LeCroy

Operator's Manual

SPARQ Series

Signal Integrity Network Analyzers

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SPARQ Overview

Welcome and thank you for purchasing your LeCroy SPARQ series Signal Integrity Network Analyzer. The SPARQ is a new concept in S-Parameter acquisition, allowing users to measure S-parameters and time-domain responses quickly, easily, and inexpensively.

What the SPARQ does: An Overview

#1 SPARQ Capability: S-parameters, Quick

The SPARQ uses time-domain reflectometry (TDR) and Time Domain Transmissometry (TDT) as the underlying method to measure the S-Parameters of a device under test. In addition to S-parameters, the SPARQ generates time-domain results as well, including step response, impulse response, rho, and Z.

The SPARQ uses both patented and patent-pending technologies to:

- Acquire the TDR and TDR waveforms at high speed: roughly 10x faster than a typical sampling oscilloscope. This is accomplished using LeCroy's **Coherent Interleaved Sampling** architecture, which ensures coherent sampling while remaining synchronous to the TDR pulse.
- Determine S-parameters of the device under test via an algorithm that de-embeds other system components, including the internal relay assembly, and, optionally, the attached cables, adapters and fixture.

Operator's Manual Structure

This manual takes a combined approach to documenting the SPARQ hardware and software. It includes sections covering main systems of the application. Coverage includes elements of the user interface, including menus, dialogs and the main window, and most include **How To** sections describing how to use many of the SPARQ application's features. It also includes a Theory of Operation section that goes into further detail of the technologies used in the generation and acquisition of the TDR and TDT waveforms, and the analysis performed to obtain S-parameter and time-domain results.

Support

When your product is delivered, verify that all items on the packing list or invoice copy have been shipped to you. Contact your nearest LeCroy customer service center if anything is missing or damaged. If there is something missing or damaged, and you do not contact us immediately, we cannot be responsible for replacement. If you have any problems with your product, please refer to the LeCroy website at http://www.lecroy.com to find out how to contact an applications engineer for technical support.

Thank You

We truly hope these materials provide increased comprehension when using LeCroy's fine products.

Sincerely,

David C. Graef

LeCroy Corporation
Vice President and Chief Technology Officer

Unpacking Your SPARQ

After unpacking the contents, confirm that there are no missing items from the following:

- Your SPARQ instrument
- SMA cables (one for each SPARQ port)
- USB 2.0 cable
- Power cord

The **Accessory Kit** includes the following items standard:

- 2.92 mm female-to-female adapters (one for each SPARQ port)
- Torque wrench
- Universal wrench
- USB memory stick

If a **SPARQ-OSLT** calibration kit was purchased along with your SPARQ, the accessory kit will also include:

- 2.92 mm male-to-male adapter (qty 2)
- 2.92 mm Open/Short adapter, female
- 2.92 mm Open/Short adapter, male
- 50 ohm termination, male
- 50 ohm termination, female

  Calkit files will be included on the USB memory stick.

Please take the time to verify the items purchased and promptly report any missing items or issues to us using **Contact LeCroy for Support** (on page 85).

Safety Requirements

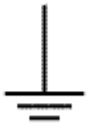
This section contains information and warnings that must be observed to keep the instrument operating in a correct and safe condition. You are required to follow generally accepted safety procedures in addition to the safety precautions specified in this section.

Safety Symbols

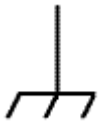
Where the following symbols appear on the instrument's front or rear panels, or in this manual, they alert you to important safety considerations.

This symbol is used where caution is required. Refer to the accompanying information or documents in order to protect against personal injury or damage to the instrument.

This symbol warns of a potential risk of shock hazard.



This symbol is used to denote the measurement ground connection.



This symbol is used to denote a frame or chassis connection.

This symbol is used to denote a safety ground connection.

On (Power). This symbol is marked next to the AC power ON/Stand-by switch located on the back of the instrument. When the switch is flipped to position, the PWR LED on the front panel lights-up Green, indicating the Power ON status of the instrument.

Stand-by (Power). This symbol is marked next to the AC power ON/Stand-by switch located on the back of the instrument. When the switch is flipped to this position, the PWR LED on the front panel is turned Off.

CAUTION

The **CAUTION** sign indicates a potential hazard. It calls attention to a procedure, practice or condition which, if not followed, could possibly cause damage to equipment. If a **CAUTION** is indicated, do not proceed until its conditions are fully understood and met.

WARNING

The **WARNING** sign indicates a potential hazard. It calls attention to a procedure, practice or condition which, if not followed, could possibly cause bodily injury or death. If a **WARNING** is indicated, do not proceed until its conditions are fully understood and met.

CAT I

Installation (Overvoltage) Category rating per EN 61010-1 safety standard and is applicable for the instrument front panel measuring terminals. **CAT I** rated terminals must only be connected to source circuits in which measures are taken to limit transient voltages to an appropriately low level.

Operating Environment

The instrument is intended for indoor use and should be operated in a clean, dry environment. Before using this product, ensure that its operating environment is maintained within these parameters:

Temperature: 5 °C to 40 °C.

Humidity: Maximum relative humidity 80% for temperatures up to 30 °C decreasing linearly to 50 % relative humidity at 40 °C.

Altitude: Up to 10,000 ft (3,048 m) at or below 30 °C.

Note: Direct sunlight, radiators, and other heat sources should be taken into account when assessing the ambient temperature.

WARNING

The instrument must not be operated in explosive, dusty, or wet atmospheres.

CAUTION

Do not exceed the maximum specified front panel terminal voltage levels. Refer to Specifications for more details.

Safety Certification

The design of the instrument has been verified to conform to applicable EN 61010-1, UL 61010-1 2nd Edition and CSA C22•2 No•61010-1-04 safety standards for the following limits:

- Installation (Overvoltage) Categories II (Mains Supply Connector) & I (Measuring Terminals).
- Pollution Degree 2.
- Protection Class I.

PLEASE NOTE THE FOLLOWING:

- Installation (Overvoltage) Category II refers to local distribution level, which is applicable to equipment connected to the mains supply (AC power source).
- Installation (Overvoltage) Category I refers to signal level, which is applicable to equipment measuring terminals that are connected to source circuits in which measures are taken to limit transient voltages to an appropriately low level.
- Pollution Degree 2 refers to an operating environment where normally only dry non-conductive pollution occurs. Conductivity caused by temporary condensation should be expected.
- Protection Class 1 refers to grounded equipment, in which protection against electric shock is achieved by Basic Insulation and by means of a connection to the protective ground conductor in the building wiring.

Cooling

The instrument relies on forced air cooling with an internal fan and ventilation openings. Care must be taken to avoid restricting the airflow around the apertures (fan holes) at the side and rear of the instrument. Ensure adequate ventilation by leaving the required 10 cm (4 inch) minimum gap around the sides and rear of the instrument.

CAUTION

Do not block the ventilation holes located on both sides and rear of the instrument. Do not allow any foreign matter to enter the instrument through the ventilation holes, etc.

The instrument also has internal fan control circuitry that regulates the fan speed based on the ambient temperature. This is performed automatically after start-up with no manual intervention required.

AC Power Source

100 to 240 VAC (+/-10%) at 50/60 Hz

No manual voltage selection is required because the instrument automatically adapts to line voltage.

Power Consumption

Maximum power consumption in Operating Mode: 80 Watts

Maximum power consumption in Standby Mode: 7 Watts.

Power and Ground Connections

The instrument is provided with a 10A/250V 18AWG rated grounded cord set containing a molded three-terminal polarized plug and a specific IEC-60320 (Type C13) connector for making line voltage and safety ground connections. The AC inlet ground terminal is connected directly to the frame of the instrument. For adequate protection against electrical shock hazard, the power cord plug must be inserted into a mating AC outlet containing a safety ground contact.

WARNING - Electrical Shock Hazard

Only use the power cord provided with your instrument.

Any interruption of the protective conductor inside or outside of the instrument, or disconnection of the safety ground terminal creates a hazardous situation. Intentional interruption is prohibited.

In Standby mode, the instrument is still connected to the AC supply. The instrument can only be placed in a complete Power Off state by physically disconnecting the power cord from the AC supply.

Calibration

The recommended calibration interval is one year. Calibration should be performed by qualified personnel only.

Cleaning

Clean only the exterior of the instrument, using a damp, soft cloth. Do not use chemicals or abrasive elements. Under no circumstances allow moisture to penetrate the instrument.

Avoid electrical shock hazard by unplugging the power cord from the instrument before cleaning.

Abnormal Conditions

Operate the instrument only as intended by the manufacturer.

If you suspect the instrument's protection has been impaired, disconnect the power cord and secure the instrument against any unintended operation.

The instrument's protection is likely to be impaired if, for example, the instrument shows visible damage or has been subjected to severe transport stresses.

Proper use of the instrument depends on careful reading of all instructions and labels.

WARNING

Any use of the instrument in a manner not specified by the manufacturer may impair the instrument's safety protection.

Installing SPARQ Software

Finding the Installers

The installers for the SPARQ application are delivered along with your SPARQ, either on a **USB memory key** included in the Accessories Case, and/or on the **SPARQ memory card**. The SPARQ memory card is readable by your PC, so files may be copied off of it at any time.

LeCroy regularly releases software upgrades that may include additional features and fixes.The latest revision of the SPARQ software is downloadable from the LeCroy website at **www.lecroy.com**.

> **Note**: Before installing software and drivers, be sure to review the **SPARQ System Requirements** (on page 24) topic.

Selecting an Installer

Installers can be found from the LeCroy homepage by clicking the **Support** menubar, and selecting **Software Downloads**.

There are two versions of the SPARQ installer available; one for **32-bit** (x86) Windows and another for **64-bit** Windows operating systems.

- **SPARQInstaller.exe**: Use this installer for 32-bit (x86) operating systems, including Windows XP, Windows Vista and Windows7.
- **SPARQInstaller64.exe**: Use this installer for Windows Vista x64 and Windows7 x64 operating systems.

Do not run SPARQInstaller.exe or SPARQInstaller64.exe on LeCroy Oscilloscopes. Doing so can cause both SPARQ and oscilloscope applications to malfunction. Topics later in this manual cover how to select an installer and configure a version of the SPARQ application for use on a LeCroy oscilloscope.

Software Installation

Follow these instructions when installing the SPARQ application on typical PCs.

> **Note**: Do not install **SPARQInstaller.exe** or **SPARQInstaller64.exe** on LeCroy oscilloscopes.

Topics later in this manual cover how to select an installer and configure a version of the SPARQ application for use on a LeCroy oscilloscope.

Connect the SPARQ to your PC using a USB cable and power-up the SPARQ using the on/off switch on the back of the unit.

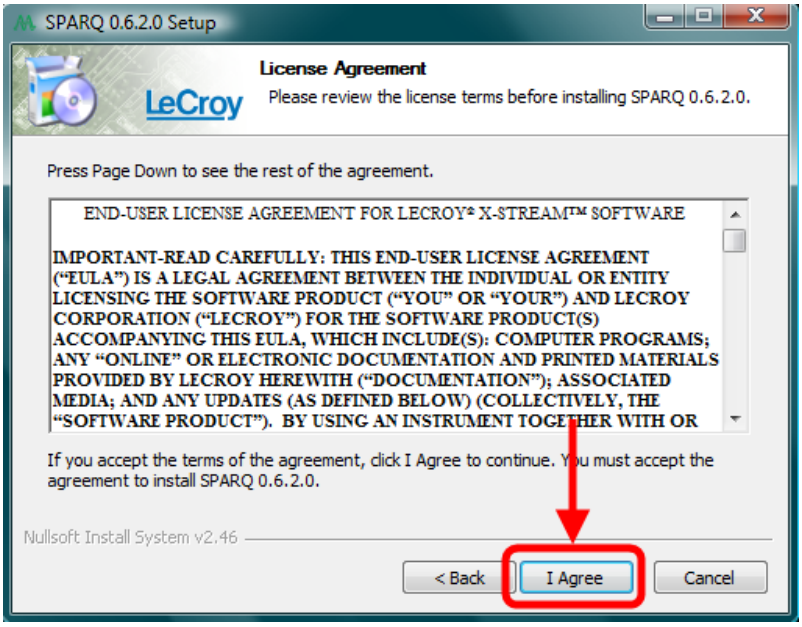
- Depending on your version and configuration of Windows, you may be prompted to **Scan and fix the volume SPARQ_CAL (X:)**. Close this window, or click **Continue without scanning**.
- Depending on your version and configuration of Windows, you may also see a window titled **Autoplay**. Close this window.

> **Note**: The SPARQ memory card is configured as read-only.

Now, run the installer by double-clicking on the installation file (**SPARQInstaller.exe** or **SPARQInstaller64.exe**) either downloaded from **www.lecroy.com** or by selecting the appropriate installer included with the SPARQ.

The **SPARQ Setup Wizard** is shown after the installer unpacks and steps you through the installation process. Click the **Next** button to continue.

The **License Agreement** screen is then shown. Accept the terms of the agreement and click the **I Agree** button to proceed with the installation.

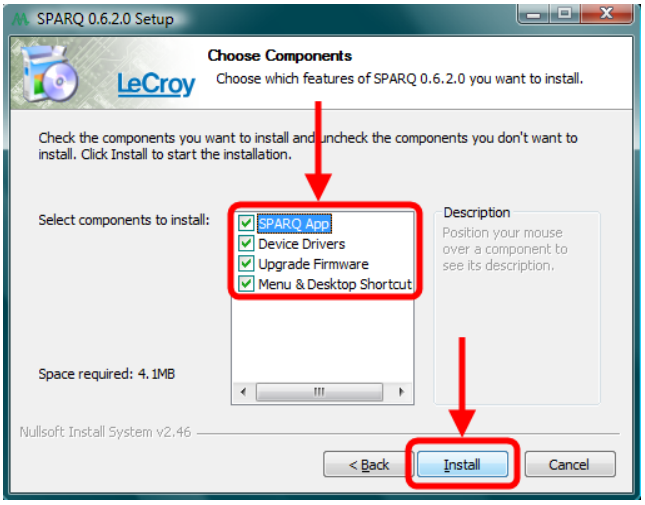


The Choose Components screen is shown. Mark the checkboxes for the desired components (described as follows) for your installation.

- **SPARQ App** - Select to install the main SPARQ application and required files.
- **Device Drivers** - Select to install the USB device drivers required for the PC to communicate with the SPARQ. Two drivers are installed, and can be found in the Device Manager utility on your PC.
- **Upgrade Firmware** - Selecting enable the installer to determine whether the microcode used in the SPARQ requires upgrading. If the installer includes a newer version of the microcode, the **Hardware Programmer** screen (as follows) is shown.

- **Menu & Desktop Shortcut** - Select to have the installer add a SPARQ folder to the LeCroy section of your Start Menu programs and place a SPARQ shortcut on your desktop.

With your selections made, click the **Install** button to proceed.

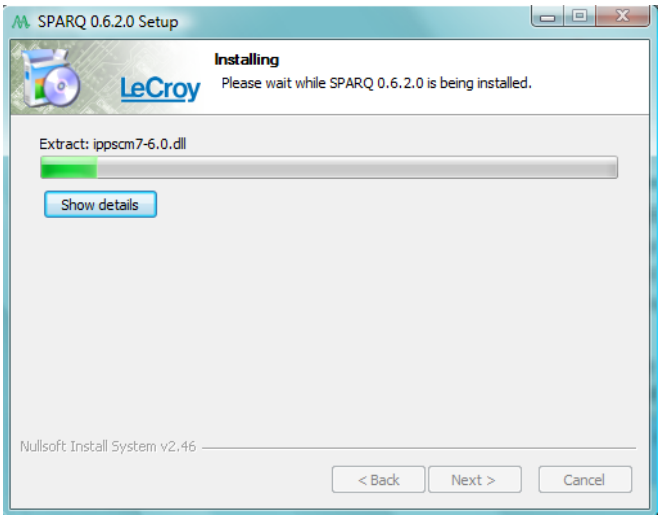


Hardware Programmer Screen - If the **Upgrade Firmware** checkbox was marked prior to clicking the **Install** button, and the installer includes a newer version of microcode than currently installed in the SPARQ, the **Hardware Programmer** screen is shown. This is a separate window from the SPARQ Installation Wizard.

Click on any active **Upgrade** buttons on the **Hardware Programmer** screen to begin the microcode upgrade process. A progress box is shown indicating the status of the upgrade.

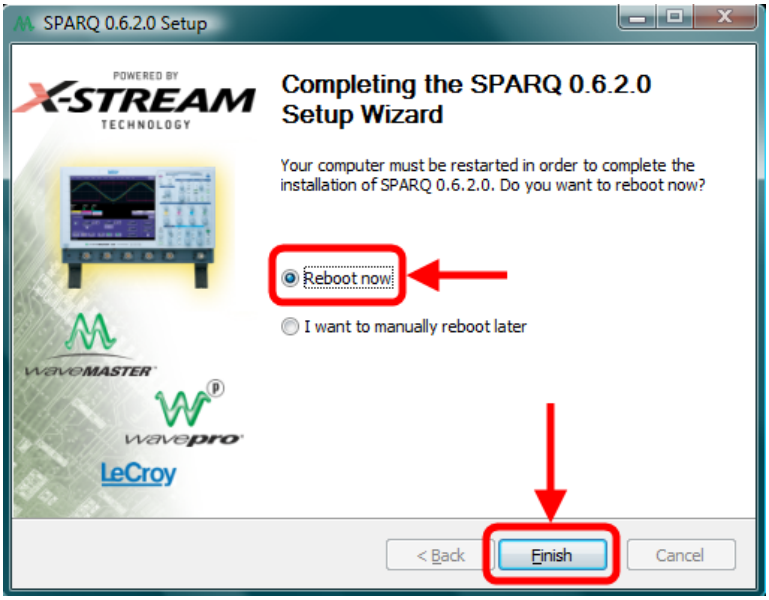
Note: Never power down the SPARQ or your PC during the microcode installation process.

Whether or not the **Hardware Programmer** screen is shown, the **Installing** screen continues and progress bar indicates the status of the installation.



When the installation finishes, the **Installing** screen closes and the **Completing the SPARQ Setup Wizard** screen is shown.

Choose the **Reboot now** option and click the **Finish** button to complete your SPARQ installation.



Selecting an Installer for use on LeCroy Oscilloscopes

COMING SOON FROM LECROY - Software that installs on specific oscilloscope models and allows you to operate your SPARQ from the instrument (instead of a separate PC).

Installation Instructions: LeCroy Oscilloscopes - COMING SOON

COMING SOON FROM LECROY - Software that installs on specific oscilloscope models and allows you to operate your SPARQ from the instrument (instead of a separate PC). A subsequent firmware version containing this specific controller software is upcoming.

This topic eventually explains the installation to operate the SPARQ from your LeCroy Oscilloscope.

Initial Checkout

An **Initial Checkout** must be completed **after**:

1. Installing your SPARQ software on your PC.
2. Powering down your SPARQ and rebooting your PC.
3. Re-initialize your SPARQ as explained in the **SPARQ System Operation** (on page 18) topic.

When the SPARQ application is launched on your PC (after rebooting) the program performs various initializations. The application also copies and unpacks calibration files stored on the SPARQ's memory card. Finally, the application's main window is shown.

Now, you're ready to perform an **Initial Checkout** using the following steps:

1. Go to **SPARQ Setup → Instrument Setup**.
2. Click **Run Self Test**. The SPARQ application determines if there are any missing calibration files. If the Self test does not result in a **Self Test succeeded** message, a problem must be resolved before using your SPARQ. Please refer to the **Troubleshooting** topic for more information.
3. If your self test succeeded, learn how to use your SPARQ by working through the **Getting Started Tutorial and Example - 2 Port Measurement** (on page 19) topic.

SPARQ System Operation

Power-Up Sequence

This manual makes reference to your SPARQ system. Your SPARQ system is comprised of the following components:

- Your SPARQ unit.
- Your PC with the SPARQ application correctly installed.
- The USB cable connecting your SPARQ unit and your PC.

For proper operation, initialize your system components in the following order:

1. Start your PC normally.
2. Connect your SPARQ to your PC using the USB cable provided.
3. Power-up your SPARQ unit.
4. Now, wait approximately 10 seconds until Windows detects your SPARQ and loads the necessary device drivers.

   Note: Depending on your Windows operating system, you may be prompted to **Scan and fix SPARQ_CAL (D:)** . If so, click **Continue without scanning**. Other operating systems may show an **AutoPlay** window, which should just be closed.

5. Now, launch the SPARQ application on your PC.

SPARQ Application Operational Notes

1. The SPARQ application expects the SPARQ hardware unit to be powered up and the required device drivers to be present on your PC. Device drivers typically load promptly after the SPARQ is turned on, or when a running SPARQ is connected to your PC. However, load times vary. Should the application show a **No HW detected** message, its likely that the drivers did not finish loading before launching the application.
2. Leave the USB cable connected while operating the SPARQ application. The application does not re-connect to the SPARQ if the cable is disconnected and reconnected.
3. Similarly, leave the SPARQ unit powered up while running the SPARQ application on your PC. If the SPARQ unit is rebooted while the PC application is running, it is recommended to exit the application, power down the SPARQ, and bring the system up as per the instructions as explained in the **Power-Up Sequence** topic.
4. **Hibernate** and **Sleep** modes are not supported; the SPARQ PC application loses communication with the SPARQ unit when the PC sleeps or hibernates. If your PC Hibernates or Sleeps, restart your system by exiting the application, powering down the SPARQ, and bringing the system up as per the instructions as explained in the **Power-Up Sequence** topic (previous).

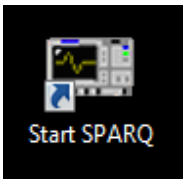
Getting Started Tutorial and Example - 2 Port Measurement

This tutorial walks through a simple 2-port measurement setup. You need your SPARQ, two of the supplied cables, and one of the supplied 2.92 mm female-to-female adapters, or any other device under test (DUT) you may wish to use. The SPARQ software should be installed on your PC as per the **Installing SPARQ Software** (on page 14) topic.

Note: This tutorial includes several optional steps not required when taking a quick, basic measurement. Feel free to skip optional steps.

Instrument and Software Setup

1. Connect your SPARQ unit to your PC with the USB cable.
2. Power up the SPARQ. The SPARQ is detected, and USB drivers load. A window may be shown alerting you that a new drive has been detected; close this window.
3. Run the SPARQ application on your PC by double-clicking the **Start SPARQ** shortcut.



4. Attach two of the supplied cables to ports 1 and 2 of your SPARQ unit. Attach the end of the cable NOT labeled **DUT** to the SPARQ, and tighten to the correct torque. De-embedding of these cables is handled in interfaces covered in step 6 as follows.


Take care to only turn the nut on the cable, and not to rotate the adapter. Doing so degrades the performance of both the cable and adapter. In general, **never** rotate the center conductor of a cable or adapter when inserted into a mating receptacle.

---

5. Reset the SPARQ application to the factory defaults by accessing **File → Recall Setup...** from the menu bar. The Recall Setup dialog is shown. Click the **Recall Default** button.

Note: Performing a Recall Defaults is recommended in order to establish a known setup starting point.

6. Now, select **SPARQ Setup → Instrument Setup**. The Instrument Setup dialog is shown and includes text boxes and Browse buttons for selecting the S-parameter files for up to 4 ports over cables attached on your system.

   The SPARQ uses these files to de-embed the cables as part of the algorithm determining the S-parameters of the DUT.

   - Click the checkbox to **De-embed Cables**. Although de-embedding cables is not required, always use this feature when using cables for which the S-parameters are available.

- The SPARQ is shipped with the S-parameters for the cables included standard with the instrument. Click the **Browse** buttons and navigate to the specific file location. The default location is **C:\LeCroy\SPARQ\SPARQ\Cables**. If the files are not in this folder, they may be included on a USB memory key supplied with your SPARQ. Each file is labeled with a serial number matching the cables supplied with your SPARQ.

Connect the cables to the Device Under Test (DUT)

Attach the cables to a simple DUT, such as one of the 2.92 mm female-female adapters supplied with SPARQ. As described previously, tighten by turning the nut on the cables without rotating the adapter with respect to the cable.

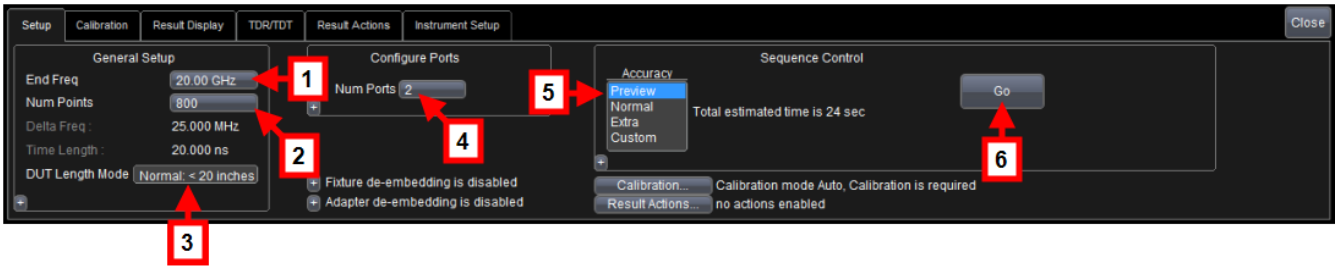
Setup the SPARQ Application for a Measurement

Access the **Main Setup Dialog** (on page 31) by clicking the Setup action button or selecting **SPARQ setup → Main Setup** from the menu bar. The Main Setup dialog includes most of the setups required.

Make the following settings (from left to right).

PLEASE NOTE THE FOLLOWING:

- Provide values in entry boxes by touching/clicking twice inside fields. Many fields provide a numeric keypad for entering accurate values.
- Many of the values are defaults and require no change.



Numbered callouts correspond with the following explanations.

1. **End Freq** - Enter **40 GHz**.
2. **Num Points** - Enter **400**.
3. **DUT Length Mode** - Select **Normal:< 20 inches**.
4. **Num Ports**: Enter **2** (in the Configure Ports section of the dialog).
5. **Sequence Control/Accuracy:** Select **Preview**.

Note: The **+** buttons on dialogs expand to show additional fields for more advanced SPARQ settings.

Start your measurements by clicking the **Go** button on this dialog. But first, let's explorer a little bit more of the SPARQ user interface by working through the following sections.

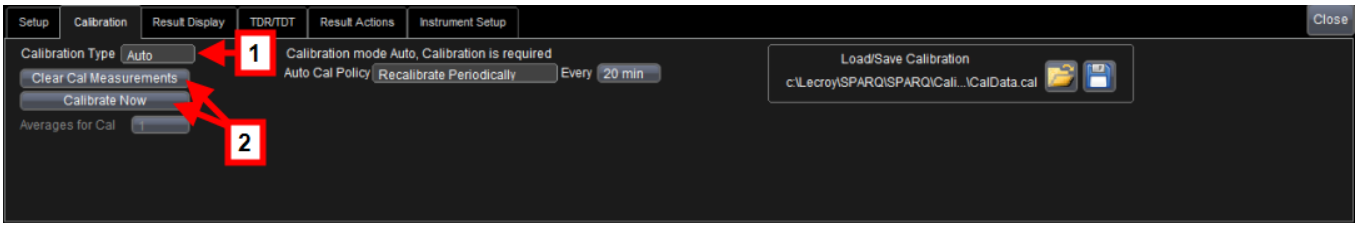
Some Additional SPARQ User Interface Settings

Use the following steps to make some SPARQ setting/adjustments.

Access the **Main Setup Dialog** (on page 31) by clicking the Setup action button or selecting **SPARQ setup → Main Setup** on the menu bar. Now, touch the **Calibration** tab (or click the **Calibration** button on the **Main Setup** dialog) to access the **Calibration Dialog** (on page 36) and make the following settings (from left to right).

PLEASE NOTE THE FOLLOWING:

- Provide values in entry boxes by touching/clicking twice inside fields. Many fields provide a numeric keypad for entering accurate values.
- Many of the values are defaults and require no change.



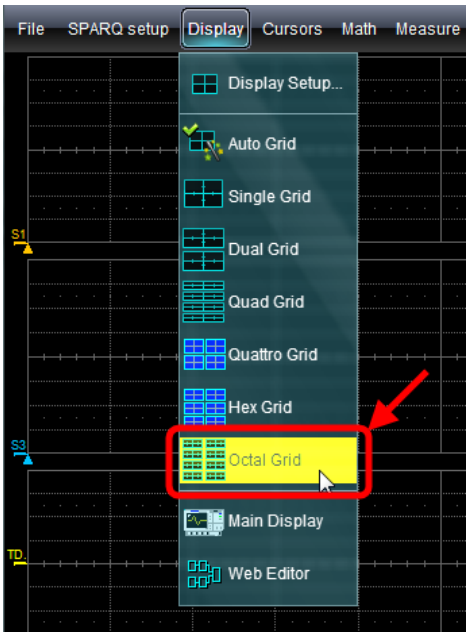
1. Ensure the **Calibration Type** is set to **Auto**. This sets up the SPARQ to use the internal calibration kit.
2. The Calibration dialog includes buttons to **Clear Cal Measurements** (clear the calibration data) currently being used, and to **Calibrate Now** (execute a calibration sequence).

> **Note**: Clicking **Clear Cal Measurements** does not actually delete any calibration files on the SPARQ or your PC. It simply clears out the calculated calibration data (an intrinsic part of S-Parameter calculation).

Trace Display Setup (Optional)

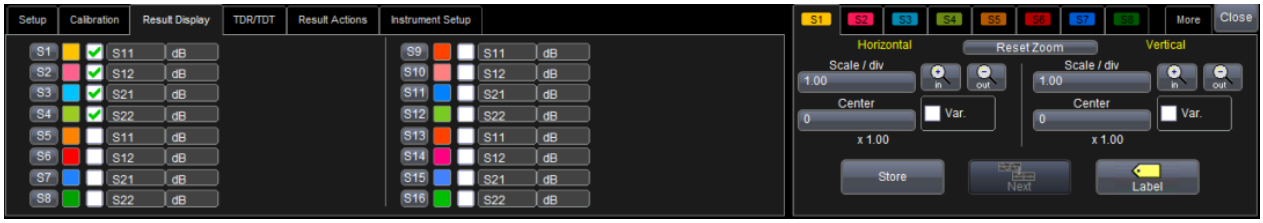
If desired, setup your trace display using the following steps:

1. Select **Display → Octal Grid** from the menu bar to simultaneously show 8 grids.

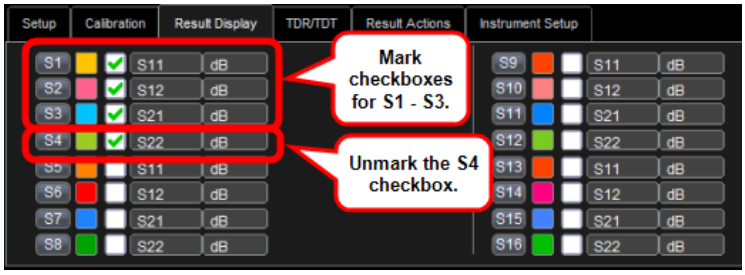


> **Note**: SPARQ measurements are independent of the traces currently displayed. S-Parameter results can be chosen for display either before, after, or during measurement sequences.

2. Now, select **SPARQ setup → Result Display** from the menu bar. The **Result Display Dialog** (on page 38) is shown and is used to choose which S-Parameter traces to display. There are 16 slots available. Configure the slots as follows:



- **S1** - Click the selector boxes to the right of the checkbox to configure trace S1 to show **S11**, with **dB** units.
- **S2** - Click the selector boxes to the right of the checkbox to configure trace S2 to show **S12**, with **dB** units.
- **S3** - Click the selector boxes to the right of the checkbox to configure trace S3 to show **S22**, with **dB** units
- **S4** - Click the selector boxes to the right of the checkbox to configure trace S4 to show **S12**, with **deg** units



- Mark the checkboxes next to **S1**, **S2**, and **S3**, and unmark any others that are checked.

Automatically Save Results Setup (Optional)

If desired, configure your SPARQ to automatically save your results using the following steps:

Select **SPARQ Setup → Result Actions**. The **Result Actions** dialog is shown and is where you can specify the actions for your SPARQ to take when S-Parameter measurements are complete.

- Click the **Browse** button next to the **Save Results** entry box to provide a **filename** and specify a **location** for the saved results.
- Mark checkboxes to **Append Timestamp** information to your results and even **Enable Actions** such as **Beep**, **Save**, and **Email**.

Taking a Measurement

Begin the calibration and measurement sequence by either clicking the **Go** action button, or clicking the Go button shown on the **Main Setup Dialog** (on page 31). You can hear the relays switch as the **Short, Open, Load, Thru (SOLT)** calibration standards are placed in the signal path, followed by the switching of the TDR pulse to port 1, and then port 2.

- The yellow **Status bar** to the right and just below the grid that displays the progress of the measurement sequence.
- The **Setup** dialog will become disabled while the measurement sequence is in progress.

When the measurement is complete, the S-parameter waveforms configured for display are posted, and the results are saved as described in the previous section.

Analyzing the Results and Advanced Controls (Optional)

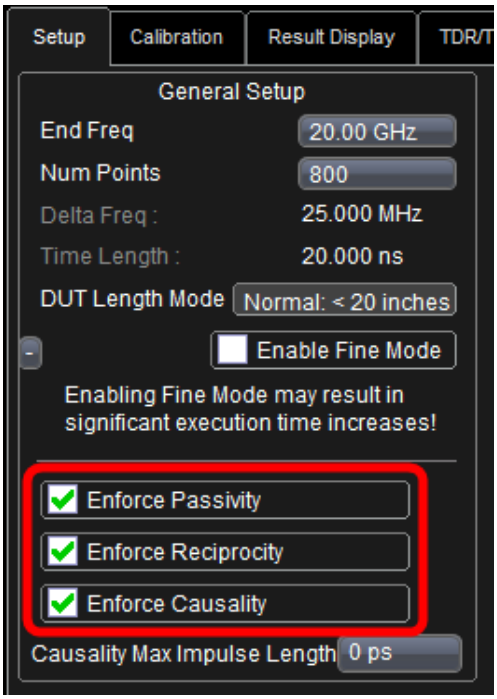
With a completed measurement, S-parameter traces can be further analyzed in various ways such as **System Setting Modifications**, **Zooming**, and **Cursor Measurements**.

Quite a few settings can be configured to your personal preference for the Display or changing the Grid Configuration.

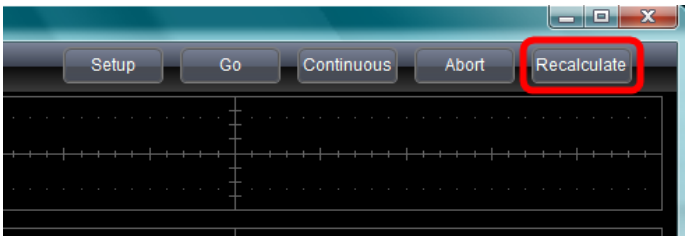
SPARQ System Setting Modifications

Let's use the following steps to modify several inputs to the S-parameter calculation using the advanced controls:

1. Select **SPARQ setup → Main Setup** to access the **Main Setup Dialog** (on page 31). This dialog includes most of the setups required.
2. Click any of the **+** buttons to display advanced setting fields.
3. In the lower left section of the screen, click the checkboxes to **Enforce Passivity**, **Reciprocity**, and **Causality**.



4. Click the **Recalculate** button at the top-right part of the screen to recalculate the S-parameters.

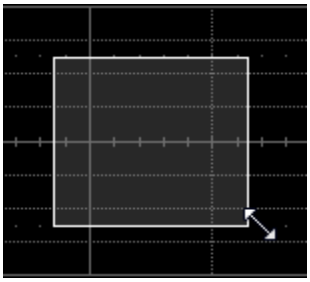


5. Watch the Status box as it indicates the SPARQ is **Calculating**.

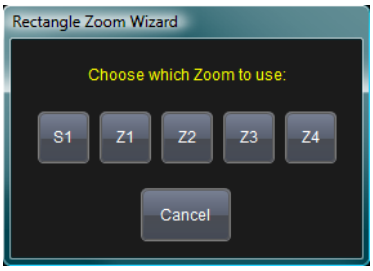
Note: You can click the **Recalculation** button if the changes made to the SPARQ setup do not affect the underlying TDR/TDT acquisition.

Zooming

Zoom any trace for a better view by drawing (touch and drag) a rectangle around a grid display region of interest.



The **Rectangle Zoom Wizard** pop-up is shown where you can select a zoom slot for use when displaying your zoomed area.



A zoom trace display label for your newly created zoom is then added to others shown in between the grid display and the lower dialogs.

Next Steps

- If you plan to setup S-Parameter measurements (which are more complicated), see **Configuring Ports for a Measurement** (on page 49)
- If you would like to learn more about taking a measurement with a SPARQ, see **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46)
- If you would like to learn more about how the SPARQ operates, see the **SPARQ Theory of Operation Overview** (on page 76)

SPARQ System Requirements

Minimum recommended PC specifications for running the SPARQ application include the following:

- **Operating System** - Running **32-Bit Windows XP with SP2**,or **32** or **64-Bit versions of Windows Vista** or **7**.
- **Processor** - An **Intel Core 2 Duo, 2.4GHz (or more)**.
- **RAM** - At least **2 GB of RAM (or more)**.
- **HDD Space** - At least **150 MB (or more)** of free HDD space.
- **Display** - Minimum **1280 x 780** pixels
- **Connectivity** - USB2.0 High-speed

Note: If running SPARQ from a compatible LeCroy oscilloscope, your instrument firmware must be at least **version 6.0.1.x or higher**.

SPARQ User Interface Components

Screen Layout, Groupings, and Controls

The SPARQ application user interface includes the following elements:

- **Menu Bar**
- **Action Buttons**
- **Grid Display Area**
- **Trace Descriptor Labels**
- **Dialog Area**
- **Status Bar**
- **Status Box**

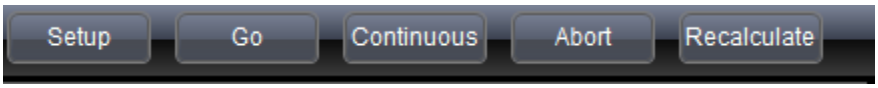
Menu Bar

Along the top of the application screen are menus (starting from the far left) used for accessing various dialogs and to perform specific actions. The menus include the following:

- **File Menu** (on page 56)
- **SPARQ Setup Menu** (on page 30)
- **Display Menu and Setup Dialog** (on page 65)
- **Cursors System** (on page 67)
- **Math Menu** (on page 70)
- **Measure Menu** (on page 75)
- Utilities
- Help

Action Buttons

Along the top of the application screen are several buttons (toward the right) for frequently-performed actions.



- **Setup** - Click to open the **Main Setup Dialog** (on page 31)
- **Go** - Click to initiate the sequencer. If a calibration is required, a calibration sequence is initiated, followed by a measurement sequence. See **Sequence Control** (on page 35) dialog and **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46)
- ***Continuous*** - Click to initiate Continuous mode, in which a new measurement begins after the last one is complete.
- **Abort** - Click to request aborting the measurement in progress, and to return to an idle state. Note: depending on the step currently being performed, aborting a measurement make take some time.
- **Recalculate** - Recalculates the S-parameters using the currently acquired waveforms. Use Recalculate when modifying selections such as **Enforce Passivity** and **End Freq** that are input to the S-Parameter calculation but that do not change the TDR/TDT acquisition settings.

Grid Display Area

Traces are displayed within the grid section of the display. The number of grids can be modified via the **Display Menu and Setup Dialog** (on page 65). Each grid has 10 divisions horizontally, and 8 divisions vertically.

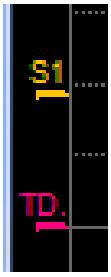
Traces

Traces are shown in the grids. Their position and scaling can me modified as explained in the **Zooming and Repositioning Traces** (on page 72) topic. The following types of traces can be displayed:

- **TDR** waveform: trace name TDR1.
- **TDT** waveform: trace name TDR2.
- **Result** waveforms: S1 through S16.
- **Math** waveforms: F1 through F8.
- **Zoom** waveforms: Z1 through Z4.
- **Memory** waveforms: M1 through M4.

Grid Display Markers

Indicators on the Grid Display's left edge are labeled with abbreviated trace names and denote **Yaxis=0 position...** waveform locations.



Trace Descriptor Labels

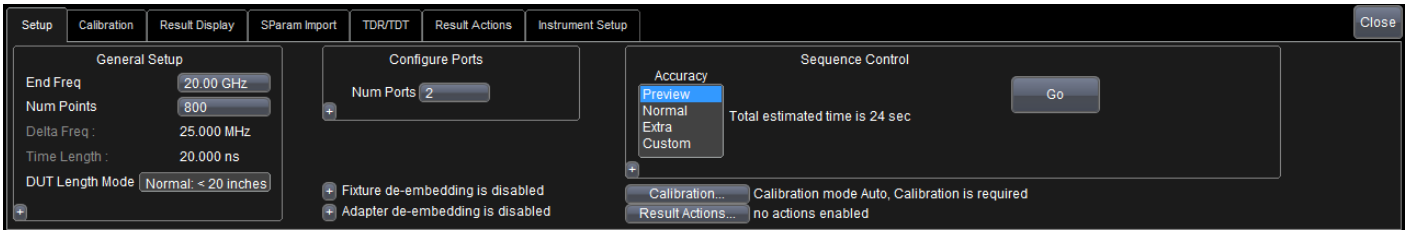
The boxes between the Grid Display and the Dialog Areas show basic information about your traces. Clicking a Trace Descriptor label opens its corresponding dialog in the Dialog Area.

Inside Trace Descriptor labels, the following information is provided:

Trace Name - Shown in formats such as TDR1, S1, and Z2.
Trace Description - For example, SD1D1, or zoom(S1).
Vertical Scale - For example, 5.00dB/div, or 100mV/div.
Horizontal Scale - For example, 5ns/div, or 2GHz/div.
Cursor value(s) - When cursors are turned on, cursor values are displayed here as well.

Dialog Area

Configuration screens and other dialogs appear at the bottom of the display. One or more tabs may be available for selection in the dialog display. Click **Close** to dismiss the dialog.

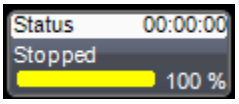


Status Bar

Shown on the entire lower strip of the application screen, this text area displays various status messages (usually towards the lower left). The LeCroy logo, Date, and Time are always shown.

Status Box

To the far right of the Trace Descriptor label region, this box is always shown and displays the progress of all measurements.



SPARQ Folder Structure

The SPARQ application installer creates the following folders which are used for storing SPARQ-related data:

Adaptors

C:\LeCroy\SPARQ\SPARQ\Adapters

Default folder for storage of S-parameter files used to de-embed adaptors.

Cables

C:\LeCroy\SPARQ\SPARQ\Cables

Default folder for storage of S-parameter files used to de-embed cables.

Calibration

C:\LeCroy\SPARQ\SPARQ\Calibration

Default folder for storage of calibration data.

Fixtures

C:\LeCroy\SPARQ\SPARQ\Fixtures

Default folder for storage of S-parameter files used to de-embed Fixtures.

Calibration

C:\LeCroy\SPARQ\SPARQ\Calibration

Currently unused; Calibration files from the SPARQ are stored in **C:\LeCroy\SPARQ\Calibration\SPARQ**.

Results

C:\LeCroy\SPARQ\SPARQ\Results

Default folder for the S-parameter files generated and saved by the SPARQ. See **Save Results** for details.

Hardcopy

C:\LeCroy\SPARQ\HardCopy

Default folder for screen-shots saved by the SPARQ. See **Print Setup (Hardcopy) Dialog** for details.

S-Parameter Measurement System Overview

Measuring S-Parameters is the fundamental purpose of the SPARQ. Here is an overview of the steps taken to make a measurement. For more details, see **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46) and **Getting Started Tutorial and Example - 2 Port Measurement** (on page 19).

Setting up for a Measurement

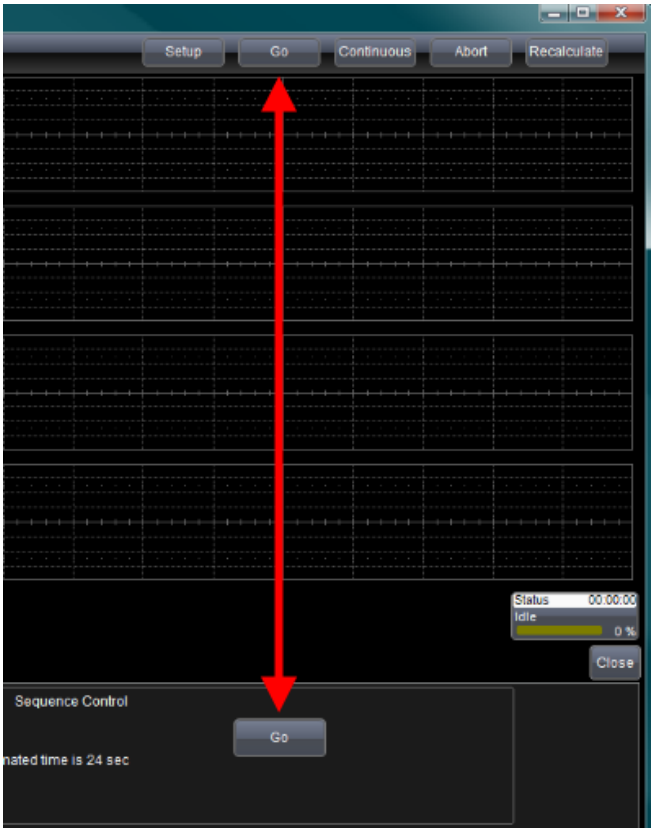
Configuring the SPARQ to make S-Parameter measurements is handled from the Main Setup dialog. Access the **Setup** dialog by either clicking the **Setup** button at the top right of the application, or select **SPARQ setup → Main Setup** from the menu bar.

Here are links to other sections that contain useful information:

- **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46)
- **Configuring Ports for a Measurement** (on page 49)
- **SPARQ Setup Menu** (on page 30)

Starting a Measurement

Measurements are started by touching the **Go** button on the top right of the application, or the one in the **Setup** dialog.



The SPARQ Sequencer

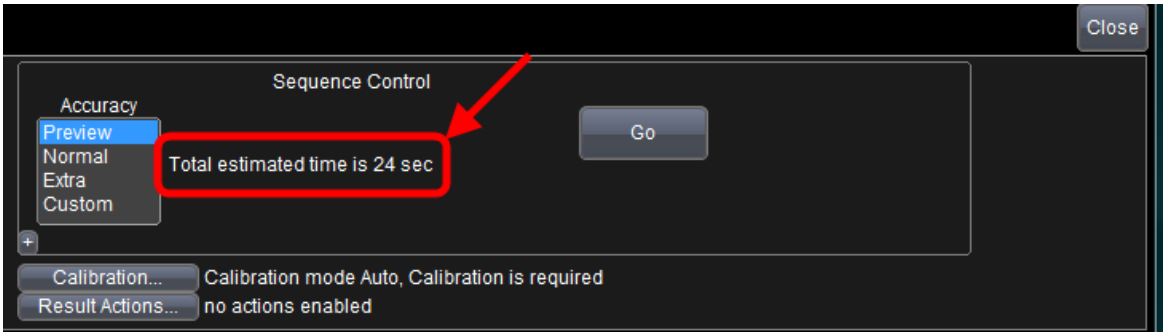
When the Go button is touched, your SPARQ executes a chain of events handled by the sequencer. If calibration is required, a calibration sub-sequence is included in the chain. During the calibration sub-sequence, the pulser/sample module is switched to **O**, **S**, **L**, and **T** calibration standards, and the TDR waveform is acquired (TDR for the T step of the sequence). During the measurement sequence, the TDR pulser/sampler and TDT sampler are routed to each combination of ports, and waveforms are acquired to which the calibration is applied. Finally, a measurement algorithm performs the S-parameter calculations.

Aborting a Measurement

Abort a sequence in progress by clicking the **Abort** button at the top right of the application. The sequence is aborted at the end of the step currently being processed.

Completion Time Estimates

An estimated time for sequence completion is shown in the **Sequence Control** section of the **Setup** dialog.

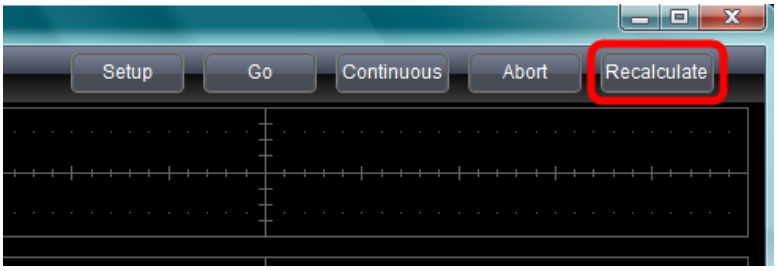


S-Parameter Results

The last step in the sequence is the calculation of the S-parameter results. The Status Bar indicates **Calculating** during this step. When the calculation is complete, the Result waveforms selected for display are shown, and the SPARQ returns to an idle state.

Further Analysis

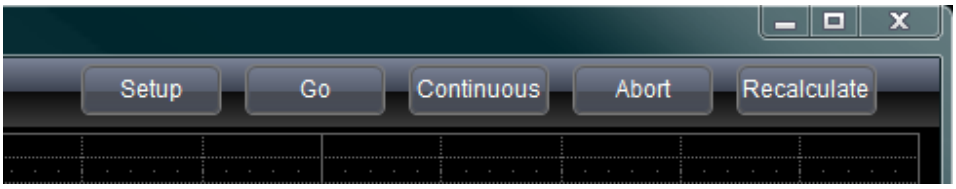
Additional analysis can be performed on the most recently acquired data. After making changes to the SPARQ setup, click the **Recalculate** button at the top-right part of the screen to recalculate the S-parameters.



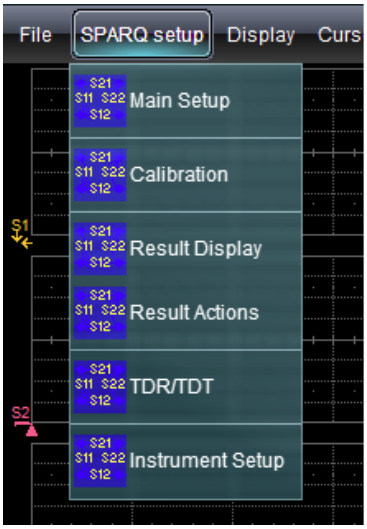
Additional waveforms can also be added to the display, including **Results** waveforms, **Math**, **Zoom**, and **Memory** traces, along with **Cursors** and **Parameter** Measurements.

SPARQ Setup Menu

The SPARQ Setup menu can be used to open the following dialogs. However, it is quicker to click the **Setup** button at the top right of the screen.



Notice how each dialogs is a separate corresponding tab.



- **Main Setup Dialog** (on page 31)
- **Calibration Dialog** (on page 36)
- **Result Display Dialog** (on page 38)
- **SParam Import Dialog** (on page 39)
- **TDR/TDT Dialog** (on page 40)
- **Result Actions Dialog** (on page 42)
- **Instrument Setup Dialog** (on page 42)

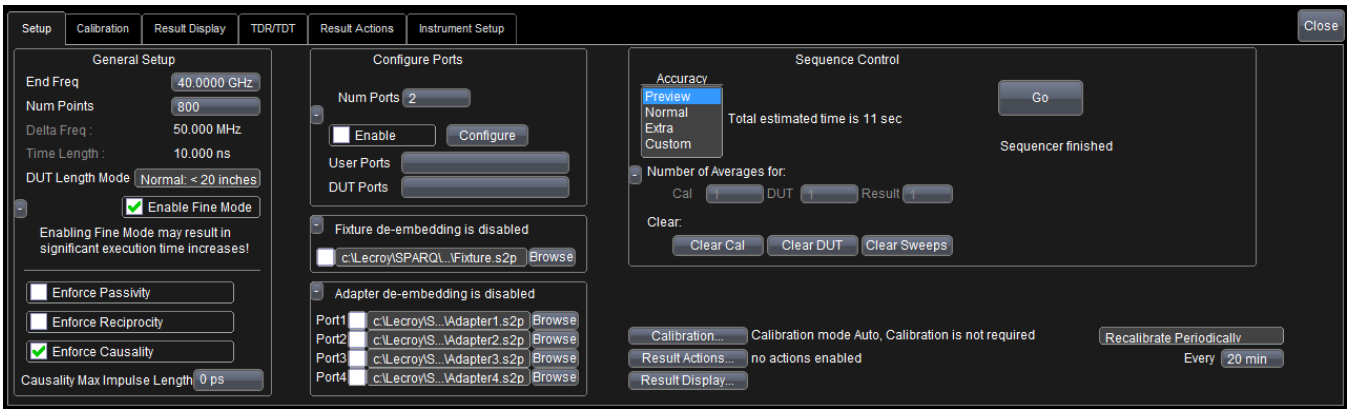
Main Setup Dialog

The **Setup** dialog contains all configuration settings used for performing an SOLT calibration cycle and for taking a measurement on your DUT. Access the **Setup** dialog by either clicking the **Setup** button at the top right of the application, or select **SPARQ setup → Main Setup** from the menu bar.

Setup your SPARQ by modifying settings on each dialog to match your system configuration and accuracy requirements. Each section on dialogs have both **basic** and **advanced** setup fields. Open or close advanced settings on dialogs by clicking **+/ -** buttons.

The **Setup** dialog includes the following sections:

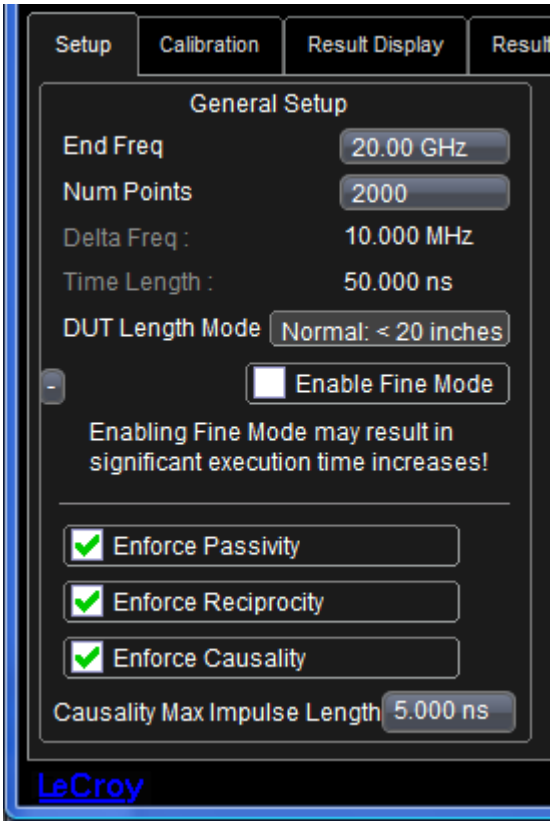
- **General Setup** (on page 32)
- **Configure Ports** (on page 33)
- **Fixture De-embedding** (on page 34)
- **Adapter De-embedding** (on page 34)
- **Sequence Control** (on page 35)
- **Setup Dialog: Additional Items** (on page 36)



General Setup

The **General Setup** section of the **Setup** dialog includes the following settings. Click the **+** button to see the advanced settings described as follows. Open the **Setup** dialog by either touching the **Setup** button at the top right of the application, or select **SPARQ setup → Main Setup** from the menu bar.

Related Topic: **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46)



1. **End Frequency** - Enter the frequency for the measurement. The frequency provided is the last frequency point in the output S-parameter file.
2. **Num Points** - Enter the number of points for the measurement. **Num Points+1** becomes the number of points in the S-parameter waveforms and number of data points in the output S-parameter files. (The first point is DC, the last at End Frequency, resulting in **Num Points+1** points.
3. **Delta Freq** - (Calculated) The SPARQ determines a value for **Delta Freq** based on the **End Frequency** and **Num Points** chosen. The value is the difference between successive points in Sij waveforms and in the output S-Parameter file..
4. **Time Length** - (Calculated) The SPARQ determines a value for **Time Length** based on the **End Frequency** and **Num Points** chosen.
5. **DUT Length** - Select **Normal** or **Long** as is appropriate for your DUT. This selection determines the repetition rate of the pulser and of the timebase used for the signal acquisition:
   - **Normal**: 5 MHz pulser repitition rate with 5ns/division
   - **Long**: 1 MHz pulser repitition rate with 20ns/division

Related Topic: **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46)

General Setup Advanced Settings

Clicking any **+** button expands the dialog displaying the advanced configuration options.

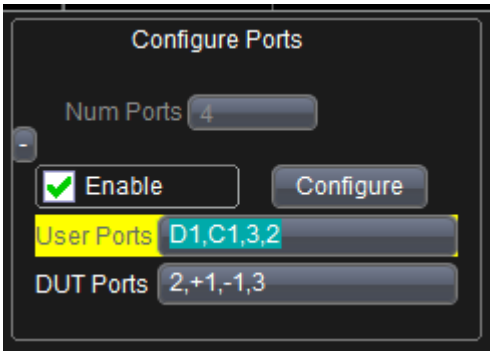
1. **Enable Fine Mode** - Select to have finer resolution for the entry of the **End Frequency** and **Num Points**. Enabling fine mode may result in significantly longer execution time.
2. **Enforce Passivity** - Select to require that the calculated S-parameter matrix obey the passivity, i.e. that the norm of the S-parameter matrix be less than 1: ||S|| <= 1. Select to enforce passivity when planning to use the output S-parameter file in a model that requires passivity be obeyed.
3. **Enforce Reciprocity** - Select to require that the calculated S-parameter matrix obey reciprocity, i.e. that $S_{ij} = S_{ji}$. Select to enforce passivity when planning to use the output S-parameter file in a model that requires reciprocity be obeyed.
4. **Enforce Causality** - Select to enforce that impulse responses cannot occur prior to the impulse generation.
5. **Causality Max Impulse Length** - Advanced setting.

Configure Ports

The **Configure Ports** section of the **Setup** dialog includes following settings.

Num Ports - Enter the number of ports used in your configuration. If this setting is grayed out, then the advanced configuration is in place; otherwise, the SPARQ will use the lowest input port numbers corresponding to the number of ports selected, with port/DUT assignments.

Note: After changing the number of ports, your SPARQ may go through a calculation sequence and indicates **Processing** on the status bar.

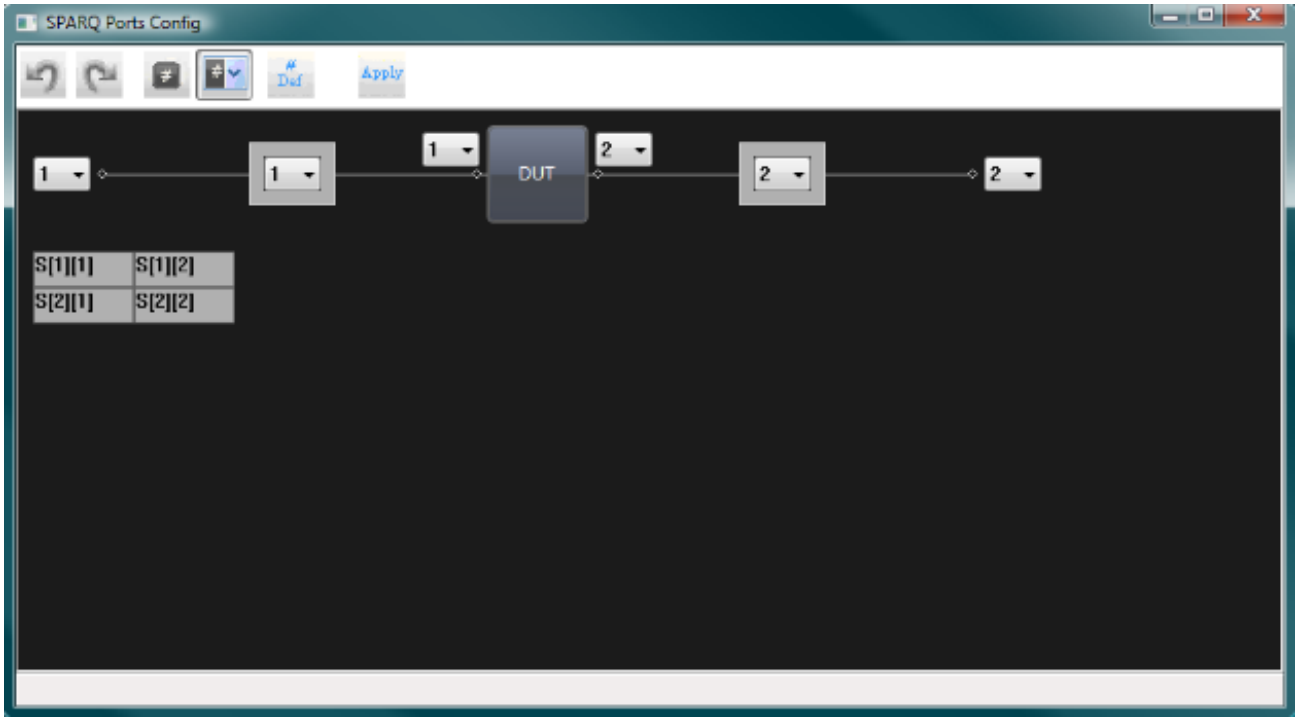


Configure Ports Advanced Settings

Click the **+** button to expand advanced configuration options. See **Configuring Ports for a Measurement** (on page 49) for detailed instructions on setting the port configuration.

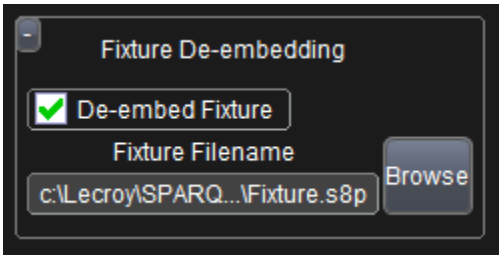
1. **Enable** - Selects to use the configuration determined by te SPARQ Ports Config dialog. This configuration is reflected in the **User Ports** and **DUT Ports** list boxes.
2. **User Ports** - Displays the association of the Port Ordering Selectors in the SPARQ Port Config dialog to S-parameter port numbers. The list is automatically populated when applying configuration in the **SPARQ Port Config** dialog which is invoked by clicking **Configure**, or a list can be manually entered. (Using the **SPARQ Port Config** dialog is recommended.)
3. **DUT Ports** - Displays the association of DUT ports (assumed to be the same as the SPARQ ports) to S-parameter port numbers. The list is automatically populated when applying a configuration in the **SPARQ Port Config** dialog which is invoked by clicking **Configure**, or a list can be manually entered. (Using the **SPARQ Port Config** dialog is recommended.)

4. **Configure** - Click this button to open the SPARQ Ports Config dialog for advanced configuration of port assignments.



Fixture De-embedding

The **Fixture De-embedding** section of the **Setup** dialog includes the following settings.



De-embed fixture - Mark this checkbox to enable de-embedding

Fixture Filename - Click the **Browse** button and select the S-parameter file for the fixture holding the DUT.

Adapter De-embedding

The **Adapter De-embedding** section of the **Setup** dialog includes the following settings.

Port # Checkbox - Mark the checkboxes to enable adapter de-embedding for the respective port number.

Adapter Filename - Click the **Browse** button to select the S-parameter file for the fixture holding the DUT.

Sequence Control

The **Sequence Control** section of the **Setup** dialog includes the following settings.

1. **Go** - Click to initiate the sequencer. If a calibration is required, a calibration sequence is initiated, followed by a measurement sequence. See **Sequence Control** (above) dialog and **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46) for more information.
2. **Accuracy** - Select the accuracy setting to use for the measurement. Different accuracy selections incorporate varied amounts of averaging. The higher the accuracy selected, the longer the measurement takes. Accuracy choices have average as the following table shows.

Accuracy	Cal averages	DUT averages	Result averages
Preview	1	1	1
Normal	10	10	1
Extra	10	10	10
Custom	Custom	Custom	Custom

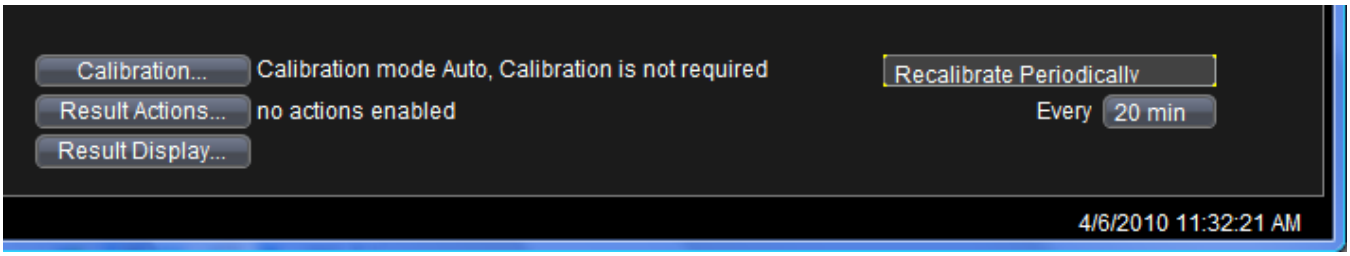
Note: Click the **+** button to expand advanced configuration options including controls for number of averages used.

3. Number of averages for **CAL** - Enter the number of acquisitions to be averaged to generate the TDR waveform used to calculate the SOLT calibration.
4. Number of averages for **DUT** - Enter the number of acquisitions to be averaged to generate the final TDR/TDT waveforms used in measuring the S-parameters of the DUT.
5. Number of averages for **Result** - Enter the number of S-Parameter waveforms to be averaged prior forming the final S-Parameter waveform results.
6. **Clear Cal** - Clears the waveforms used for the **Open, Short, Long, Through (SOLT)** Calibration. Clearing this average requires a new calibration to be performed prior to making a new measurement. This action can also be invoked via the **Calibration Dialog** (on page 36).
7. **Clear DUT** - Clears the TDR waveforms used for the most recent DUT measurement.
8. **Clear Sweeps** - Clears the result waveforms.

Related Topic: **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46)

Setup Dialog: Additional Items

The Setup dialog also includes the following shortcut buttons and settings.



1. **Calibration...** - Jumps to the **Calibration Dialog** (below).
2. **Result Actions...** - Jumps to the **Result Actions Dialog** (on page 42).
3. **Result Display...** - Jumps to the **Result Display Dialog** (on page 38).
4. **Auto Calibration Policy** - Select one of three options specifying when calibration sequence is to occur.
   - **Recalibrate Always**
   - **Recalibrate Periodically**
   - **Only Recalibrate as Required**

   This control may also be set from the **Calibration Dialog** (below).
5. **Every (Recalibration interval)** - Set the amount of time to pass (in minutes) between **periodic recalibrations**.

Calibration Dialog

Use the **Calibration** dialog to configure your rur calibration settings. Access the Calibration dialog by selecting **SPARQ Setup → Calibration** from the menu bar.

The dialog contains different controls based on the selection of **Auto** or **Manual Calibration Type**. On SPARQ **M** units, only the **Manual** calibration type is available. On all other models, select either **Auto** or **Manual**.

Auto Calibration Type

The dialog contains the following settings and actions when the calibration type is set to **Auto**.

1. **Calibration Type** - With **Auto** selected, your SPARQ uses the internal calibration feature where the execution of a calibration cycle performs an SOLT calibration using a calibration kit embedded in the unit.
2. **Clear Cal Measurements** - Click this button to clear the calibration currently in use. This action can also be executed from the **Sequence Control** section of the Setup dialog (advanced settings).
3. **Calibrate Now** - Click this button to execute a calibration cycle.

   Keep in mind that a calibration is executed when the **Go** button is clicked if:

   - No calibration data is present.

     OR

- The SPARQ is configured to **Always Recalibrate** as explained in the **Setup Dialog: Additional Items** (on page 36) topic.

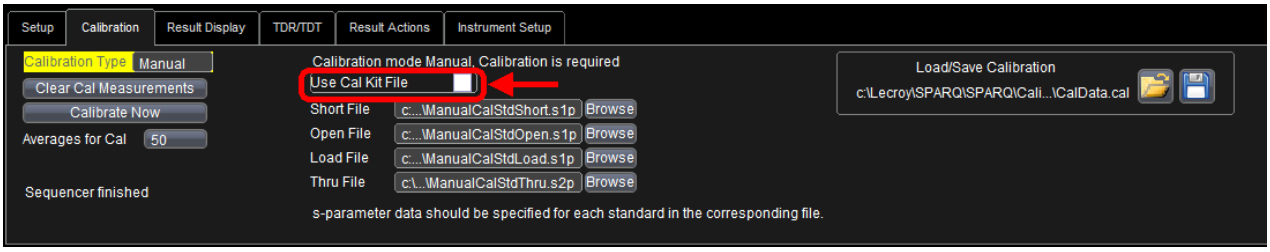
4. **Averages for Cal** - This setting is only active if custom is selected for the Accuracy setting in the Setup dialog. When active, enter the number of acquisitions to be averaged to generate the TDR waveforms used to calculate the SOLT Calibration. Otherwise, the number of acquisitions used for the average is displayed.
5. **Auto Calibration Policy** -Select one of three options specifying when calibration sequence is to occur.
   - **Recalibrate Always**
   - **Recalibrate Periodically**
   - **Only Recalibrate as Required**
6. **Recalibration interval** - Set the amount of time to pass (in minutes) between **periodic recalibrations**.

   This control may also be set from **Calibration Dialog** (on page 36).
7. **Load/Save Calibration** - Click the **Load** (folder) button to load a previously-saved calibration file, or click the **Save** (floppy disk) button to save the current calibration data.

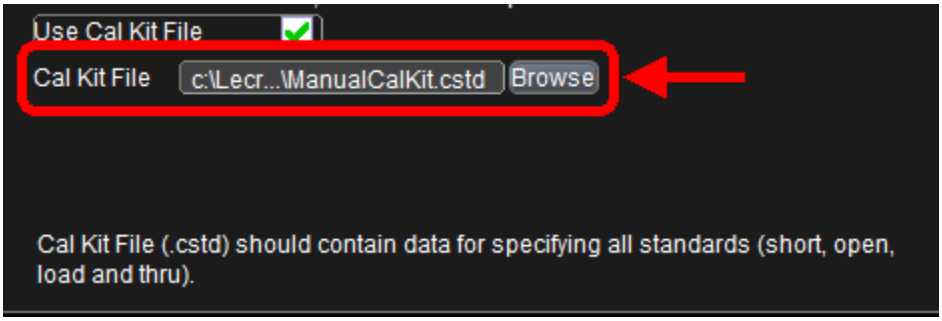
Manual Calibration Type

When selecting **Manual Calibration Type**, additional controls become visible on the **Calibration** dialog.

1. **Use Cal Kit File** - Mark this checkbox to use a calibration kit file (rather than separate files for the SOLT adapters).



   When marked, the **Cal Kit File** selection box is shown instead of the **Short**, **Open**, **Load**, and **Thru** selector controls.
2. **Cal Kit File** - Filepath and name for the **.cstd** calibration kit data file.



   When unmarked, the Cal Kit File controls are hidden and **SOLT** controls are shown.
3. **Short File** - Filepath and name for the **.s1p** file describing the **Short** adapter.
4. **Open File** - Filepath and name for the **.s1p** file describing the **Open** adapter.
5. **Load File** - Filepath and name for the **.s1p** file describing the **Load** adapter.
6. **Thru File** - Filepath and name for the **.s2p** file describing the **Thru** adapter.

Related Topic: **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46)

Result Display Dialog

Use the **Result Display** dialog to select the waveforms for showing on the Grid Display of the SPARQ application. Access the **Result Display** dialog by selecting **SPARQ Setup → Result Display** from the menu bar.

The main display contains **Sx** result traces, while the right-hand dialog contains the **Zoom Controls** (on page 44) for the selected Results trace.

Sx Configuration Dialog (Result Display Dialog)

There are 16 slots available for displaying S-parameter and time domain results. The slots are numbered **S1** through **S16**, (generalized as **Sx**), and each row contains the following GUI elements:

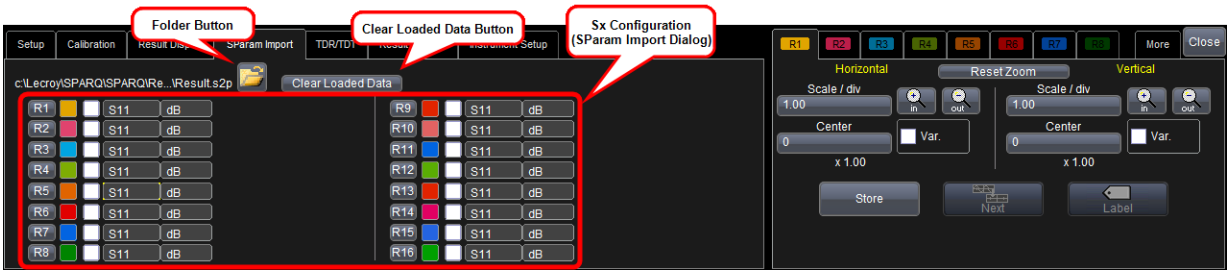
1. **Sx Shortcut button** - Clicking the button with the Sx label opens the zoom control dialog for the corresponding Sx trace.
2. **Trace Color box** - Click to display a color selection window.
3. **Trace Visible checkbox** - Enables/Disables the calculation and display of the corresponding Sx trace.
4. **S-parameter selector** - Selects which S-parameter is calculated.The selection box will include a list of S-parameters that match the port configuration for the measurement.
5. **Result Type** - Selects the type of result to calculate and display:

   - **dB** - S-parameter magnitude, in dB units
   - **Mag** - S-parameter magnitude, fractional amplitude/attenuation
   - **dB** - 10log(^{Mag})
   - **Real** - Real component of the S-parameter
   - **Imag** - Imaginary component of the S-parameter
   - **Deg** - S-parameter phase, in degrees
   - **Rad**- S-parameter phase, in radians
   - **Step** - Step response of the selected S-parameter
   - **Impulse** - Impulse response of the selected S-parameter
   - **Rho** - Reflection coefficient; rho = (Zt-Z) /(Zt+Z)
6. **Risetime** - 10-90% risetime of the step used in the **Step** and **Impulse** response result types.

Related Topic: **Zooming and Repositioning Traces** (on page 72).

SParam Import Dialog

Use the **SParam Import** dialog to import .s[n]p Touchstone files saved by the SPARQ or by other instruments such as VNAs. In order for the importation of the .s[n]p file to work, the formatting must meet the requirements described in **Touchstone File Format** (on page 45). Access the Result Display dialog by selecting **SPARQ Setup → SParam Import** from the menu bar.



Rx Configuration (SParam Import Dialog)

There are 16 slots available for displaying S-parameter and time domain results. The slots are numbered **S1** through **S16**, (generalized as **Sx**), and each row contains the following GUI elements:

1. **Folder button** - Click to navigate to the location of your .s[n]p file. Upon a success import, indicators showing the number of ports, number of points and end frequency are displayed.
2. **Clear Loaded Data** - Click to clear the selected .s[n]p file and Rx traces.
3. **Rx Shortcut button - Clicking the button with the Rx label opens the zoom control dialog for the corresponding Rx trace.**
4. **Trace Color box** - Click to display a color selection window.
5. **Trace Visible checkbox** - Enables/Disables the calculation and display of the corresponding Sx trace.
6. **S-parameter selector** - Selects which S-parameter is calculated.The selection box will include a list of S-parameters that match the port configuration for the measurement.
7. **Result Type** - Selects the type of result to calculate and display:

- **dB** - S-parameter magnitude, in dB units
- **Mag** - S-parameter magnitude, fractional amplitude/attenuation
- **dB** - 10log(^{Mag})
- **Real** - Real component of the S-parameter
- **Imag** - Imaginary component of the S-parameter
- **Deg** - S-parameter phase, in degrees
- **Rad**- S-parameter phase, in radians
- **Step** - Step response of the selected S-parameter

- **Impulse** - Impulse response of the selected S-parameter
- **Rho** - Reflection coefficient; rho = (Zt-Z) /(Zt+Z)

8. **Risetime** - 10-90% risetime of the step used in the **Step** and **Impulse** response result types.

Related Topic: **Zooming and Repositioning Traces** (on page 72).

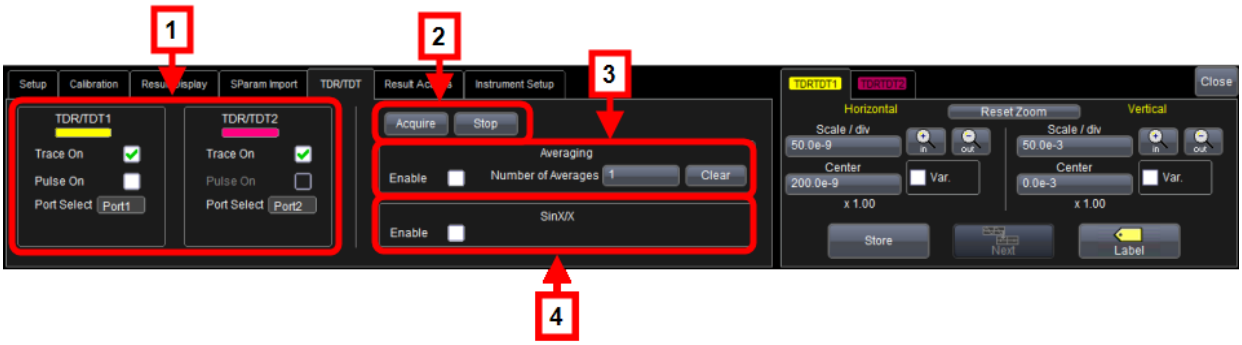
TDR/TDT Dialog

Use the TDR/TDT Dialog to manually control the TDR/TDT functionality of the SPARQ. Access the **TDR/TDT** dialog by selecting **SPARQ Setup → TDR/TDT** from the menu bar.

The main dialog handles configuration for TDR/TDT operation, while the right-hand dialog is used to for **Zoom Controls** (on page 44).

TDR/TDT Main Dialog Controls

Numbered callouts on the following screen-shot correspond to respective explanations.



1. **TDR/TDT1 and TDR/TDT2 Settings** - The TDR/TDT traces can each be configured using the following controls:

- **Trace On** - Marking or unmarking the checkbox selects whether the trace is on or off.
- **Pulse On** - Selects whether the trace is a TDR source
- **Port Select** - Selects the port where the TDR/TDT trace is routed.

> **Note**: TDR pulses can only be routed to one port, meaning SPARQs containing a single pulser/sampler can only have one of the two TDR/TDR traces configured with the **Pulse On** checkbox marked.

2. **Acquisition Control Section**

- **Acquire** - Click to initiate TDR operation and signal routing to the selected ports.
- **Stop** - Click to stop TDR operation.

3. **Averaging Section**

- **Enable** - Mark this checkbox to enable the following averaging settings.

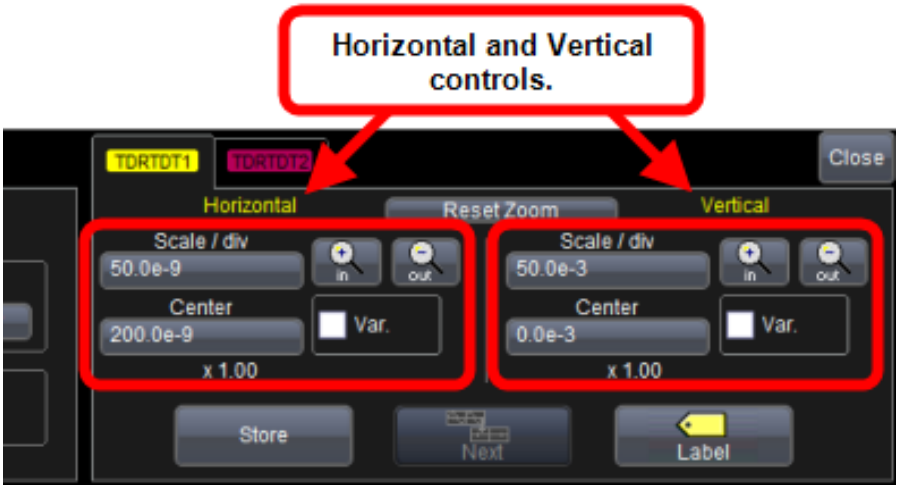
- **Number of Averages** - Enter then number of sweeps to average to form the TDR/TDT waveform
- **Clear** - Click to clear the average. The TDT/TDT traces are erased.

2. **SinX/X Section**

- **Enable** - Mark this checkbox to enable SinX/X fitting of the samples.

TDR/TDT1 and TDR/TDT2 Right-Hand Dialog Controls - Zoom Settings

Horizontal and Vertical Controls



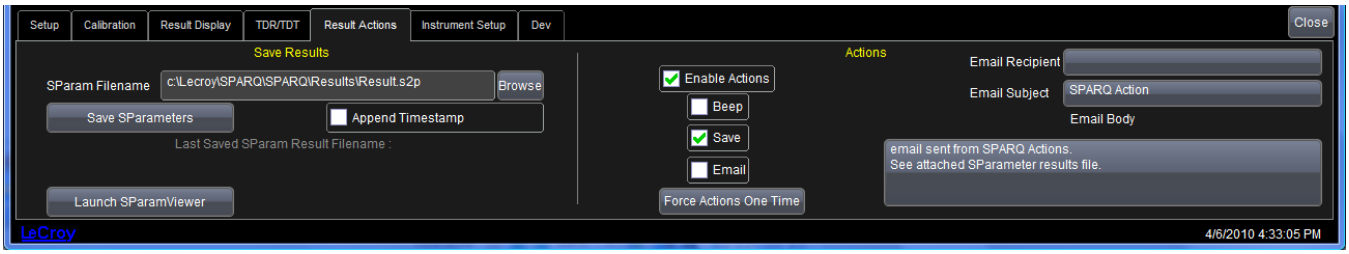
- **Scale/div** - Enter a value to use for the for time/div (volts/div). The SPARQ shows the corresponding zoom factor in this section of the user interface
- **Center**- Enter the time (voltage) for the center line of the grid.
- **Var**(iable) - Unmarking this checkbox causes 1-2-5 steps when clicking the in/out magnifiers; while marking the checkbox utilizes a finer step size.
- **In/Out**- Click to zoom in or zoom out from the center of the grid.

Action Buttons

- **Store** - Stores the TDR/TDT waveform into a Memory trace.
- **Next** - Moves the TDR/TDT waveform to the next grid. If the button is disabled, enable it by clicking **Display → Auto-Grid** from the menu bar and turning off the automatic assignment of grids.
- **Label** - Opens the Trace Annotation pop-up window.
- **Reset Zoom**- Click to set the zoom settings of the trace so the magnification factors are 1.

Result Actions Dialog

The Result Actions dialog specifies where to save the output S-Parameter file, and actions that can be executed after a measurement is complete. The dialog is invoked via the menu path **SPARQ Setup → Result Actions**, and includes two sections: **Save Results** and **Actions.**



Save Results Section:

1. **SParam filename** - Click in the textbox to open a virtual keyboard to enter the filename and path for the S-Parameter file, or click the Browse button to open a dialog.
2. **Save S-Parameters** - Click this button to save the S-parameter results to a Touchstone file.
3. **Append Timestamp** - enables/disables saving the timestamp to the Results dialog.

Actions Section:

1. **Enable Actions** - Enables/disables actions globally.
2. **Beep** - Configures the SPARQ to beep after a measurement is complete.
3. **Save** - Configures the SPARQ to save the S-parameter file after a measurement is complete.
4. **Email** - Configures the SPARQ to email the S-parameter file after a measurement is complete..
5. **Force Actions one time** - Executes all actions once for testing purposes
6. **Email Recipient** - Enter the email address of the recipient for the **Email** action.
7. **Email Subject** - Enter a subject for emails.
8. **Email Body** - Enter any text to be included in the body of emails sent.

Instrument Setup Dialog

The **Instrument Setup** dialog specifies whether to de-embed the cables and adapters attached to the SPARQ, and include entry boxes for the corresponding S-parameter files for the cables and adapters. The dialog is invoked via the menu path **SPARQ Setup → Instrument Setup.**

Related Topic: **Making an S-Parameter Measurement Using Auto Cal Mode** (on page 46))

1. **De-embed cables** - Checkbox which enables/disables the cable de-embedding feature. If the SPARQ is an "M" type, or if the user has selected Manual calibration via the Calibration dialog, then de-embedding will not be used.
2. **Filepath and Browse** buttons- (one for each port, for cables and adapters.) Click to invoke a dialog to select the S-parameter file to use to de-embed the cable connected to each port.
3. **Run Self Test** - Click to execute a self-test that checks various SPARQ components. (Note: This does not test the performance of the hardware, but confirms that software components checkout OK.
4. **SelfTest Log** - Click to open the Event Log window for the self test function.

Using Multiple SPARQ Units

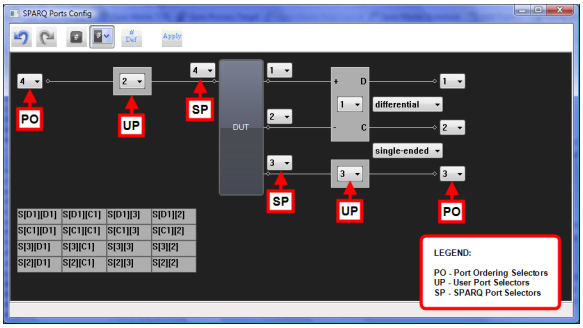
Your SPARQ software can be used to control multiple SPARQ units. However, only one SPARQ can be connected and controlled at a time by a single PC. When connecting to a different SPARQ, the calibration data from the new unit is copied to the PC. The calibration data filenames include the SPARQ serial number in order to avoid any issue of overwriting calibration files or incorrectly using cal data from a different unit.

Note: After switching to a different SPARQ, users should confirm the correct cables are selected using the **Instrument Setup Dialog** (on page 42) dialog.

SPARQ Port Config Window

The **SPARQ Ports Config** Window is the advanced mode for setting up the port configuration, which is typically only required when using mixed-mode S-parameters. For instructions on using this screen, see **SPARQ Config Ports Window** which is a section of **Configuring Ports for a Measurement** (on page 49).

The are 5 types of selectors in this window. Starting with the center **DUT** button and moving outwards, they include:



- **DUT** - This is a button used to configure the number of ports and their arrangement.

- **SP** - SPARQ Port selectors.
- **UP** - User Port selectors.
- **Single/differential** - Selectors for choosing single versus differential are shown when the DUT configuration results in greater than 1 port on a side.
- **PO** - Port Ordering selectors.

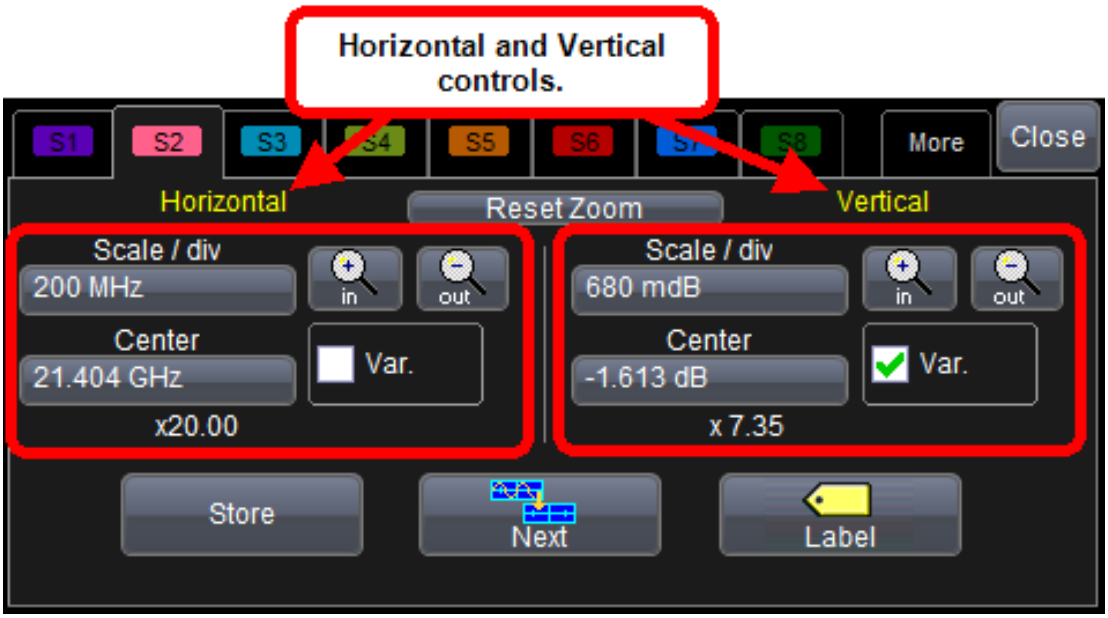
Zoom Controls

All waveforms can be zoomed by highlighting a region of interest with the mouse, or by manipulating the settings in the Zoom Control dialog. This right-hand dialog is shown by clicking the trace descriptor for a particular **Sx** or **TDR/TDT** trace.

Related topic - **Zooming and Repositioning Traces** (on page 72)

Regardless of Sx or TDR/TDT trace, Zoom Control dialogs include **Horizontal and Vertical Controls** and **Action Buttons**.

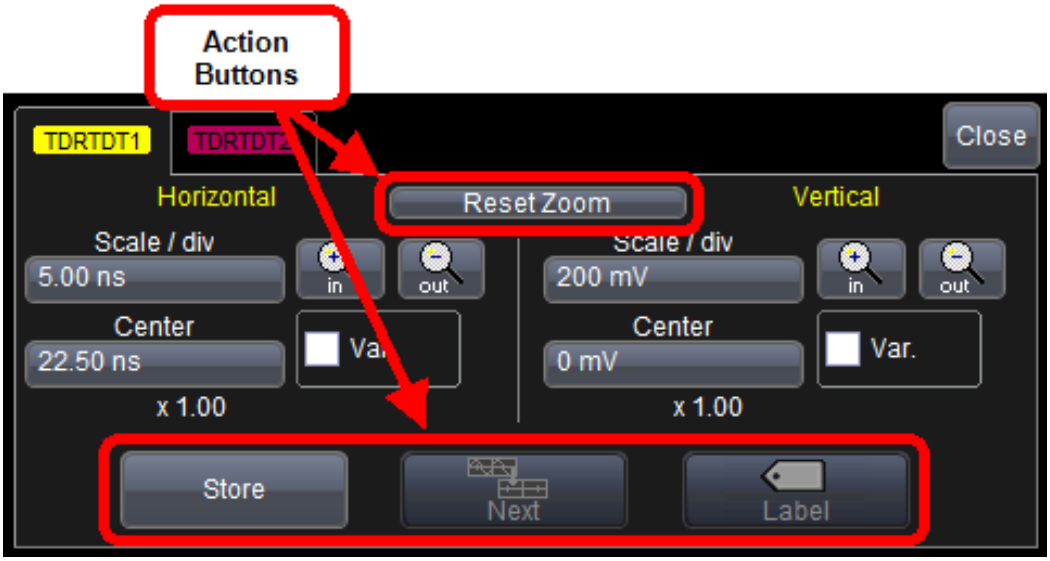
Horizontal and Vertical Controls



- **Scale/div** - Enter a value to use for the for time/div (volts/div). The SPARQ shows the corresponding zoom factor on this section of the interface.
- **Center** - Enter the time (voltage) for the center line of the grid.
- **Var**(iable) - Unmarking this checkbox causes 1-2-5 steps when clicking the in/out magnifiers; while marking the checkbox utilizes a finer step size.
- **In/Out** - Click to zoom in out from the center of the grid.

Action Buttons

Note: For **Fx math** traces, these controls are included in the configuration dialog for the math trace itself.



- **Store** - Stores the waveform into a Memory trace.
- **Next** - Moves the waveform to the next grid. If this button is disabled, enable it by selecting **Display → Auto-Grid** (which turns off automatic grid assignments).
- **Label** - Opens the Trace Annotation pop-up window.
- **Reset Zoom** - Clicking this button resets the zoom settings of the trace to a magnification factor of 1.

Touchstone File Format

Touchstone is a file format used for specifying S-parameters. It is a standard that is commonly adopted by vector network analyzers (VNAs), time-domain network analyzers (TDNA) and EDA tools such as microwave simulators.

The SPARQ component interprets Touchstone files in the following manner:

1. The extension must be in the form **.s[N]p** where [N] corresponds to the number of ports in the device. For example, a two port S-parameter file has an extension ".s2p".
2. Lines cannot be longer than 2000 characters.
3. Lines beginning with **!** are comment lines. Comments must be at the front of the file. No comments are allowed once the frequencies and S-parameter values start.
4. There should be at least one line that begins with '#'. This line is a line that contains tokens that help interpret the S-parameters. Valid tokens are:
    - **Hz** – frequencies are in Hz.
    - **MHz** – frequencies are in MHz.
    - **GHz** – frequencies are in GHz.
    - **MA** – S-parameters are in magnitude/angle form where the magnitudes are true magnitudes and the angle is in degrees.
    - **RI** – S-parameters are in real/imaginary form.
    - **DB** – S-parameters are in magnitude/angle form where the magnitude is in decibels and the angle is in degrees.
5. If the above tokens are not found, the frequencies are assumed to be in MHz, and the S-parameters are assumed to be in magnitude/angle form.
6. The S-parameters for each frequency are assumed to be listed as:

[frequency] (S11) (S12) …(S1[N])(S21) (S22) … (S2[N]) … (S[N]1) (S[N]2) … (S[N][N])

where N is the number of ports dictated by the file extension, except for two-port S-parameters which are assumed to be listed as [frequency] (S11) (S21) (S12) (S22) according to the standard.

7. All S-parameters are assumed to be 50 Ohm. In S-parameter files, on the line beginning with '#', usually there is a token pair: R [Z0] where [Z0] is the characteristic impedance. We assume Z0 is 50 and ignore these tokens.
8. All frequencies are assumed to go from the first frequency listed to the last frequency listed with constant frequency spacing.

Other Notes about S-parameter file interpretation and usage.

S-parameters provided to the virtual probe will tend to have various frequency scales, differing in both resolution (frequency spacing) and range (start frequency and end frequency). The virtual probe component will resample all S-parameter sets onto a new frequency scale dictated by the system sample rate (half the sample rate will be the last frequency) and the time length (see Time Length) – where the time length dictates the new frequency resolution. In performing this resampling, it is important to understand that the resolution may be higher or lower than the original resolution and that the frequency range may require extrapolation of points. When the frequency range is higher than that provided in the S-parameter data (i.e. the S-parameters are not provided to half the system sample rate), then the S-parameter data will be set to zero at these extra required data points. Furthermore, most S-parameter data does not go to DC, because VNAs don't measure data to DC, and therefore the DC response is also extrapolated by setting the low frequency points equal to the first frequency provided in the S-parameter data.

What this means is that it is helpful to follow some simple rules that will maximize the effectiveness of the SPARQ.

- Take S-parameter data as low in frequency as the VNA allows to minimize DC extrapolation errors.
- Take S-parameter data up to one half of the system sample rate. In other words, if you are going to supply waveforms to the virtual probe at 40 GS/s, it is good to provide data up to 20 GHz. Otherwise, if the frequency content of the signal provided to the system is much lower, then it is unnecessary to sample at a high sample rate anyway.
- Take S-parameter data with sufficient frequency resolution. The resolution that needs to be provided depends on the electrical lengths of the circuit elements involved. In other words, if you have a cable that is 5 ns long, and there are reflections going on in the system, then taking data at maybe one tenth the minimum frequency resolution of 1/5 ns = 200 MHz (like 20 MHz) is a good idea. Said differently, in a more practical manner, if there are lots of bumps and wiggles in the S-parameters that are narrow in frequency, then you will need to measure S-parameter data with an appropriate frequency resolution to capture these bumps and wiggles. Usually the narrowness of the bumps and wiggles becomes smaller when the electrical lengths of circuit elements becomes longer.

Making an S-Parameter Measurement Using Auto Cal Mode

Making measurements with the SPARQ involve the following steps. Each is covered in more detail in following sections including links to various dialogs containing configuration setting information.

1. Configure the setup.
2. Configure the calibration settings.
3. Connect the cables to the SPARQ and DUT.
4. Configure cable, adapter, and perform fixture de-embedding.
5. Calibrate and perform the measurement.
6. View and save the results.

Making SPARQ measurements is simple; however, just like with any measurement scenario, care must be taken to avoid mistakes leading to measurement errors.

Note: All of the following steps use dialogs and fields shown once **SPARQ setup → Main Setup** is selected from the menu bar.

Configure the Setup

The **Setup Dialog** contains almost all settings required for specifying the details of the S-Parameter measurement, including the port configuration, number of points and end frequency of the output S-Parameter file, and the DUT length:

1. Configure the settings in the **General Setup** (on page 32) and **Configure Ports** (on page 33) sections of the dialog, and Fixture De-embedding, if appropriate. See the **Configuring Ports for a Measurement** (on page 49) for detailed instructions on setting up the port configuration in both **Basic** and **Advanced** modes.
2. Select a setting for **Accuracy** in the Sequence Control section. The Accuracy setting determines the amount of averaging performed during the calibration, DUT, and result calculation stages of the measurement process.
    - Use **Preview** mode to obtain results quickly, but with less accuracy. This setting is useful when setting up a new measurement in order to confirm reasonable results, or when only needing to view the results (as opposed to when higher accuracy results are needed in the output S-parameter file).
    - Use **Normal** mode to obtain results in a reasonable amount of time with higher accuracy than Preview mode
    - Use **Extra** mode to obtain the highest accuracy apart from **Custom** mode, but with a longer acquisition time than Preview or Normal modes.

Calibration Settings

Calibration settings are configured from the **Calibration Dialog** (on page 36). There are very few settings to configure, especially when using **SPARQ E** models (which include an internal calibration kit).

- Use the **SPARQ E's** internal calibration feature by selecting the **Auto Calibration Type**. Users can select the **Manual Calibration Type** and calibrate using their own calibration kit. **Manual Calibration Type** requires specific details of your calibration kit by either loading a cal kit **.cstd** file, or by loading S-parameter files for **Short**, **Open**, **Load**, and **Thru** adapters.
- When using the **Auto Calibration Type**, your SPARQ performs calibration from an average of **N** TDR acquisitions. The value of **N** is configured in the **Sequence Control** (on page 35) section of the Setup dialog. Change the number of averages used by selecting Custom on the Accuracy field, and clicking **+** to show advanced controls, which include a setting for the number of averages used for the calibration.
- When using the Manual Calibration Type, the number of averages is changed from the **Calibration Dialog** (on page 36).
- For convenience, the Calibration Dialog also includes action buttons for clearing out the current calibration being enforced and to perform a calibration cycle. Additionally, you can mark the checkbox to specify that your SPARQ **Always Recalibrate**.

Connecting Cables to the SPARQ and DUT

The SPARQ ships with high-phase stability cables that are serialized, along with the S-parameter files for each cable.

- Connect the end of the cables labeled DUT to your device under test, and the other end to your SPARQ.
- If you plan to not use the cables provided with your SPARQ, ensure they are clearly labeled for accurate connections, and serialize them for consistent matching to a SPARQ port.

Note: Every cable is slightly different. Always connect cables consistently to your SPARQ. Cable rearrangements produce different results.


Use best practices when connecting and disconnecting cables taking care to tighten the cables to proper torque, and avoiding static discharge that damages or degrades the sampling heads in your SPARQ.

Tip: Unless using other cables, attach the cables provided with your SPARQ and leave them connected. There is no need to disconnect the cables when they are not being used; doing so can lead to misplaced cables, or may result in accidentally connecting cables backwards or to a port associated with a different cable's S-parameter file.

Cable, Adapter Configuration and Fixture De-embedding

The SPARQ calculates S-Parameters using an algorithm including S-parameter descriptions of system components, both internal and external. Use the de-embedding features of the SPARQ whenever possible:

- Use the **Instrument Setup Dialog** (on page 42) to enable and configure de-embedding of your cables. This entails selecting the S-parameter file for each cable so it can be de-embedded. These files are found on the SPARQ's memory card, and are automatically copied from the SPARQ to the **C:\LeCroy\SPARQ\SPARQ\Cables** location on your PC.
- Similar to cable de-embedding, the Adapter De-embedding section of the Setup dialog is used to enable and configure de-embedding of adapters (connected to the cables).
- Lastly, go to the **Fixture De-embedding** (on page 34) section of the **Main Setup Dialog** (on page 31) to enable and configure de-embedding of your fixture (if using one).

Note: The SPARQ ships with 2.92 female-to-female adapters for connecting to devices with male connectors.

Calibrate (Auto Calibration Mode) and Performing the Measurement

When using a **SPARQ E** model, the **Auto Calibration Mode** easily performs the calibration step without any need to connect and disconnect any calibration standards. Perform the measurement using the following steps:

- Start your measurement sequence by either clicking the **Go** action button (top-right of the application), or clicking the Go button from the **Sequence Control** (on page 35) section of the **Setup** dialog.
- In **Auto** mode, a calibration cycle is executed, followed by the measurement.
- Information shown during the measurement include the **Status Box** (far right of the Trace Descriptor label region), which shows a progress indicator bar as the sequence progresses. The Setup dialog provides the total estimated time of the calibration and the measurement sequence.

When using the **Auto Calibration Mode**, there is **no need to perform a separate calibration step**. If a calibration cycle is required, its executed when clicking the **Go** button. If a calibration is already in force (meaning that the OSLT calibration has already been performed, then a calibration cycle is only executed if the Auto Cal Policy is set to **Recalibrate Always** in either the **Calibration Dialog** or in the advanced settings of the **Sequence Control** section of the **Setup** dialog is marked.

For convenience, the Calibration Dialog also includes action buttons for clearing out the current calibration (**Clear Cal Measurements**) and to perform a calibration cycle **(Calibrate Now**). Additionally, you can set the Auto

Cal Policy to **Recalibrate Always**, **Recalibrate Periodically**, or **Only Recalibrate As Required** from either the **Calibration** (Basic Setting) or **Setup** (Advanced Setting) dialogs.

Viewing and Saving Results

When the sequence is complete, the S-parameters selected on the **Result Display Dialog** (on page 38) are shown, and the SPARQ returns to an idle state. If not configured to save automatically, the S-parameter file may be saved using the **Result Actions Dialog** (on page 42).

Configuring Ports for a Measurement

Port configuration is done via the **Configure Ports** (on page 33) section of the **Main Setup Dialog** (on page 31). The port configuration is a key component of the SPARQ setup as it determines how many ports to use and which ports are wired differential pairs to name a few.

Ports can be configured the following ways:

1. Using Setup dialog Basic controls, configuring the **Num Ports** setting.

   OR

2. Using Setup dialog Advanced controls (shown by clicking any **+** image on the dialog).

Choosing Between Basic and Advanced Setup

The **Basic Setup** is typically sufficient for single-ended S-parameter measurements. **Advanced Setup** is used for configurations requiring mixed-mode S-parameters, or where there is a need to modify the SPARQ-port to S-parameter port mapping, or to modify the port ordering in the output S-parameter file.

Basic Setup

Basic setup only requires entering the number of ports in the **NumPorts** box on the **Configure Port** section of the Setup dialog. Access the **Main Setup Dialog** (on page 31) by clicking the **Setup** action button or selecting **SPARQ setup → Main Setup** from the menu bar.

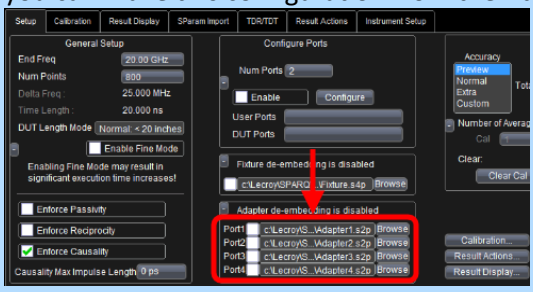
When using the basic port setup, the port definitions in the S-parameter matrix corresponds to the SPARQ input ports, and the results in the output **.s[n]p** file is formatted as described in the **Touchstone File Format** (on page 45) section of this manual.

Note: When performing single-ended measurements, the basic setup is usually sufficient.

Advanced Setup

Advanced setup mode is especially required when configuring **mixed-mode S-parameter measurements**. It also allows control of the mapping between SPARQ port and S-parameter port definitions, and even allows users to change the ordering of S-Parameters in the output **.s[n]p** file.

Example: If you plug into SPARQ ports 1 and 2, but want to have the S-parameter port assignments reversed, you can make this configuration from the Advanced Setup controls on the **Setup** dialog.



See the **Single-Ended Advanced Use-Case Example** topic for more information.

Advanced mode setup entails specifying the mapping between SPARQ ports and S-parameter ports, and defining the port ordering.

This is done by directly entering information in the **User Ports** and **DUT Ports** entry boxes (as follows, and also described in the **Using the User Ports and DUT Ports Entry Boxes** section).

However, you may find it more convenient to use the **SPARQ Ports Config** dialog (as follows).

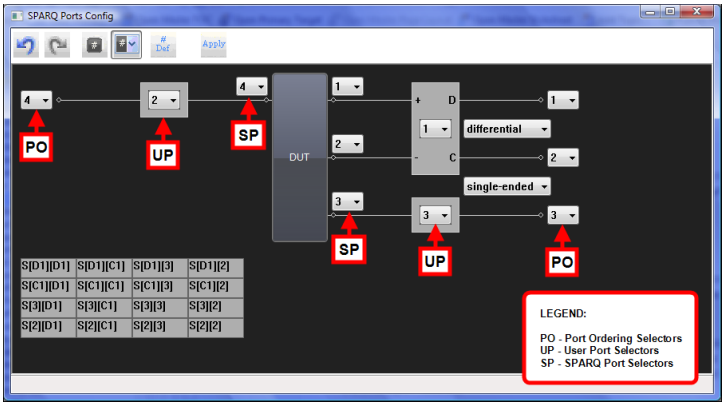
Note: The flexibility provided by the advanced setup can lead to unusual and non-standard arrangements of the S-parameter matrix and corresponding **.s[n]p** file. Refer to the **Advanced Setup Guidelines** topic for more information.

Using the SPARQ Ports Config Window

Access the **SPARQ Ports Config** window, by first clicking the **Setup** action button at the top right of the application, opening the **Setup** dialog. Now, click any **+** on the Setup dialog to show Advanced settings. Finally, on the Configure Ports section of the dialog, click the **Configure** button showing the **SPARQ Ports Config** window. Now, use the following instructions to configure the port setup with the **SPARQ Ports Config** window.

Abbreviations Used

- **SP** - SPARQ Port selectors
- **UP** - User Port selectors
- **PO** - Port Ordering selectors



1. Click the **DUT** box (its actually a button). A window is shown where you can select the number of ports to use and the number of ports to associate with the left side of the DUT box (the remainder are on the right side).

Note: The purpose of associating ports with a left or right side is done to facilitate pairing-up ports to be configured as differential. Otherwise, the selection is arbitrary.

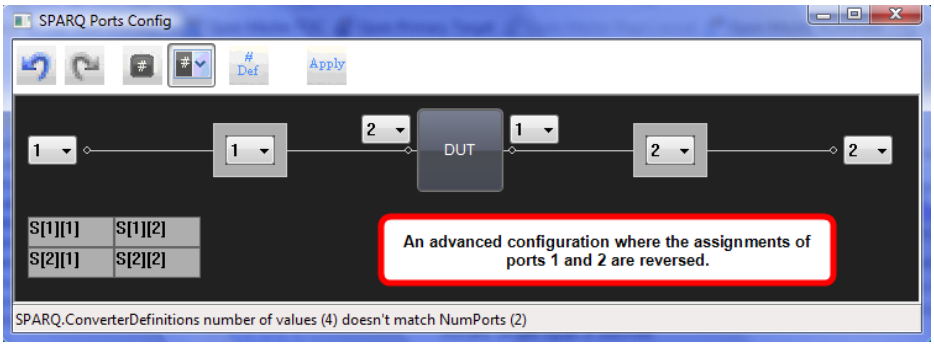
2. Configure the **SPARQ Port selectors** (**SP** labels) on both sides of the DUT box. These correspond to the port numbers on your SPARQ. If you have any differential pairs, configure the selectors so the differential pair is on adjacent ports.
3. If performing mixed-mode S-parameter measurements, select **differential** from the corresponding selector boxes. Selecting differential adds a **single-ended to mixed-mode converter** node to the diagram. Confirm that the **+** and **-** pins of the converter are connected to the correct SPARQ ports selected using the SPARQ port selectors.
4. Configure the **User Port selectors**, (**UP** labels). Along with the SPARQ Port selections, these determine the mapping of SPARQ ports to S-Parameter port assignments. The selections for the User Ports are the port numbers corresponding to the subscripts of the S-parameters selected for display in the SPARQ.
5. Configure the **Port Ordering selectors** (**PO** labels). These determine the row and column where the associated User Port (**UP** selectors) appear in the S-parameter matrix shown on the window. They also determine the ordering of the S-parameters in the output **s[n]p** file.
    - ***Single-ended example*** - If the Port Ordering selector is set to 4 and is connected to single-ended User Port 3, then row and column 4 of the S-parameter matrix includes the entries with subscript 3.
    - ***Mixed-mode example*** - If the Port Ordering selector is set to 3 and is connected to the C pin of a single-ended to mixed-mode converter assigned to User Port 2, then row and column 3 of the S-parameter matrix includes the entries with subscript C2.
6. The S-parameter matrix corresponding to the configuration is shown in the lower left area of the **SPARQ Ports Config** window. This matrix determines how the output **s[n]p** file is arranged. See the **Touchstone File Format** (on page 45) topic for more information. If port numbers are duplicated in the configuration, the matrix includes "???????" entries.
7. When finished, click the **Apply** toolbar button on the top of the **SPARQ Ports Config** window. The **Apply** action updates the **User Ports** and **DUT Ports** entry boxes showing on the **Setup** dialog of the main application window. See the **Using the User Ports and DUT Ports Entry Boxes** section for more informaiton about using these entry boxes.

Note: After using the aforementioned steps to configure your ports, the **SPARQ Ports Config** window can be closed or left open as desired.

Single-Ended Advanced Use-Case Example

As an example, say **Port 1 on your DUT** is connected to **SPARQ port 2**, and **DUT port 2** is connected to **SPARQ port 1**.

If basic mode is used for the setup, S11 measured by the SPARQ corresponds to the reflection coefficient of DUT port 2. This can be corrected using the advanced mode to change the assignments of the SPARQ Port selectors. The following image shows SPARQ port 1 associated with User Port 2, and vice-versa.



Advanced Setup Guidelines

A large degree of control over the mapping of SPARQ inputs, S-Parameter matrix port assignments, and ordering, makes it possible to order the S-matrix in a non-standard, confusing manner. Luckily, typical use-cases do not require non-standard configurations. Generally, the following guidelines apply:

- Connect **DUT port 1** to **SPARQ port 1**; **2 to 2**, **3 to 3**, and so forth, whenever possible.
- For single-ended measurements, match selector number assignments. Meaning, **SP port 1** to **UP port 1**, to **PO selection 1**.
- For differential signals, use the convention attaching **+** to **odd** numbered ports, and **-** to **even** numbered ports, with each differential pair using ports **(1,2)** and/or **(3/3)**.

Note: These suggestions are only meant as guidelines and recommendations. Specific uses and configurations vary.

Using the User Ports and DUT Ports Entry Boxes

The **User Ports** and **DUT Ports** entry boxes on the **Main Setup dialog** can be used to specify the port configuration. These boxes each contain a list of ports defining the connections made Using the SPARQ Port Config Window.

Note: For simplicity, labeling nomenclature **DUT Ports** can be interpreted as **SPARQ Ports**. Meaning the DUT Ports are directly mapped to the SPARQ Ports.

DUT Ports List

Users can directly enter the mapping between SPARQ port numbers (**SP** selectors) and the User Port assignments selected with the **UP** selectors. The User Ports are the port numbers corresponding to the subscripts of the S-parameters selected for display in the SPARQ.

1. When a User Port is **single-ended**, a numerical value is shown in the DUT Port list to associate the **SPARQ port** to the **B port**.
2. When a User Port is a **mixed-mode port**, the DUT Port list entries has the User Port number preceded by a **+** or **-**.

As an example, let's say the DUT Port list reads **+2**, **3**, **1**, **-2**. This can be interpreted as:

1. SPARQ port 1 <-> User port 2, + side
2. SPARQ port 2 <-> User port 3
3. SPARQ port 3 <-> User port 1
4. SPARQ port 4 <-> User port 2, - side

User Port List

Users can directly enter the mapping between the Port Ordering (**PO** selectors) and the User Port (**UP** selectors).

1. When a User Port is **single-ended**, a numerical value is shown denoting the mapping of the **User Port** to the **Port Ordering** selection.
2. When a User Port is a **mixed-mode port**, the User Port list entries have the B port number preceded by a **D** or **C** .

As an example, let's say the User Port list reads **D2**, **1**, **C2**, **3**. This corresponds to:

1. Port Ordering selection #1 <-> User port 2, D side
2. Port Ordering selection #2 <-> User port 1
3. Port Ordering selection #3 <-> User port 2, C side
4. Port Ordering selection #4 <-> USer port 3

Zooming and Repositioning Traces

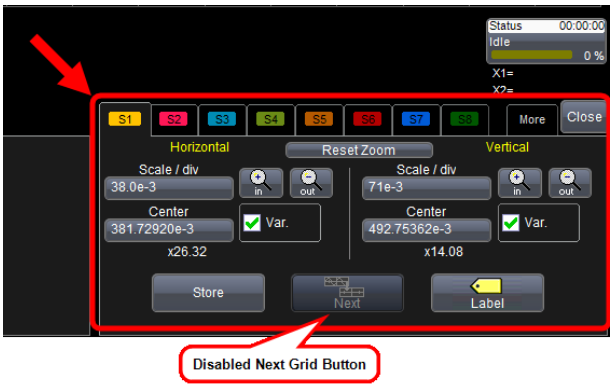
Note: This **How To** topic covering **Zooming and Repositioning Traces** pertains to both **S-Parameter Measurements** and the **Math System**. It is added to both sections for convenience.

Traces appearing on the Grid Display can be manipulated as covered in the following sections:

- Moving Traces to a Different Grid
- Shifting Trace Position Using Click-and-Drag
- Shifting Trace Position Using Zoom Settings on the Trace Configuration Dialog
- Zooming Traces Using Click-and-Drag
- Zooming Traces While Creating New Math Traces (Fx)
- Zooming Traces While Creating New Zoom Traces (Zx)
- Resetting a Zoom

Moving Traces to a Different Grid

1. Click the Trace Descriptor label for the trace you wish to move. The **Trace Configuration** dialog for the corresponding trace is then shown on the far right of the dialog area.



2. If the **Next Grid** button is enabled, click it to move the trace from one grid to the next. If the **Next Grid** button is grayed out (disabled), enable it by turning **Auto Grid** off using one of the following ways:
   - Access the Display Setup dialog from **Display → Display Setup...** and select any Grid Configuration other than Auto.
   - Toggle the Auto Grid function off by selecting **Display → Auto Grid** on the menu bar.

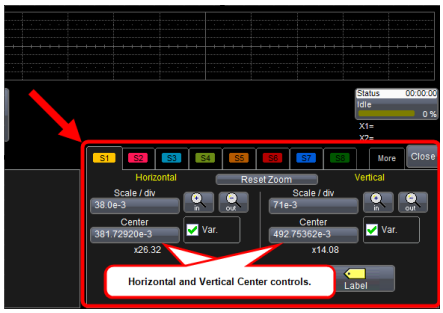
Note: This should remove a green checkmark on the Auto Grid menu bar option, indicating its disable status.

Shifting Trace Position Using Click-and-Drag

1. Move your pointer over the trace . The cursor should change to show crossed lines with arrows.
2. Click and drag either horizontally or vertically to move the trace. To move both horizontally and vertically, move in one dimension, release, and then follow this procedure to move the trace in the other dimension.

Shifting Trace Position Using Zoom Settings on the Trace Configuration Dialog

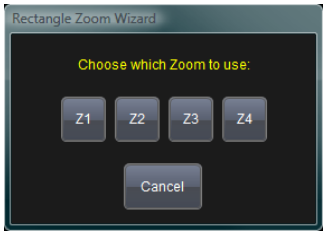
1. Click the Trace Descriptor label for the trace you wish to shift. The **Trace Configuration** dialog for the corresponding trace is then shown on the far right of the dialog area.



2. Click either Center control (Horizontal or Vertical) twice and the **Center** pop-up numeric keypad is shown.
3. Use the **Center** pop-up numeric keypad to provide a new value, and then click **OK**.

Zooming Traces Using Click-and-Drag

1. Draw a rectangle on the Grid Display around a specific trace's region. Do this by clicking-and-dragging to create diagonal corners of a desired rectangular region.
2. When you release the click-and-drag, the Rectangle Zoom Wizard pop-up is shown.



Select the name of the **trace** being zoomed **Zx**, or click **Cancel** on the pop-up.

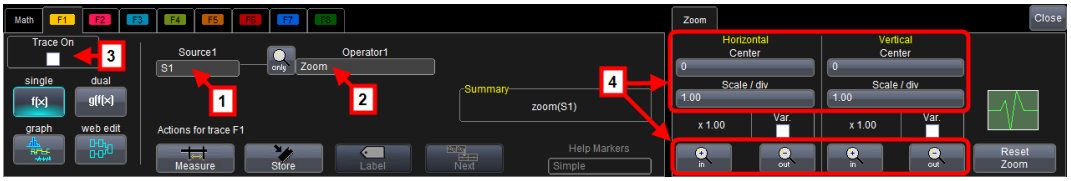
If **Zx** is chosen, a Zoom trace is configured displaying a copy of the selected waveform.

- You can adjust the zoom factor on the **Zx** trace by repeating the aforementioned click-and-drag step on the same Zx trace.

- You can also adjust the zoom factor on the **Zx** trace from the corresponding Zx settings dialog accessed either from **Math → Zoom Setup...** on the menu bar, or by clicking the corresponding Zx **Trace Descriptor Label**.

Zooming Traces While Creating New Math Traces (Fx)

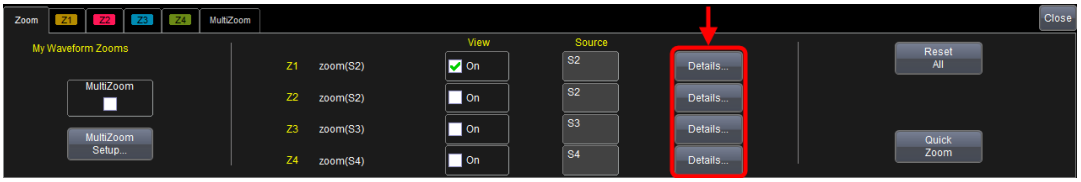
Select **Math → F1 Setup...** from the menu bar. The **F1 Trace Configuration** dialog is shown. Numbered callouts on the following screen-shot correspond to respective explanations.



1. Click **Source1** and the **Select Source** pop-up is shown. Select the desired source trace on the pop-up and click **OK**.
2. If **Operator1** is not set to Zoom, click the **Operator1** control and the **Select Math Operator** pop-up is shown. Choose **Zoom** from the list on the **Select Math Operator** pop-up.
3. Click the **Trace On** box on the far-right of the dialog.
4. Setup horizontal and vertical **Center** and **Scale/div** values as desired, or click respective **+** and **-** magnifier buttons to zoom **in** or **out**.

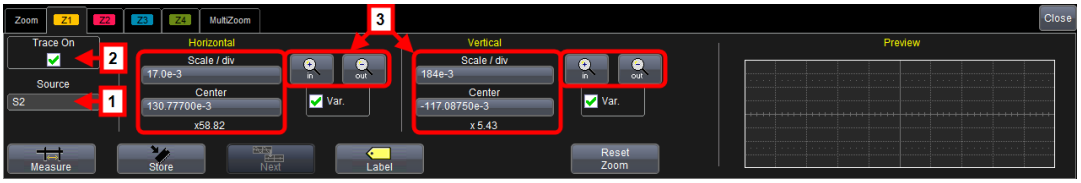
Zooming Traces While Creating New Zoom Traces (Zx)

Select **Math → Zoom Setup...** from the menu bar. The **Zoom** dialog is shown.



Click an unused Zoom trace's **Details** button and its respective **Zx Configuration Dialog** is shown.

Now, on your selected Zoom trace's **Zx Configuration Dialog** use steps 1, 3, and 4 as explained in the previous **Zooming Traces While Creating New Math Traces (Fx)** section. The same steps apply only controls are located in slightly different places on this dialog.



1. Click **Source1** and the **Select Source** pop-up is shown. Select the desired source trace on the pop-up and click **OK**.
2. Click the **Trace On** box on the far-right of the dialog.
3. Setup horizontal and vertical **Center** and **Scale/div** values as desired, or click respective **+** and **-** magnifier buttons to zoom **in** or **out**.

Resetting a Zoom

Reset a specific zoom by clicking its corresponding **Trace Descriptor** label. Its corresponding **Trace Configuration** dialog is shown. Now, click the **Reset Zoom** button. The Reset Zoom button location varies for different types of traces.

File Menu

Overview

The **File** menu is used to open the following dialogs and to execute several actions (many already covered in the **Save/Recall** section of **Common Tasks** covered earlier in this manual):

- **Saving and Recalling Waveforms** (on page 57)
- **Saving Table Data** (on page 60)
- **Saving and Recalling Setups** (on page 61)
- **Disk Utilities** (on page 63)
- **Print Setup (Hardcopy) Dialog**

File Menu Action Items:

- **Print** - Executes a **hardcopy** action. Configuration from the **Print Setup** dialog determines what happens when Print is selected.
- **Minimize** - Minimizes the SPARQ application window.
- **Windowed** - Changes the windowing mode to **Windowed** state, where the application window can be resized by clicking-and-dragging the application frame.
- **Exit** - Exits the application.

Save/Recall

Overview

The **Save/Recall** section allows for storage and retrieval of **Waveforms**, **Table Data**, and **Instrument Setups**. It even provides **Disk Utilities** for arranging the file/folder structure on your instrument's hard drive.

Directly access each Save/Recall dialog (**Waveform**, **Table**, **Setups**, and **Disk Utilities** on the **File** menu on the menu bar. A main Save/Recall dialog is available which provides buttons (essentially links) to the aforementioned dialogs for specific Save/Recall functions.

Saving and Recalling Waveforms

Saving Waveforms

The Save Waveform dialog is used to save displayed waveforms to either a memory trace or to text or binary file formats.

Note: This dialog is for saving waveforms. Save S-parameter files, using the **Result Actions Dialog** (on page 42).

Access the **Save Waveform** dialog by selecting **File → Save Waveform** from the menu bar.

1. Select either **Memory** or **File** by touching either respective button on the **Save To** portion of the dialog.

Note: When **Memory** is selected, only **Source** and **Destination** controls are shown on the Save Waveform dialog. When **File** is selected, many more controls are available. Regardless, the controls are used as explained in the following steps.

2. Touch inside the **Source** field and select a source from the **Select Source** pop-up. The source can be any trace; for example, a channel (C1–C4), math function (F1–F4), or a waveform stored in non-volatile RAM (M1–M4).
3. **Destination** - Click to show the available memory traces when saving to memory.
4. Touch inside the **Trace Title** data entry field to change the default name of your waveforms (if desired). Use the pop-up keyboard to type the new name.

Note: You can change the name but not the sequence number.

CAUTION

If you use a name ending with a number instead of a letter, the instrument may truncate the number. This is because, by design, the first waveform is automatically numbered 0, the second 1, etc. For example, if you want to use waveform name **XYZ32** but it is not preceded by waveforms XYZ0 through XYZ31, the waveform is renumbered with the next in sequence.
If you need to use a number in your waveform's name, append an alpha character at the end of the number: **XYZ32a**, for example.

5. If you are saving to a file, touch the **Data Format** field and select a format type.

- **Binary** - saves the file to LeCroy's binary file format. This format is documented in various Remote Control Manuals for LeCroy Oscilloscopes. Selecting **Binary** results in the smallest possible file size, and is recommended when recalling waveforms to LeCroy instruments.

  Note: Binary files can be converted to ASCII using LeCroy utilities such as **ScopeExplorer** or **WaveStudio**.

- **ASCII** -Text output file (.txt extension).
- **MATLAB** - Text output file compatible with MATLAB (.dat extension).
- **Excel** - Text output file compatible with Excel (.csv extension).
- **MathCad** - Text output file compatible with Excel (.prn extension).

Depending on your selection, you may need to touch the **SubFormat** field and select a subformat.

- **Word** - Available when selecting the Binary format, specifies the samples in the output file are represented with 16 bits. Always use this option unless Byte mode is pre.
- **Byte** - Available when selecting Binary format, specifies the samples in the output file are represented with 8 bits.

  Note: Using this option can result in a loss of output file resolution.

- **Amplitude only** - Specifies the output file include amplitude data for each sample, but not sample time information.
- **Time and Amplitude** - Specifies the output file include both time and amplitude data for each sample.
- **With Header** - Specifies to include a header with scaling information.

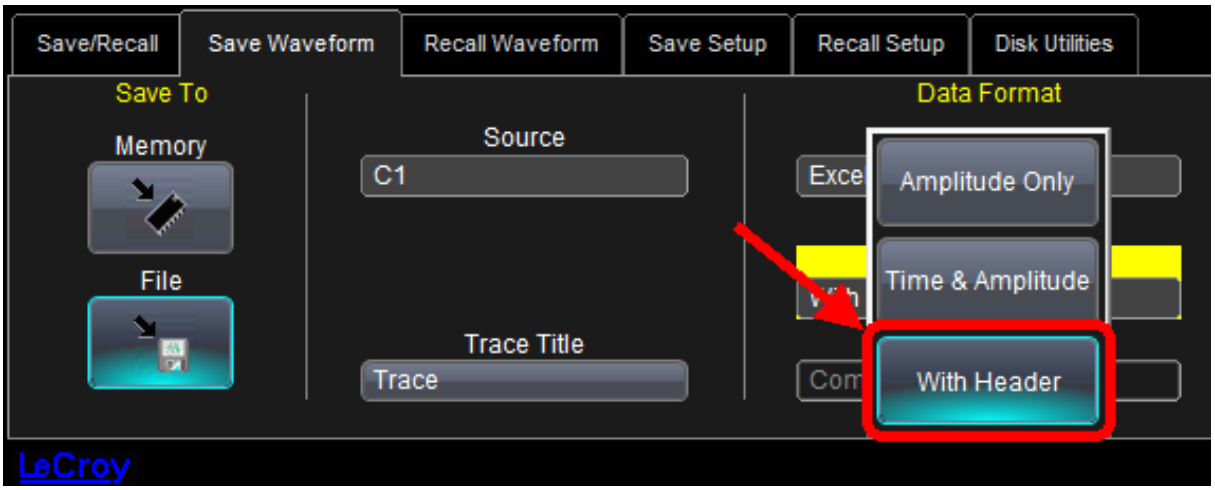
If you select **ASCII**, touch the **Delimiter** field and select a delimiter character from the pop-up menu. Choose from **comma**, **space**, **semicolon**, or**tab**delimiters.

PLEASE NOTE THE FOLLOWING:

- Select **Audio** to save your waveforms into the .wav format.
- The **WaveML** format, which enables XML output, is used for persistence traces.

Vector Signal Analysis (VSA) Support Software Option

Before we continue saving our waveform, users with the VSA Support Software option can choose **With Header** from the **SubFormat** field.



This stores the waveform in **VSA recall** format for later use.

Note: An Analysis function also comes with the VSA Software which can send signal traces to VSA as a recording (time domain) file.

6. You can use the **Auto Save** feature to automatically save a waveform to disk after each new trigger. You can enable Auto Save from the **Save Waveform** dialog by touching one of the **Auto Save** buttons.

Select **Wrap** (old files overwritten) or **Fill** (no files overwritten).

CAUTION

If you select **Fill**, you can quickly use up all disk space on your hard disk.

---

7. Touch the **Browse** button next to the **Save file in directory** field and navigate to the location where you want the file saved. The file name is assigned automatically and is shown under the field.
8. Finally, touch the **Save Now!** button.

Recalling Waveforms

Note: Only .trc files were saved in binary format can be recalled into the oscilloscope.

Access the **Recall Waveform** dialog by selecting **File → Recall Waveform** from the menu bar.

1. Select either **Memory** or **File** by touching either respective button on the **Recall From** portion of the dialog.

Note: When **Memory** is selected, only **Source**, **Destination**, and **Show on recall** controls are shown on the Recall Waveform dialog. When **File** is selected, many more controls are available. Regardless, the controls are used as explained in the following steps.

2. If recalling from Memory, touch inside the **Source** field and select a source stored in non-volatile RAM (M1–M4) from the **Select Source** pop-up.
3. Touch inside the **Destination** field and select a location for storage (memory or file) from M1 to M4.
4. **Show on Recall** - Mark this checkbox to have the memory trace shown on the grid display after recalling the waveform.
5. When saving a File, touch inside the **Show only files** field and select an area to limit the search (**channels**, **math functions**, or **memory**).
6. Touch inside the **Recall files from directory** data entry field and enter the path using the pop-up keyboard. You can also touch the **Browse** button and navigate to the file. Touch inside the **Next file will be recalled from data entry** field and enter the path using the pop-up keyboard. Or, touch the **Browse** button to navigate to the file.
7. **Up /Down arrows** - Use these buttons to cycles through files in the selected folder from the **Show only files** control.
8. When finished, touch the **Recall Now!** button.

Saving Table Data

Access the **Save Table** dialog by selecting **File → Save Table** from the menu bar.

1. Touch inside the **Source** field and select a source from the **Select Source** pop-up. The source can be any trace; for example, a channel (C1–C4), math function (F1–F4), or a waveform stored in non-volatile RAM (M1–M4).
2. Touch inside the **Table Title** data entry field to change the default name of your waveforms (if desired). Use the pop-up keyboard to type the new name.

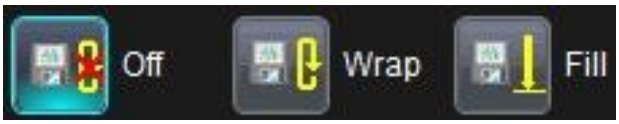
Note: You can change the name but not the sequence number.

CAUTION

If you use a name ending with a number instead of a letter, the instrument may truncate the number.

This is because, by design, the first waveform is automatically numbered 0, the second 1, etc. For example, if you want to use waveform name **XYZ32** but it is not preceded by waveforms XYZ0 through XYZ31, the waveform is renumbered with the next in sequence.
If you need to use a number in your waveform's name, append an alpha character at the end of the number: **XYZ32a**, for example.

3. Choose either ASCII text or Microsoft Excel for the storage **Format** of you table data.
4. Now, choose from **Comma**, **Space**, **Semicolon**, and **Tab** values on the **Delimiter** control.
5. You can use the **Auto Save** feature to automatically save a waveform to disk after each new trigger. You can enable Auto Save from the **Save Waveform** dialog by touching one of the **Auto Save** buttons.



Select **Wrap** (old files overwritten) or **Fill** (no files overwritten).

CAUTION
If you select **Fill**, you can quickly use up all disk space on your hard disk.

6. Touch the **Browse** button next to the **Save file in directory** field and navigate to the location where you want the file saved. The file name is assigned automatically and is shown under the field.
7. Finally, touch the **Save Now!** button.

Saving and Recalling Setups

The Save/Recall Setup dialogs allow for quick saving and recalling of up to six oscilloscope panel settings internally on your instrument. If desired, you can also save and recall your oscilloscope panel settings as an .lss file to a specific hard disk location, a network location, or USB drive.

Saving Oscilloscope Setup(s)

Access the **Save Setup** dialog by selecting **File → Save Setup** from the menu bar. Now use one of the following two methods to save setup(s).

Saving Setup(s) Internally on Your Instrument

Save your settings **internally on your instrument** by touching inside one of the six **SetupX** data entry fields on the **Save to Internal Setup** part of the screen and providing a name. Now, touch its corresponding **Save** button directly to the left.

Your setup file is then saved to the **D:\Internal Setups** location on your instrument and the current date/time is shown above the **SetupX** data entry field.

OR

Saving Setup(s) Directly to a File

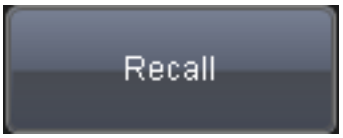
Save your setup(s) **directly to a file** by using controls on the **Save To File** section on the right side of the dialog. Touch inside the **Save panel to file** data entry field. Use the pop-up keyboard to provide a path to the destination folder. Or touch **Browse** to navigate to the destination folder. Finally, touch the **Save Now** button.

Recalling Oscilloscope Setup(s)

Access the **Recall Setup** dialog by selecting **File → Recall Setup** from the menu bar. Now use one of the following two methods to save setup(s).

Recalling Setup(s) Internally on Your Instrument

Recall your settings located **internally on your instrument** by touching inside one of the six **Recall** buttons on the **Recall From Internal Setup** part of the screen.



Each Recall button is labeled with a corresponding setup storage slot. If a setup is stored, **SetupX** is shown along with the **date/time of the save**, otherwise, the slot is labeled **Empty**.

OR

Recalling Setup(s) Directly from a File

Recall your setup(s) **directly from a file** by using controls on the **Recall From File** section on the right side of the dialog. Touch inside the **Recall panel from file** data entry field. Use the pop-up keyboard to provide a path to the destination folder. Or touch **Browse** to navigate to the destination folder. Finally, touch the **Recall Now** button.

Recalling Default Settings

Disk Utilities

Use the Disk Utilities dialog to arrange the file/folder structure on your instrument's hard drive. You can delete files, folders, or create new folders.

Note: All Disk Utilities can also be accomplished using the standard Microsoft Windows® file management tools.

Access the **Disk Utilities** dialog by selecting **File → Disk Utilities** from the menu bar.

Deleting a Single File

1. Touch the **Delete** button on the **Disk Utilities** to make sure this button is selected.

2. Touch inside the **Current folder** data entry field and use the pop-up keyboard to enter the path to the folder containing the file for deletion.
   OR
   Touch the **Browse** button and navigate to the folder.
3. Touch inside the **File to be deleted** data entry field and use the pop-up keyboard to enter the name of the file.
   OR
   Touch the **Browse** button and navigate to the file.
4. Once you have located the file, touch the **Delete File** button.

Deleting All Files in a Folder

1. Touch the **Delete** button on the **Disk Utilities** to make sure this button is selected.

2. Touch inside the **Current folder** data entry field and use the pop-up keyboard to enter the path to the folder that contains the file you want to delete.
   OR
   Touch the **Browse** button and navigate to the folder.
3. Once you have located the folder, touch the **Empty Folder** button.

Creating a Folder

1. Touch the **Create** button on the **Disk Utilities** to make sure this button is selected

2. Touch inside the **Current folder** data entry field and use the pop-up keyboard to enter the path for folder creation and **be sure to including the folder name**.
3. Finally, touch the **Create Folder** button.

Note: **Disk Space** data for **Size**, **Free**, and **File(s)** is available on the far right of the dialog for convenience.

Print Setup (Hardcopy) Dialog

Setting Up the Printer

Access the **Print Setup** dialog by selecting **File → Print Setup...** from the menu bar.

OR

Press the PRINT front panel button. Then, touch the **Print Setup** button on the **Print** flyout menu.

The Hardcopy dialog is then shown.

Note: Settings made on this dialog controls the action occuring when **File → Print** is selected.

There are four configurable modes or destinations offered on the Print Setup dialog: **Printer**, **Clipboard**, **File**, or **Email**.

Printer Mode

Selecting **Printer** mode, makes the **File → Print** function print the application window. The following additional Print Setup dialog settings are also available:

1. **Selected Printer** - Click to display a selector from which a printer can be chosen. The list of printer currently configured via Windows is displayed.
2. **Colors** - Click to display a selector with the following choices:
   - **Standard** - The color scheme for printing is the same as the current interface display.
   - **Print** - The background of the grid portion of the SPARQ display is printed in white (to save ink).
   - **Black & White** - A black & white version of the SPARQ application is printed.
3. **Orientation** - Select between portrait and landscape orientations.
4. **Properties** - Clicking the Properties button shows the Windows Print dialog for the configured printer.
5. **Add Printer** - Click to open the standard Windows Printer Control Panel .
6. **Hardcopy Area** - Designates the selected area used for the Hardcopy action from the following choices:

   - **Grid Area Only** - Selects the portion of the application including the entire grid display.
   - **DSO Window** - Selects the full SPARQ application window.
   - **Full Screen** - Selects the entire display shown on your screen.
7. **Print** - Clicking this button executes a Print action; however, using this method always includes the Print Setup dialog in the print results.

Selecting use **File → Print** from the menu bar after selecting a different dialog allows the printing of dialogs other than Print Setup.

Clipboard Mode

Selecting **Clipboard** mode, makes the **File → Print** function copy the screen-shot area to the Windows clipboard. The following controls are available on the dialog when Clipboard mode is selected:

1. **Colors** - Refer to the Print Mode section for details.
2. **Hardcopy Area** - Refer to the Print Mode section for details.

File Mode

Selecting **File** mode, makes the **File → Print** function save the screen-shot area to a file. The following controls are available on the dialog when File mode is selected:

1. **File Format** - Select an image format for the output file from the following available formats.

   Note: For best reproduction of the screenshot, use **.png** or **.bmp** formats.

   - **Joint Photographic Experts Group (.jpeg)** - JFIF Compliant(.jpg). Select for JPEG (.jpg) formatting.
   - **Portable Network Graphics (.png)** - Select to create a .png file.
   - **Tagged Image File Format (.tif)** - Select to create a .tif file.
   - **Windows Bitmap (.bmp)** - Select to create a .bmp file.
2. **Filename** - Click to enter a file name prefix ending with a letter. The instrument appends an incrementing numerical value followed by the file extension. Any numbers manually entered at the end of the filename are ignored.
3. **Directory** - Click Browse or enter the filepath of the folder where files should be saved.
4. **Colors** - Refer to the Print Mode section for details.
5. **Hardcopy Area** - Refer to the Print Mode section for details.

Email Mode

When selecting Email mode via the Email button on the left side of the dialog, the **File → Print** action will email a file containing the screenshot via the server and to the selected recipient configured on the Email Setup Dialog

1. **File Format** - Refer to the File Mode section for details.
2. **Colors** - Refer to the File Mode section for details.
3. **Prompt for message** - When checked, a pop-up window is shown where you can add a message to the outgoing email.
4. **Hardcopy Area** - Refer to the Print Mode section for details.

Changing the Default Printer

1. If you want to change the default printer, minimize the instrument application by touching **File** in the menu bar, then **Minimize** in the drop-down menu.
2. Touch the **Start** button in the task bar at the bottom of the screen.
3. Select **Settings**, then **Printers**.
4. Touch the printer you want to set as the default printer, then touch **File, Set as Default Printer**.

Display Menu and Setup Dialog

Display Menu

The **Display** menu provides controls for determining how many grids are shown on the grid display area and some aspects as to how the traces are shown. The menu items include the following:

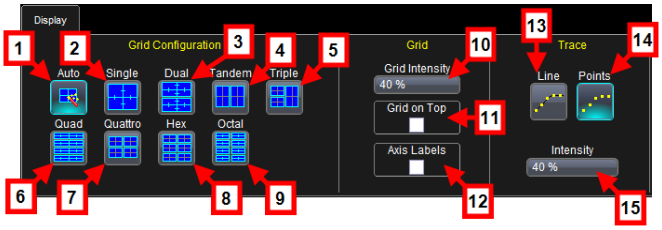
1. **Display Setup...** - Selecting this item shows the **Display Setup** dialog, described in the following section.
2. **Auto Grid** - Selecting Auto Grid toggles the **auto grid** operation on and off.

> **Note**: Auto grid must be turned off to manually move traces between grids.

3. **Single Grid** - Selects single grid operation. When selected, all subsequent traces are then shown in a single grid. Use Single grid to look at a single trace, or for comparing two traces
4. **Dual Grid** - Selects 2 grid operation.
5. **Quad Grid** - Selects 4 grid operation, with each grid stretching across the screen.
6. **Quatto** Grid - Selects 4 grid operation, with the grids placed in a 2 X 2 arrangement.
7. **Hex Grid** - Selects 6 grid operation,with the grids placed in a 3 X 2 arrangement.
8. **Main Display** - Returns to the main application screen.
9. **Web Editor** - Switches to Web Edit mode, where operations can be cascaded in a flow-chart style interface.

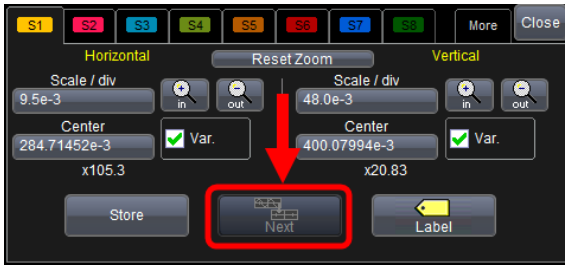
Display Setup Dialog

Selecting **Display Setup...** from the Display menu shows the **Display** setup dialog, which includes the following items:



Grid Configuration

1. **Auto Grid** - Selecting **Auto** grid mode automatically sets the grid style and determines which grid shows what trace(s). In Auto Grid mode, the **Next Grid** action button on the right-hand trace configuration dialog is disabled.



2. **Single** - Selects single grid operation. All traces are shown on a single grid. Use Single to look at an individual trace, or to compare two traces.
3. **Dual** - Two grids displayed; one on top of the other.
4. **Tandem** - Two grids shown in a side-by-side configuration for maximum height (amplitude).
5. **Triple** - Three grids shown; similar side-by-side configuration as tandem only the right side shows two grids on top of each other, while the one on the right takes up the full grid height.
6. **Quad** - Four grids displayed; each one stretched across the screen.
7. **Quattro** - Four grids are shown in a 2 X 2 arrangement.
8. **Hex** - Six grids are displayed in a 3 X 2 arrangement.
9. **Octal** - Eight grids displayed in two columns of 4 grids.

Grid settings

10. **Grid Intensity** - Enter an intensity percentage for the gridlines. A 0% setting turns gridlines off completely.
11. **Grid On Top** - Marking this checkbox draws the gridlines over the traces.
12. **Axis Labels** - Marking this checkbox shows labels which indicate min and max axis values.

Trace Settings

13. **Line** - Clicking this button shows the samples connected by line segments
14. **Points** - Clicking this button shows the samples disconnected.
15. **Intensity** - Enter a intensity percentage value for the trace.

Cursors System

Cursor System Overview

The Cursor Menu includes items for setting up the horizontal and vertical cursors that are used to make quick measurements of horizontal and vertical waveform values. Cursors are markers — lines, cross-hairs, or arrows — that you can move around the grid or the waveform itself. Use cursors to make fast, accurate measurements and to eliminate guesswork. information about the vertical coordinate is displayed in the trace descriptor boxes; horizontal (X) coordinate information appears under the Status box on the left side of the window.

Related content: **Standard Cursors** and **Making Cursor Measurements** (on page 68)

Cursor Menu and Dialog

The **Cursors Menu** includes the following items:

1. **Cursor Setup...** - Selecting this item opens the **Standard Cursors** dialog.
2. **Off** - Turns off the cursors.
3. **Horizontal Abs(olute)** - Turns on the "horizontal absolute" cursor. This selection allows users the ability to set the X position of a single cursor. The value of the X position and Y coordinate information for each trace at the X position are displayed in the trace descriptor boxes for all waveforms with a common X-Axis unit (such as all time-domain traces). The Y information that is displayed and the choice of X-Axis unit is determined by the settings made in the **Standard Cursors** dialog.
4. **Horizontal Rel(ative)** - Turns on the "horizontal relative" cursors. This selection allows users the ability to set the X position of a two cursors. The X position values and corresponding Y coordinate information for each trace are displayed in the trace descriptor boxes for all waveforms with a common X-Axis unit (such as all S-Parameter traces). The Y information that is displayed and the choice of X-Axis unit is determined by the settings made in the **Standard Cursors** dialog.
5. **Vertical Abs(olute)** - Turns on the "vertical absolute" cursor. This selection allows users access to a single cursor to measure the vertical position of the cursor for each trace.
6. **Vertical Rel(ative)** - Turns on the "vertical relative" cursors. This selection allows users to access two cursors to measure the vertical coordinates of the cursors for each trace.

Standard Cursors Dialog

1. **Cursors On** - Controls whether the cursors are on or off.
2. **Cursor Type** - Select one of the 4 cursor types. (See descriptions above)
    A. **Horizontal Abs(olute)**
    B. **Horizontal Rel(ative)**
    C. **Vertical Abs(olute)**
    D. **Vertical Rel(ative)**

3. **X-Axis** - Selects the set of traces that will have cursors displayed via the X-axis unit. This is only visible when selecting Horizontal Rel or Horizontal Abs cursor types.
4. **Show** - The choices displayed for "Show" depend on the selection chosen for **Cursor Type**, and is only visible when selecting to use either Horizontal Rel or Vertical Rel cursors. The cursor result(s) are shown in the trace descriptor box.
    - **Absolute** - Display the Y value of each cursor.
    - **Delta** - Displays the difference of the Y values.
    - **Abs+Delta** - Displays absolute and delta cursors together.
    - **Slope** - Displays the slope between cursors.
5. **Position:**

    Track- Active only when using relative cursors. When checked, cursors will both move when one is moved via a click-drag action. The separation between the cursors will remain fixed.

    Position 1 - The position of cursor #1 (dash-dot line style) is shown, and can be directly entered by clicking twice to open a numeric keypad.

    Position 2 - The position of cursor #2 (dashed line style) is shown when selecting either horizontal relative of vertical relative cursors, and can be directly entered by clicking twice to open a numeric keypad.

Making Cursor Measurements

Cursors are important tools aiding you in measuring signal values. Cursors are markers - lines, cross-hairs, or arrows - you can move around the grid or the waveform itself. Use cursors to make quick measurements and to eliminate guesswork. There are two basic types:

- **Horiz(ontal)** (generally Time or Frequency) cursors are markers moved horizontally along the waveform. Placing them at a desired location along the time axis allows you to read the signal's amplitude at the selected point in time.
- **Vert(ical)** cursors are lines moved vertically on the grid to measure the amplitude of a signal.

See **Cursors System** (on page 67) for descriptions of the options included in the Cursors menu and in the Standard Cursors dialog.

Turning Cursors on or off

Cursors can be shown or hidden using the appropriate item on the Cursor Menu, or by selecting controls on the the **Standard Cursors** configuration dialog (shown by selecting **Cursors → Cursor Setup...** from the menu bar).

Choosing a Cursor Type

Four cursor types of cursors are selectable from either the **Cursors** menu or the **Standard Cursors** dialog.

Horizontal Abs(olute)

Use **Horizontal Abs(olute)** to find the **Y value** of a waveform at a specific **X coordinate**.

For example, say you want to know the dB value at 10.33H GHz, you can set the cursor for this exact value using the **Position1** control on the **Standard Cursors** configuration dialog. The dB value entered for this frequency is then shown on the trace descriptor label for all traces having X-axis units of frequency when the **active X-axis** is configure for Hz.

Horizontal Rel(ative)

Use **Horizontal Rel(ative)** to find **Y values** at **2 specific X values**, or to make **delta-x** or **delta-y** measurements.

For example, say you want to measure the frequency difference between two waveform peaks, you can position the Horizontal Rel(ative) cursors at the peaks, and read off the delta-X from the right side of the screen just under the **Status box**. Use the **Show** section of the Standard Cursors dialog to display the following:

- **Absolute** - Both Y values in the trace descriptor box.
- **Delta, Abs+Delta, Respectively** - And/or show the delta-y value.
- **Slope** - Show the slope, meaning delta-y / delta-x.

Vertical Abs(olute)

Use **Vertical Abs(olute)** for a visual reference line corresponding to a certain vertical grid position. This is helpful to use when eyeballing a Y value not necessarily at a specific X-axis value, such as the position of a voltage plateau in a TDR trace. The cursor appears at the same position on each grid, and the corresponding Y value is shown on the trace descriptor label for each trace.

Vertical Re(ative)

Use **Vertical Re(ative)** for visual reference lines corresponding to two vertical grid positions. This cursor type allows for quick Deta-Y measurements on Y-values at non-specific time values, such as the position of a voltage plateau in a TDR trace.

Setting the Y Coordinate Readout

When using either Horizontal or Vertical Relative cursors, you can select one of several readout modes for Y coordinate information. The selection is made on the **Show** section of the **Standard Cursors** dialog.

Setting Cursor positions

The position of a cursor can be set two ways:

1. Click and hold directly on the cursor, and then drag left or right
2. Set the position explicitly using the **Position** controls on the **Standard Cursors** configuration dialog.

Marking the **Track** checkbox moves both Position 1 and 2 cursors simultaneously when using either **Horizontal** or **Vertical Relative** cursors.

Positions are set in units of divisions (ranging from -4 to +4) for vertical cursors, and in the units selected in the X-Axis configuration for horizontal units.

Finding Cursor Measurement Results

Vertical results are shown on corresponding trace descriptor labels, while horizontal results are shown on the right side of the application underneath the Status Box.

Horizontal Curosr Behavior - Zoomed Traces

The X-coordinate of a cursor includes physical units such as time or frequency, and the cursors are shown on all traces with the selected X-axis unit. However, not all traces need to have the same scaling on the X-axis.

For example, you may wish to show both the complete S11 trace, along with a zoom of the central 5%, as shown in the following figure. Notice how a cursor is shown on the lower grid, but not on the upper grid. The reason is the X-coordinate of the cursor is not within the range of X values being shown in the zoom trace. The cursor must be moved into the zoomed region, becoming visible on the upper grid, by clicking-and-dragging the cursor in the lower trace over to the highlighted portion of the trace (corresponding to the zoomed region). If the zoomed region is extremely narrow, you may wish to reduce the zoom magnification factor to facilitate moving the cursor into the zoomed region.

Math System: Analyze with Math, Zoom and Memory Traces

The SPARQ includes analysis capabilities beyond S-Parameter measurements. Users can study the TDR and S-Parameter waveforms further via the use of Math traces, Zoom traces, Memory traces, and measure waveform properties via Cursors and Parameter Measurements. Each of these items constitute a "system" in the SPARQ software architecture, and are described below

Math System Overview

Mathematical operations can be performed on waveforms, and resulting waveform can be displayed on the grid.There are 8 "slots" that can be configured using the Math system, labeled F1 through F8, and generically referred to as Fx.

- Math traces are configured via the Math menu item Math Setup... and, for F1 through 4, the shortcut Fx Setup... items.
- Users can also call up the configuration dialog for a math trace by clicking on the trace descriptor box of a displayed math trace.
- See **Math System Dialogs** (on page 71) for descriptions of the configuration dialogs for setting up Fx math traces.

Related content: **Zooming and Repositioning Traces** (on page 53).

Zoom System Overview

The SPARQ gives users access to 4 traces dedicated to zooming in on features of other traces, The zoom traces names are Z1 through Z4, and generically referred to as Zx.

- Zoom traces are configured via the Zoom Setup... item in the Math menu, or by clicking on the trace descriptor box of a displayed zoom trace.
- Zoom traces can be created by click-dragging to demarcate a region of interest of a displayed waveform
- See **Zoom Controls** (on page 44) for information on zoom settings, andsee **Zooming and Repositioning Traces** (on page 53) for the steps to take to create a zoom.

Memory System

Memory traces contain waveforms that are either loaded from disk, or that are copies of another displayed waveform. Four memory traces are available, with trace names M1 through M4. Use memory traces when wanting to reference traces on the screen for either visual comparisons or for analysis.

- Copying a waveform to a memory is accomplished via the **Save Waveform Dialog**. Loading a waveform from disk is accomplished via **Recall Waveform Dialog**.
- Memory trace settings can be configured via the trace configuration dialog that can be accessed by clicking on the trace descriptor box of a displayed memory trace.
- Memory traces can also be used as the source for Fx and Zx waveforms.

Math Menu

The Math menu includes the following items for configuring Math functions F1 through F8, Zoom traces Z1 through Z4 and Memory traces M1 through M4.

For an overview of the Math, Zoom and Memory systems, see **Math System: Analyze with Math, Zoom and Memory Traces** (on page 69)

1. **Math Setup...** - Opens the main **Math configuration dialog.**
2. **Zoom Setup...** - Opens the main Zoom configuration dialog, which includes checkboxes to turn traces Zx on and off, Selection boxes for the source, a Details button for each Zx to switch to the Zx configuration screen
3. **Fx Setup...** - Opens the configuration dialog for Math functions F1 through F4..

4. **Memory Setup...** - Opens the summary dialog for the memory system.

Math System Dialogs

The Math system includes a "summary" dialog, and dialogs for each Fx math function. These are all "tabs" in the dialog area of the user interface.

Summary Math Dialog

This dialog is called up via selecting **Math → Math Setup...**. It serves as a summary screen, indicating the math functions that are currently in use and the assigned functions. It includes the following elements:

1. **Zoom Setup** button - Click to switch to the Zoom Setup dialog.
2. **F1 through F8** buttons - Click to open the Select Math Operator popup window for selecting a math operator for the selected math function.
3. **View Trace** checkboxes - Controls whether or not a math function is displayed.
4. **Reset All** - Resets all math functions back to the "zoom" operator. (Not to be confused with Zoom traces).
5. **Clear Sweeps** - Clears the trace for any Fx that is using cumulative data, such as the Average function. Otherwise, there is no effect.

F1..F8 Trace Configuration Dialogs

The F1 through F8 dialogs can be called up by clicking on the trace descriptor box, or, for F1 through F4, via the Math Menu. They include all configuration elements for setting up math functions. Associated with the Fx configuration dialog is a smaller dialog on the right-side of the screen that includes tabs containing zoom controls for the Fx trace, and a tab for operator-specific configurations.

1. **Trace on** - Checkbox to control whether or not the Fx trace is displayed.
2. **Fx type** buttons - Select from the following choices:
   - **Single** - Select to use a single math operation.
   - **Dual** - Select to chain two operations
   - **Graph** - Select to route the output of a math operation to a second operation that is one of several operations categorized as "Graph" operations.
   - **Web Edit** - Select to use the Fx trace as the output of a processing chain defined using the web editor interface.
3. **Source1** - Select to open the Select Source popup for selecting a source for the math function
4. **Source2** - Visible when Operator1 requires two inputs (such as the "Sum" operator). Select to open the Select Source popup for selecting the second source for Operator1.
5. **Source3** - Visible when using Dual math, and when Operator2 requires two inputs (such as the "Sum" operator). Select to open the Select Source popup for selecting the second source for Operator2.
6. **Action buttons** - Resets all math functions back to the "zoom" operator. (Not to be confused with Zoom traces).
7. **Clear Sweeps** - Clears the trace for any Fx that is using cumulative data, such as the Average function. Otherwise, there is no effect.

Zoom Control dialog

Associated with the Fx configuration dialog is a smaller dialog on the right-side of the screen that includes a tab containing **Zoom Controls** (on page 44) for the Fx trace.

Operation-Specific Dialog

Associated with the Fx configuration dialog is a smaller dialog on the right-side of the screen that includes a tab containing operation-specific settings for the Fx trace.

Zooming and Repositioning Traces

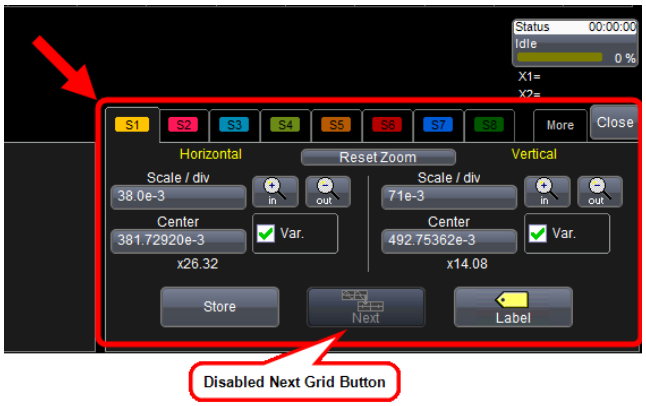
Note: This **How To** topic covering **Zooming and Repositioning Traces** pertains to both **S-Parameter Measurements** and the **Math System**. It is added to both sections for convenience.

Traces appearing on the Grid Display can be manipulated as covered in the following sections:

- Moving Traces to a Different Grid
- Shifting Trace Position Using Click-and-Drag
- Shifting Trace Position Using Zoom Settings on the Trace Configuration Dialog
- Zooming Traces Using Click-and-Drag
- Zooming Traces While Creating New Math Traces (Fx)
- Zooming Traces While Creating New Zoom Traces (Zx)
- Resetting a Zoom

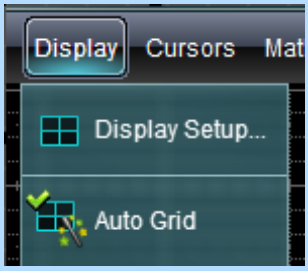
Moving Traces to a Different Grid

1. Click the Trace Descriptor label for the trace you wish to move. The **Trace Configuration** dialog for the corresponding trace is then shown on the far right of the dialog area.



2. If the **Next Grid** button is enabled, click it to move the trace from one grid to the next. If the **Next Grid** button is grayed out (disabled), enable it by turning **Auto Grid** off using one of the following ways:
   - Access the Display Setup dialog from **Display → Display Setup...** and select any Grid Configuration other than Auto.
   - Toggle the Auto Grid function off by selecting **Display → Auto Grid** on the menu bar.

Note: This should remove a green checkmark on the Auto Grid menu bar option, indicating its disable status.

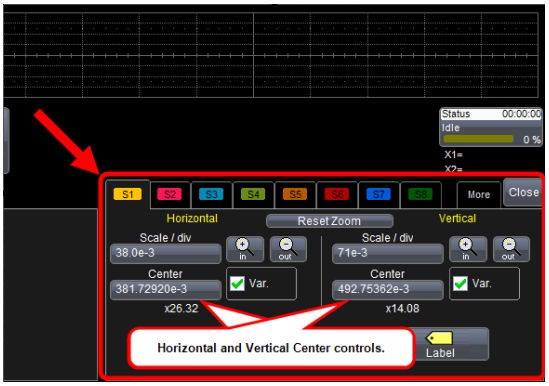


Shifting Trace Position Using Click-and-Drag

1. Move your pointer over the trace . The cursor should change to show crossed lines with arrows.
2. Click and drag either horizontally or vertically to move the trace. To move both horizontally and vertically, move in one dimension, release, and then follow this procedure to move the trace in the other dimension.

Shifting Trace Position Using Zoom Settings on the Trace Configuration Dialog

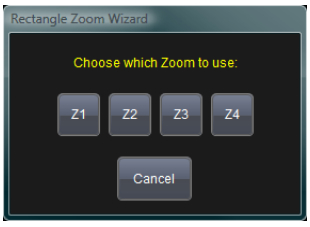
1. Click the Trace Descriptor label for the trace you wish to shift. The **Trace Configuration** dialog for the corresponding trace is then shown on the far right of the dialog area.



2. Click either Center control (Horizontal or Vertical) twice and the **Center** pop-up numeric keypad is shown.
3. Use the **Center** pop-up numeric keypad to provide a new value, and then click **OK**.

Zooming Traces Using Click-and-Drag

1. Draw a rectangle on the Grid Display around a specific trace's region. Do this by clicking-and-dragging to create diagonal corners of a desired rectangular region.
2. When you release the click-and-drag, the Rectangle Zoom Wizard pop-up is shown.



Select the name of the **trace** being zoomed **Zx**, or click **Cancel** on the pop-up.

If **Zx** is chosen, a Zoom trace is configured displaying a copy of the selected waveform.

- You can adjust the zoom factor on the **Zx** trace by repeating the aforementioned click-and-drag step on the same Zx trace.
- You can also adjust the zoom factor on the **Zx** trace from the corresponding Zx settings dialog accessed either from **Math → Zoom Setup...** on the menu bar, or by clicking the corresponding Zx **Trace Descriptor Label**.

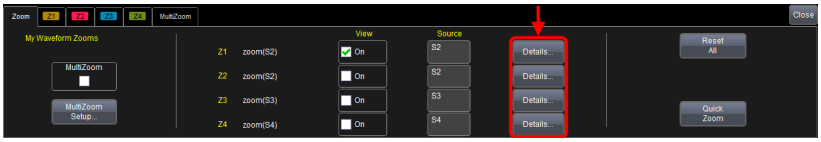
Zooming Traces While Creating New Math Traces (Fx)

Select **Math → F1 Setup...** from the menu bar. The **F1 Trace Configuration** dialog is shown. Numbered callouts on the following screen-shot correspond to respective explanations.

1. Click **Source1** and the **Select Source** pop-up is shown. Select the desired source trace on the pop-up and click **OK**.
2. If **Operator1** is not set to Zoom, click the **Operator1** control and the **Select Math Operator** pop-up is shown. Choose **Zoom** from the list on the **Select Math Operator** pop-up.
3. Click the **Trace On** box on the far-right of the dialog.
4. Setup horizontal and vertical **Center** and **Scale/div** values as desired, or click respective **+** and **-** magnifier buttons to zoom **in** or **out**.

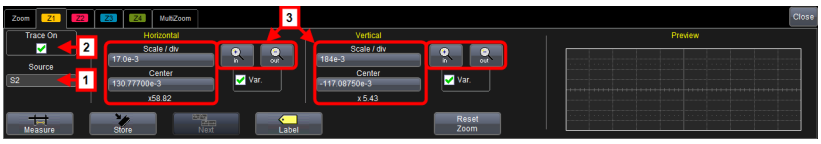
Zooming Traces While Creating New Zoom Traces (Zx)

Select **Math → Zoom Setup...** from the menu bar. The **Zoom** dialog is shown.



Click an unused Zoom trace's **Details** button and its respective **Zx Configuration Dialog** is shown.

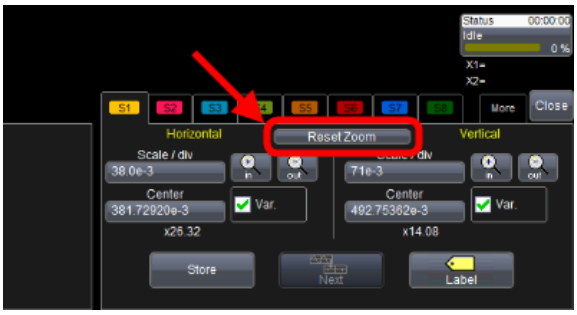
Now, on your selected Zoom trace's **Zx Configuration Dialog** use steps 1, 3, and 4 as explained in the previous **Zooming Traces While Creating New Math Traces (Fx)** section. The same steps apply only controls are located in slightly different places on this dialog.

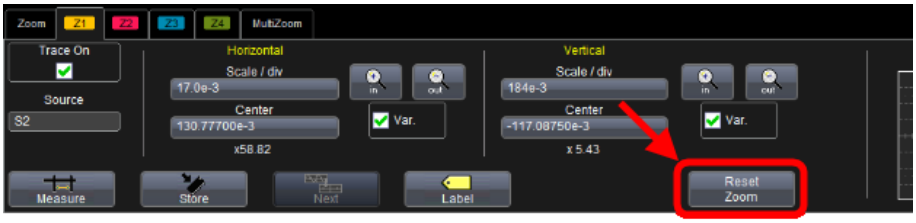


1. Click **Source1** and the **Select Source** pop-up is shown. Select the desired source trace on the pop-up and click **OK**.
2. Click the **Trace On** box on the far-right of the dialog.
3. Setup horizontal and vertical **Center** and **Scale/div** values as desired, or click respective **+** and **-** magnifier buttons to zoom **in** or **out**.

Resetting a Zoom

Reset a specific zoom by clicking its corresponding **Trace Descriptor** label. Its corresponding **Trace Configuration** dialog is shown. Now, click the **Reset Zoom** button. The Reset Zoom button location varies for different types of traces.





Measure Menu

The Measure Menu gives you access to instrument's measurement system, in which parametric measurements can be made on waveforms, and displayed in a table below the grid.Up to 8 measurements can be configured, named P1 through P8 (and generically as Px). The menu includes the following items:

1. **Measure Setup...** - Opens the main Measure configuration dialog.
2. **Off** - Turns off measurements such that the Measure Table is not displayed..
3. **My Measure** - Sets the measure mode to My Measure, in which the parameter.
4. **Standard Vertical** - Opens the summary dialog for the memory system.
5. **Standard Horizontal** - Opens the summary dialog for the memory system.
6. **Statistics On** - Turns on the statistics portion of the Measure Table
7. **Histicons On -** Turns on the histicons

Utilities Menu and Dialogs

The Utilities Menu includes two items:

1. **Utilities Setup...** - Opens a dialog with the following tabs for SPARQ utilities configuration
   - **Utilities** - Contains shortcuts to other tabs.
   - **Status** - includes information about the SPARQ unit,
   - **Remote** - Configuration information for Remote Control (Look for this feature in a subsequent SPARQ software release)
   - **Hardcopy** - Configuration dialog for the Print Setup. See **Print Setup (Hardcopy) Dialog** for more information.
   - **Date/Time** - Configuration dialog for setting the date & time of the PC running the SPARQ Application.
   - **Options** - Configuration dialog for viewing/adding keycodes for any available options.
2. **Preference Setup...**
   - **Preferences** - Dialog for configuring preferences
   - **E-Mail** - Dialog for configuring the server that is used when automatically emailing S-parameter .s[n]p files when a measurement is complete.(See **Result Actions Dialog** (on page 42))

- **Color** - Dialog for configuring trace colors.

Submitting Feedback using Tell LeCroy

FORTHCOMING!

SPARQ Theory of Operation Overview

The SPARQ uses **Time Domain Reflectometry** and **Time Domain Transmissometry** (**TDR** and **TDT**, respectively) to characterize the s-parameters of a device under test.

At the core of the SPARQ acquisition system is the **Coherent Interleaved Sampling** timebase (**CIS**). The CIS system generates a free-running clock that coherently strobes the TDR and TDT signals at about 10 MHz, with an effective sampling rate of 204.8 GS/s. The TDR pulser emits pulses with a 6 ps rise time and rep rate of either 1 MHz or 5 MHz, depending on user configuration. The pulser and the CIS timebase are both synchronized to the system's 100 MHz reference clock. The result is a phase-locked sampling system synchronized to the TDR pulse that coherently samples the waveforms at rate of about 10x faster than typical sampling oscilloscopes.

The **TDR Pulser/Sampler** and **TDT Sampler** are connected to a high-bandwidth switch matrix routing the signals to internal OSLT calibration standards when performing a calibration, and then to pairs of SPARQ ports. The resulting signals are sampled by a pair of 40 GHz sampling heads when strobed, and the sampled voltage are input to two 14 bit ADCs, which digitize the signals at the ~10 MHz strobe rate. The digitized values are sent to an FPGA that stores the values, performs fast-averaging, and reconstructs the waveforms. The resulting waveforms are then sent to the PC running the SPARQ application where S-parameters are computed using an algorithm that de-embeds all the known system components and moves the reference plane for the measurement to the DUT. Up to 16 s-parameter and time-domain results can be configured for display in the SPARQ application.

Key systems and components include:

- **TDR Pulser/Sampler and TDT Sampler Modules** (on page 79)
- **Coherent Interleaved Sampling System** (on page 79)(CIS)
- Internal Calibration Kit (SPARQ E models)
- **Switch Matrix** (on page 77)
- **SPARQ Acquisition and Measurement Process** (below)
- **S-Parameter Calculation and De-embedding Algorithm** (on page 82)
- **SPARQ Application** (on page 83)
- 100 MHz System Reference Clock
- FPGA
- Microprocessor

SPARQ Acquisition and Measurement Process

The configurations made in the **Main Setup Dialog** (on page 31) and **Instrument Setup Dialog** (on page 42) control signal acquisition and subsequent s-parameter measurements. These dialogs contain information including end frequency, number of points, number of ports, port configuration (for example, single ended or differential), averaging configuration, cable, adapter, and fixture de-embedding settings, etc.

Click **Go** in the SPARQ application, and then use the following procedure:

1. Generate sequence of steps for TDR/TDT signal routing:
    - **Calibration subsequence (Auto cal mode)**: Route TDR to **Open**, **Short** and **Load** calkit positions, and both the TDR/TDT for **Thru**.

- **DUT subsequence**: Route TDR TDT to all pairs of ports. For example, a 4-port measurement, has the following 12 combinations of port pairs - **P1/P2**, **P2/P1**, **P1/P3**, **P3/P1**, **P1/P4**, **P4/P1**, **P2/P3**, **P3/P2**, **P2/P4**, **P4/P2**, **P3/P4**, and **P4/P3**.

The calibration subsequence is included in the sequence (when a given sequence has already been executed) only if the **Auto Calibration Policy** setting warrants re-running the calibration.

Then, click **Go** and the sequence is executed.

At each step of the sequence, 250 individual TDR and TDT waveforms are acquired by the CIS acquisition system. These acquisitions are stored, averaged, and then reconstructed by the FPGA. It takes approximately 1 second to acquire the 250 TDR and TDR waveforms and to generate hardware averaged TDR and TDR waveforms.

2. Use the USB 2.0 cable connection to **transfer** the hardware averaged waveforms **to your PC**.
3. Apply any additional averaging based on your **Accuracy** settings.
4. Apply **noise filtering**.
5. Calculate the **error term matrix** from the **OSLT** waveforms.
6. **Differentiate** the **TDR** and **TDT** waveforms to obtain impulse response waveforms.
7. **Apply the ChirpZ transform** to obtain **System Sij** with the desired number of points and end frequency.
8. **De-embed known system components** including the **switch matrix**, **cables**, **adapters**, and **fixture** to obtain the S-parameters of the DUT. See **S-Parameter Calculation and De-embedding Algorithm** (on page 82) for de-embedding information.

Switch Matrix

The **Switch Matrix** is the key to the SPARQ's ability to measure S-parameters with no need for cable connection/disconnection or calibration kit adapters.

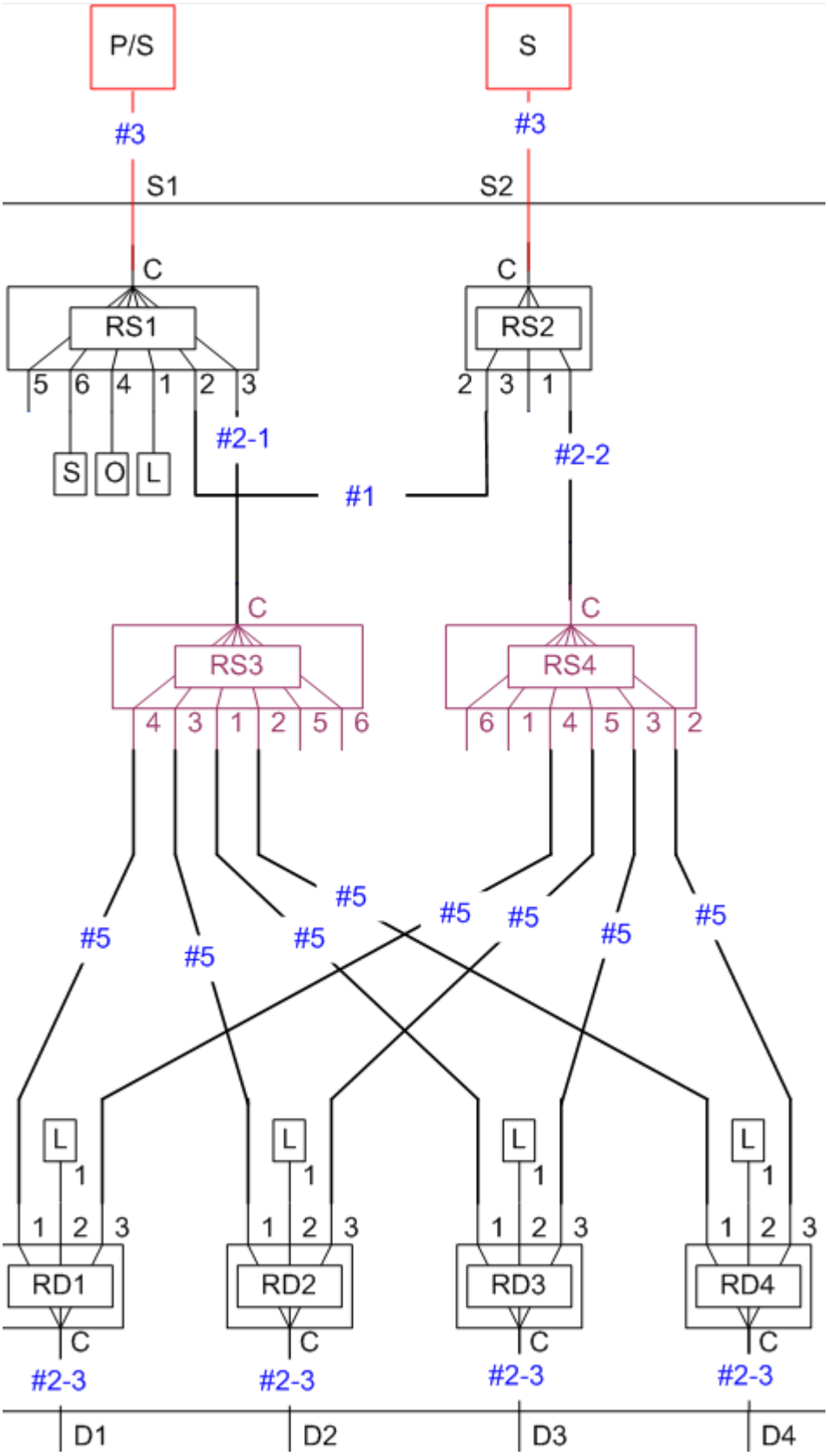
The switches are **multiport** (or multi-throw), and are rated to 40 GHz with a lifetime of 2,000,000 actuations for each individual switch position or throw. This corresponds to about 600,000 4-port S-Parameter measurements.

Note: The number of switches depends on the number of ports on your SPARQ. Two-port SPARQs have 2 switches; 4-port SPARQs have 8.

The following image shows how the switches are connected to the TDR pulser/sampler (**P/S**) and the TDT sampler (**S**) in a 4-port SPARQ. **D1** - **D4** are the SPARQ ports, **RSx** and **RDx** represent the switches.

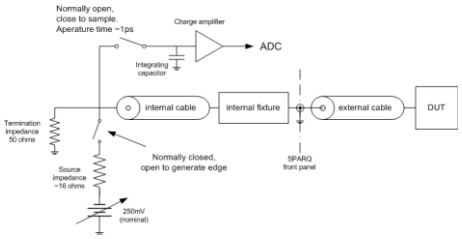
In **E** model SPARQs, the **Open**, **Short**, **Load**, and **Through** calibration kit standards are permanently affixed to specific switch throws and are placed in the signal path when performing automatic calibrations (the waveforms acquired when connected to the standards are used to calculate the error terms in the S-Parameter calculation algorithm). The TDR pulser/sampler and TDT sampler are routed to each pair of ports needed for a measurement by commanding the switches connecting the common port to the appropriate throw.

The effect the switch matrix has on the signals is handled by the SPARQ's unique approach in calculating S-parameters, which includes de-embedding of all of the different paths signals can take through the switch matrix. The de-embedding algorithm is covered in a bit more detail in the **S-Parameter Calculation and De-embedding Algorithm** (on page 82) topic.


P/S
S
#3
#3
S1
S2
C
C
RS1
RS2
5 6 4 1 2 3
2 3 1
S O L
#2-1
#2-2
#1
C
C
RS3
RS4
4 3 1 2 5 6
6 1 4 5 3 2
#5
#5
#5
#5
#5
#5
#5
L
L
L
L
1
1
1
1
1 2 3
1 2 3
1 2 3
1 2 3
RD1
RD2
RD3
RD4
C
C
C
C
#2-3
#2-3
#2-3
#2-3
D1
D2
D3
D4

TDR Pulser/Sampler and TDT Sampler Modules

The SPARQ includes a combination **Pulser/Sampler** module issuing **TDR** pulses and sampling the response. It also includes a second sampler for the **TDT** channel. A simplified schematic of the pulser/sampler is shown in the following diagram (the TDT sampler looks the same, but without the pulser circuit).



The pulser operates by rapidly opening a switch internal to the pulser/sampler module stopping the flow of current. The result is a very sharp 6 ps rise (20% - 80%) from approximately -250 mV to 0 V. The switch remains open for 30% of the time interval between pulses, which is either 200 ns or 1 µs, depending on whether the SPARQ is set to **Normal** or **Long** DUT length. Longer DUT lengths warrant a longer interval between pulses and allows enough time for capturing the full TDR pattern.

The TDR pulse propagates out of the pulser/sampler from a 2.92 mm connector, and then through a semi-rigid coaxial cable into the switch matrix, which then routes the pulse to the desired port or to the internal Calkit adaptor.

The samplers integrate charge on a capacitor during an aperture time of ~1 ps to measure the TDR and TDT waveforms. This charge is amplified, and then measured by a 14-bit ADC. The sampling of the signals occurs at precise times determined by the CIS timebase system, which generates sampling strobe signals at ~10 MHz.

Coherent Interleaved Sampling System

Overview

The SPARQ can perform TDR measurements rapidly by virtue of the **Coherent Interleaved Sampling (CIS)** timebase. Essentially, CIS acquires repetitive waveforms by generating and utilizing a free-running sampling strobe that steps through the waveform, eventually fills in all time bins by coherently sampling the waveform. At the heart of the CIS timebase are two operations:

1. Calculation of a sampling strobe frequency via the determination of a step size assuring coherent sampling.
2. Generation of a sampling strobe that is phase-locked to the 100 MHz reference clock, and then used to synchronize the entire timebase and pulser generation signal.

On the SPARQ, the strobe spacing is approximately 100 ns (but not exactly, by necessity) with a time bin spacing of about 4.88 ps, and a TDR edge rate of either 1 µs or 200 ns is used (configuration dependant). These values correspond to a ~10 MHz strobe frequency, 204.8 GS/s effective sampling rate and 1 or 5 MHz TDR pulse repetition rate.

An Example of CIS at Work

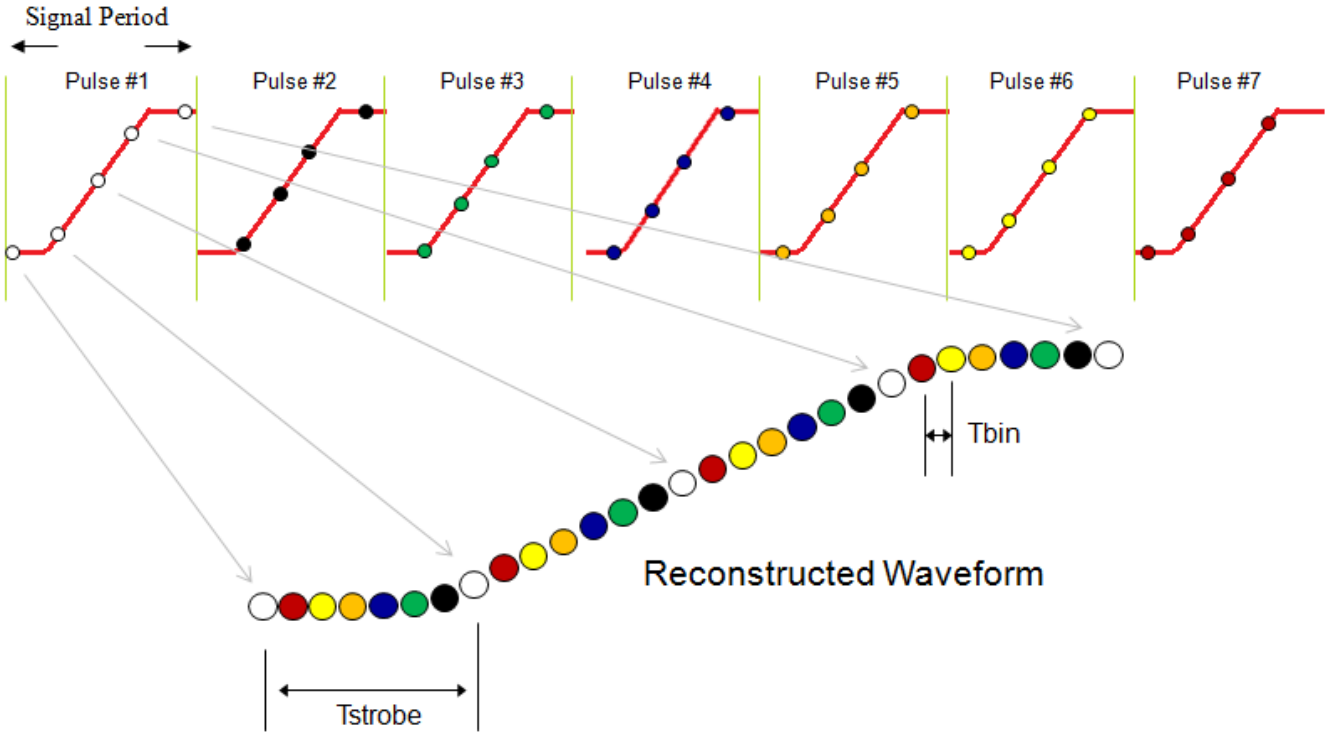
The following figure shows an example of CIS in action. It shows a repetitive waveform input to the SPARQ. The goal is to accurately reconstruct the waveform by dividing the signal into some number of time bins with size and spacing **Tbin**. Tbin is desired to be quite small - roughly 5 ps. Since current technology does not allow a continuous sampling of time bins at 5 ps resolution, the waveform needs to be sampled over multiple iterations of the waveform, and then reconstructed.

The signal is sampled every 7 time bins by a sampling strobe. After some number of waveform iterations (7 in this case), every time bin is sampled, and the samples are interleaved together to properly reconstruct the waveform.

Note: The CIS approach succeeds in acquiring TDR waveforms at a rate much higher (~10x) than typically achieved on most sampling oscilloscopes, which are often used for TDR measurements.

In the SPARQ, the frequency of the strobe is carefully determined ensuring no time bins are skipped or repeated, and the strobe is also phase-locked to the same 100 MHz system reference clock (the source of the signal used to generate the TDR pulse). The result is end-to-end synchronization of all timebase elements.

Note: There are no delay elements in use, as is the case when using sampling oscilloscopes. Delay elements can introduce non-linearities into the system, impacting measurement accuracy.



Calculation of the CIS Strobe Frequency

Consider the reconstructed waveform in the previous figure. It contains some number time bins in which the waveform has been sampled (call it **A**), a time bin spacing or size called **Tbin**, and a strobe time interval **Tstrobe**. To step through the waveform skipping a number **N** time bins at a time (**N** = **Tstrobe/Tbin**) while also ensuring all time bins are eventually sampled, the fraction **N/A** must meet the requirement and be **irreducible**. This requirement is at the heart of the CIS timebase. If we wish to enforce an exact time for the time bins, and require that time **Tstrobe** be close to a nominal value like 10 MHz, then **N** should be chosen such that $N * Tbin \sim= 1 / 10\ MHz$. The CIS timebase algorithm chooses a value for **N** meeting these requirements.

Selecting the nearest prime number to **N** often provides a suitable solution, although other values do work.

The selections for **A** and **Tbin** are based on constraints of time and memory, and in consideration of the requirement of the timebase being locked to the TDR pulse generation. The algorithm used to determine **N** is equivalent to the one used in the LeCroy WaveExpert Series Sampling Oscilloscope where the CIS timebase locks

the acquisition to a serial data pattern. The serial data concept of a **bit** or **unit interval** is also used in the SPARQ algorithm, with the unit interval being an arbitrary value of 10 ns (an exact submultiple of the TDR pulse generation period). The CIS algorithm on the SPARQ divides this unit interval time into 2048 time bins. This choice determines the time resolution of the TDR waveform as $10\ ns/\ 2048\ samples = \sim 4.88\ ps/sample$.

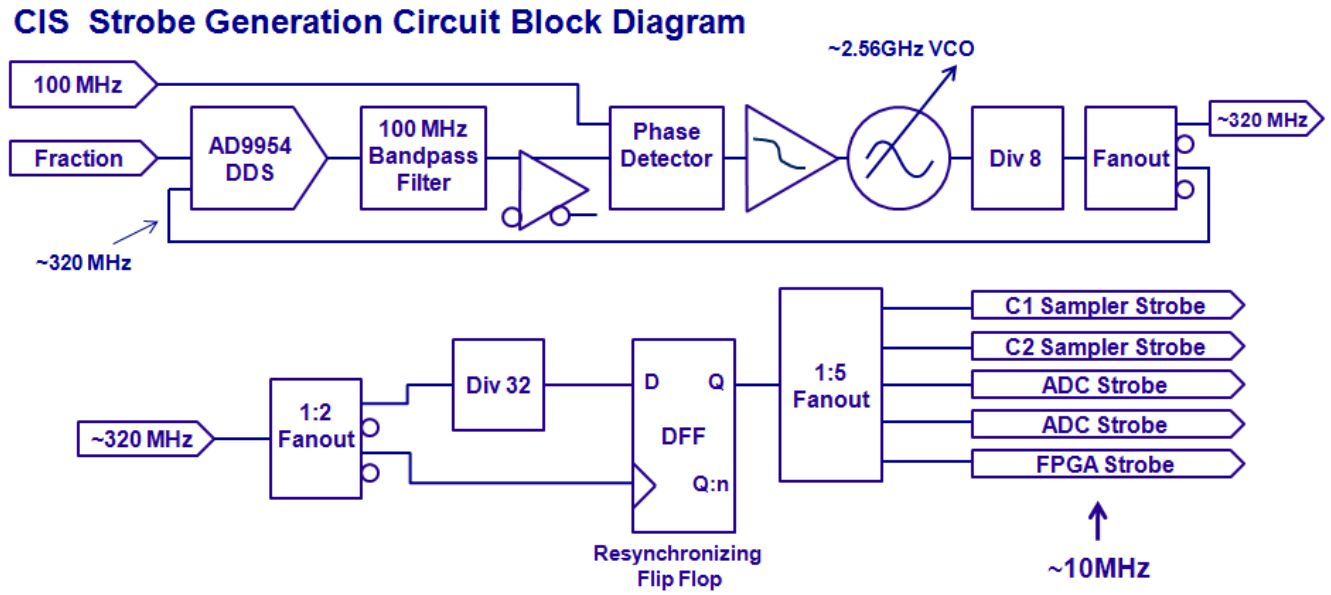
On the SPARQ, a sampling strobe of approximately 10 MHz is desired. Corresponding to 100 ns, 10 MHz would be ten of our 10 ns unit intervals. At 2048 samples per unit interval, we would have **2048 * 10 = 20480** samples.

We are now ready to choose our value for **N**, which is the **number of time bins skipped between strobes**. It should be close to 20480, so our strobe rate is close to 10 MHz. The other requirement is that **N/A** is irreducible. Since **A** is a multiple of 2048 (for example, a **1 MHz TDR pulse rate** would be covered by **100 x 2048 samples**), choosing a prime number close to 20480 works (such as 20479). This corresponds to a strobe time interval of **20479 * 10 ns / 2048 = 99.95117 ns**, corresponding to **10.00488 MHz**.

Note: The previous paragraph shows how the value chosen for **N** must be carefully selected to optimize system performance.

Generation of the Sampling Strobe

The following figure shows a block diagram of the circuit used to generate the strobe. The circuit is a PLL locking the output of a DDS (direct digital synthesizer) to the SPARQ's 100 MHz system reference clock. The DDS outputs a 100 MHz sinusoid by dividing down an input clock (~320 MHz) by a programmable fraction. The DDS output is bandpassed, and input into a phase detector (PD) comparing the filtered 100 MHz output to the 100 MHz clock. The PD output is loop filtered, and input to a VCO and subsequent divider then fed back to the DDS to complete the PLL. The fraction input to the DDS is a simple rescaling of the fraction **N/A** determined in the previous section. The ~320 MHz clock now meets the requirements for coherent sampling. It is further divided by 32 and re-synched to yield a clock with ~10 MHz frequency. We now have a clock to use as the sampling strobe that is both synchronized to the TDR pulse control circuit and meets coherent sampling requirements.



Sampling of the TDR signal

The sampling modules in the SPARQ receive the TDR and TDT signals and sampling strobe, and the samples are sent to 14 bit ADC. The digitized samples are stored in an FPGA quite capable of receiving samples at ~10 MHz.

The FPGA processes the data, averages the waveforms as per the SPARQ setup, and returns results back to the SPARQ software application when complete.

The data acquisition for one set of TDR and TDT waveforms is now complete.

S-Parameter Calculation and De-embedding Algorithm

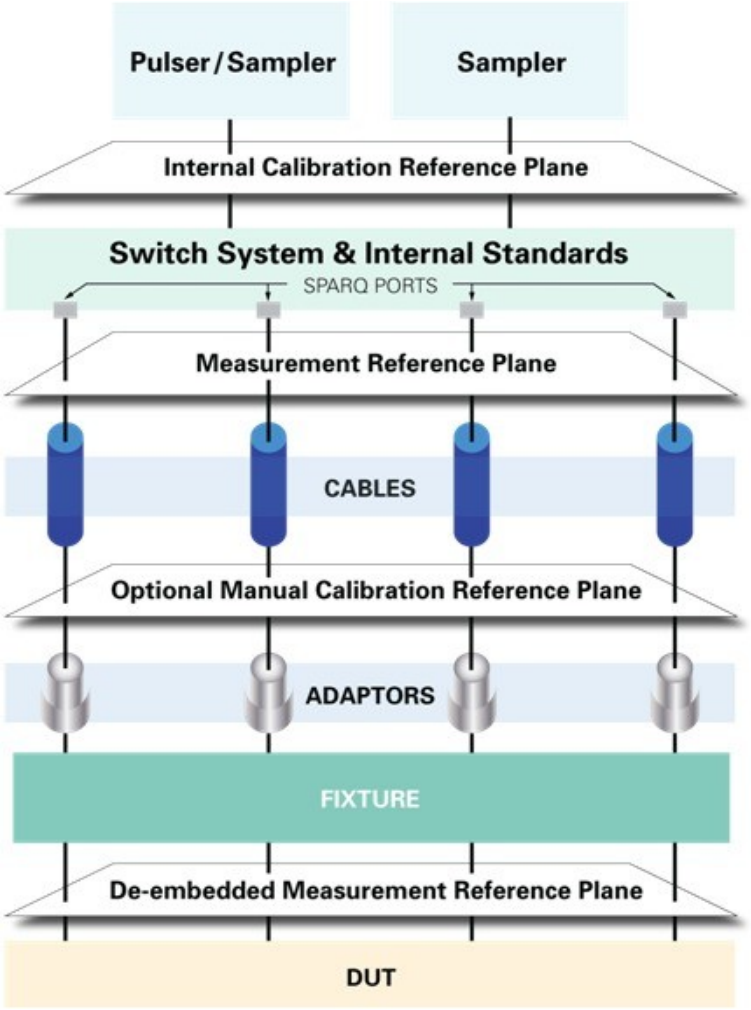
The SPARQ does not simply take a TDR waveform, apply some corrections, and then calculate S-parameters. Instead, it takes a system view. The SPARQ and DUT are a system including components both internal and external to the SPARQ. These components include the **TDR pulser/sampler** and **TDT sampler**, the **switch matrix** (which includes fixed semi-rigid cables), **external cables** connected to the SPARQ ports (and possibly to adapters and a fixture), and then the **DUT**. All of which affect the signal shape as the TDR and TDT pulses traverse the system. The effects are deterministic, and can be de-embedded. An algorithm developed at LeCroy that can determine S-parameters of an unknown component in the presence of known system components is used to de-embed the DUT from the system, and eliminates the effects of the known system components.

To accomplish this, before a SPARQ is shipped the S-parameters of the signal paths through the switch matrix and of the cables and adapters provided with the SPARQ are measured at LeCroy, and included on your SPARQ's memory card. When running the SPARQ software for the first time, the files are then copied to your PC. When obtaining S-parameters of the DUT, the de-embedding algorithm uses these S-parameters along with the error term matrix calculated from the OSLT calibration and the S-parameters measured by the SPARQ for the entire system.

PLEASE NOTE THE FOLLOWING:

- De-embedding for adapters and fixtures is enabled/disabled using the **Main Setup Dialog** (on page 31), and for cables on the **Instrument Setup Dialog** (on page 42).
- This is level of accuracy is unique to the SPARQ, and eliminates any need to perform TDR signal gating tasks in order to exclude reflections external to the DUT. Using an algorithm incorporating S-parameters of your system components solves the problem.

When using cable, adapter and fixture de-embedding along with the internal calibration feature, the reference plane for the measurement is at ports of the DUT by virtue of the de-embedding algorithm. Refer to the following image for detail. When using an external OSLT Calkit, the de-embedding is not used, and the reference plane is at the end of the cable.



SPARQ Application

The SPARQ application performs several key operations, using the hardware-averaged TDR waveforms retrieved from the SPARQ over the USB cable:

- Execution of the algorithm to convert the hardware-averaged TDR/TDT waveforms to S-parameters.
- Execution of the algorithm to convert S-parameters to time-domain results (step and impulse response, rho and Z).

Additionally, the SPARQ application is the primary interface to the SPARQ hardware, providing a GUI for SPARQ configuration and control, and for management of SPARQ results. It includes a set of capabilities for waveform analysis and zooming described in this documentation.

Note: The installer for the SPARQ application can be downloaded from the LeCroy website at www.lecroy.com, but your SPARQ hardware is required to install and run the application.

The SPARQ application is built using technology similar to the LeCroy X-Stream oscilloscopes. It is a COM automation server, which facilitates alternate means of controlling the SPARQ using any programming language supporting automation server connectivity, such as **VBScript** or **MATLAB**.

Note: Examples of VBScript controlling the SPARQ are easily found by **saving any panel setup file** and **opening it using a text editor**.

SPARQ Specifications

Note: Specifications are subject to change without notice.

Please refer to the LeCroy website at www.lecroy.com for detailed specification information.

CERTIFICATIONS

CE Compliant, UL, and cUL Listed

CE Declaration of Conformity

The instrument meets requirements of EMC Directive 2004/108/EEC for Electromagnetic Compatibility and Low Voltage Directive 2006/95/EEC for Product Safety.

EMC Directive

- EN 61326-1:2006
- EMC requirements for electrical equipment for measurement, control, and laboratory use.

Electromagnetic Emissions:

- EN 55011/A2:2002, Radiated and conducted emissions (Class A)*

Electromagnetic Immunity:

- EN 61000-4-2:2001** Electrostatic Discharge.

  (4 kV contact, 8 kV air, 4 kV vertical/horizontal coupling planes)
- EN 61000-4-3:2006** RF Radiated Electromagnetic Field.

  (3 V/m, 80-1000 MHz; 3 V/m, 1400 MHz - 2 GHz; 1 V/m, 2 GHz - 2.7 GHz)
- EN 61000-4-4:2004** Electrical Fast Transient/Burst.

  (1 kV on power supply lines, 0.5 kV on I/O signal data and control lines)
- EN 61000-4-5:2006** Surges.

  (1 kV AC Mains, L-N, L-PE, N-PE)
- EN 61000-4-6:2007** RF Conducted Electromagnetic Field.

  (3 Vrms, 0.15 MHz - 80 MHz)
- EN 61000-4-11:2004† Mains Dips and Interruptions.

  (1 cycle voltage dip, 100% short interruption)

* In order to conform to Radiated Emissions standards, use properly shielded cables on all I/O terminals.

** Meets Performance Criteria "B" limits during the disturbance; product undergoes a temporary degradation or loss of function of performance which is self-recoverable.

† Meets Performance Criteria "C" limits during the disturbance; product undergoes a temporary degradation or loss of function of performance which requires operator intervention or system reset.

WARNING

This is a Class A product. In a domestic environment this product may cause radio interference, in which case the user may be required to take appropriate measures.

Low-Voltage Directive

EN 61010-1:2001

Safety requirements for electrical equipment for measurement, control, and laboratory use.

The oscilloscope has been qualified to the following EN 61010-1 limits:

- Installation Categories II (Mains Supply Connector) and I (Measuring Terminals).
- Pollution Degree 2 (Normally only dry non-conductive pollution occurs. Occasionally a temporary conductivity caused by condensation must be expected.)
- Protection Class I (Provided with terminal for protective ground)

UL and cUL Certifications

SPARQ is UL (for USA) and cUL (for Canada) listed for product safety and conforms to the following standards:

- UL 61010-1 2nd Edition
- CSA C22.2 No.61010-04

Contact LeCroy for Support

Use the following regional contacts to find the appropriate support location nearest you.

Whether you're looking for sales or technical support, our staff can provide assistance with installation, calibration, and product knowledge regarding a full-range of our software applications and accessories.

You can also find contact information for our offices on the LeCroy Web sites shown for the following regions:

<table>
<tr><th colspan="2">Contact Your Local LeCroy Office for Sales and Technical Assistance</th></tr>
<tr><td colspan="2">United States and Canada
Phone (Sales, Applications, and Service): 1-800-553-2769 (options 1, 2, and 3, respectively) or 845-425-2000
Fax (Sales, Applications, and Service): 845-578-5985
Email (Sales, Applications, and Service): contact.corp@lecroy.com
Web Site: http://www.lecroy.com/</td></tr>
<tr><td>Korea - Seoul
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Web Site: http://www.lecroy.co.kr</td><td>Europe
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Fax (Sales and Support): + 41 22 719 2230
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Phone (Sales and Support): ++ (65) 64424880
Fax (Sales and Support): ++ (65) 64427811
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jimmy.ong@lecroy.com</td></tr>
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Fax (Sales and Support): (886) 2 8226 1368
Email (Sales and Support): sales_twn@lecoln.com.tw
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</table>

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Thank you for purchasing a SPARQ.

LeCroy

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