MCH definition, 2–4
Mean values, color code when using Limits, 2–18
Measure menu, 2–12
  descriptions, 2–12
  parameters, 3–3
measurements
  application equation
    Channel Error, A–5
    Fall Time, A–6
    Flight Time Clock, A–6
    Flight Time Data, A–5
    Hold Time, A–4
    Rise Time, A–6
    Setup Time, A–3
    Timing Quality (tq), A–4
  application test method, A–1
  GPIB program example, 2–44

localizing, 2–22
oscilloscope changes, 2–22
pattern descriptions, 2–11
plotting results, 2–18
setting up, 2–12
setup parameter selections, 2–13
starting, 2–21
taking, 2–21
test algorithms, A–1
turning off display, 2–26
tutorial lessons, 2–29
viewing results, 2–20
waveform points used by the application, 2–4
menu structure
description, 2–1
overview, 3–1
menus
Clock Speed, 2–16
Control, 2–21
Deskew, 2–16
Display Options, 2–3
Help, 2–2
Histogram, 2–19
Inputs, 2–13
Limits, 2–17
Limits Edit, 2–17
Logging, 2–22
Measure, 2–12
Plot Results, 2–18
Profiling, 2–20
Recall Setup, 2–28
Results Logging, 2–23
Save Setup, 2–27
Setup, 2–13
Test Signal Configuration, 2–16
Utility, 2–2
View Results, 2–20
Worse Case Wfms Logging, 2–23
messages
error codes, C–1
Warning, 2–3

N

not enough cycles, error message, 2–22

O

Okay, 2–2
online help, 2–2
oscilloscope
basic functions with the application, 2–2
compatibility, 1–1
deskewing probes and channels, 1–4
firmware version, 1–1
setup guidelines, A–1

P

P6248 Differential probes, 1–11
P6249 Active probes, 1–11, 1–12
parameters, reference, 3–3
PASS, color code when using Limits, 2–18
pattern generator software, 2–11
patterns, descriptions, 2–11
Phone number, Tektronix, xi
Plot For, description, 2–18
Plot Results menu
descriptions, 2–18
parameters, 3–7
probes, deskewing, 1–4, D–1
product
compatibility, 1–1
description, 1–1
requirements and restrictions, 1–1
updates, 1–2
Product support, contact information, xi
Profile format
definition, 2–26
description, 2–18
Profiling menu
parameters, 3–7
setup items, 2–20
programmer information for the oscilloscope, ix

Q

quiescent time definition, 2–4
quitting the application, 2–28

R

Rambus mother board, 1–10
Rambus system terms, 2–4
Read cycles
contact points for CTM, 1–12
inputs used for measurments, 2–13
Read even negative pulse example, 2–10
Read even positive pulse example, 2–8
Read Pulse examples, 2–8
Recall from File, 2–28
Recall Setup menu, 2–28
recalling a setup, 2–28

reference memory, record length, 2–24
reference voltage levels, 2–15
reference waveforms, loading, 2–31
requirements and restrictions, 1–1
Reset Results, 2–21, 2–26
results
  clearing from display, 2–26
  turning off display, 2–26
  viewing in various formats, 2–25
Results Logging menu
  descriptions, 2–23
  parameters, 3–8
RIMM definition, 2–4
Rise Time measurement
  application equation, A–6
  Histogram statistics, E–1
Run Time Environment version number, 1–1

S

Save Setup menu, 2–27
Save to File, 2–27
Service support, contact information, xi
setup
  default, 2–28
  parameter descriptions, 2–13
  recalling, 2–28
  saving, 2–27
  verify physical configuration, 1–15
Setup menu, 2–13
  parameters, 3–3
Setup Time, tutorial lesson, 2–32, 2–36
Setup Time measurement, application equation, A–3
side menus, 2–1
signal level measurements, A–2
Single acquisition mode, 2–21
starting
  application, 2–29
  to take measurements, 2–21
statistical results, 2–26
  turning off display, 2–26
statistics, Rise Time and Fall Time measurements, E–1
synthetic clock definition, 2–4
system under test, 1–9

T

Technical support, contact information, xi
Tektronix, contacting, xi
terms, Rambus system, 2–4
Test Signal Configuration menu
  descriptions, 2–16
  parameters, 3–5
Tq measurement, application equation, A–4
tutorial lessons, 2–29
  See also exiting the application; recalling a setup; saving a setup
  dual waveform, 2–36
  Hold Time measurments, 2–32
  Result Summary
    Channel Error, 2–38
    Setup and Hold Time, 2–35
  saving the results to a data log file, 2–38
  Setup Time measurments, 2–32
  View Details
    Channel Error Falling, 2–38
    Hold Time, 2–36
    Setup Time, 2–35

U

URL, Tektronix, xi
Utility menus
  descriptions, 2–2
  parameters, 3–9
  structure, 3–2

V

VARIABLE:VALUE TDS COMMAND, B–2
verify physical setup, 1–15
View Results menu
  descriptions, 2–20
  parameters, 3–9
viewing
  obscured parts of waveforms, 2–26
  results in a spreadsheet program, 2–25
  results in graphical formats, 2–26
  statistical results, 2–26

W

Warning messages, 2–3
waveforms
  display color, 2–4
  displayed on a verifed setup, 1–15
  measurement points, 2–4
  viewing obscured parts, 2–26
web site, 1–2
Web site address, Tektronix, xi
Worst Case Wfms Logging menu
  descriptions, 2–23
  parameters, 3–8

Write cycles
contact points for CFM, 1–12
inputs used for measurments, 2–14

Write even negative pulse example, 2–6
Write even positive pulse example, 2–5
Write Pulse examples, 2–5