LeCroy

SPARQ™
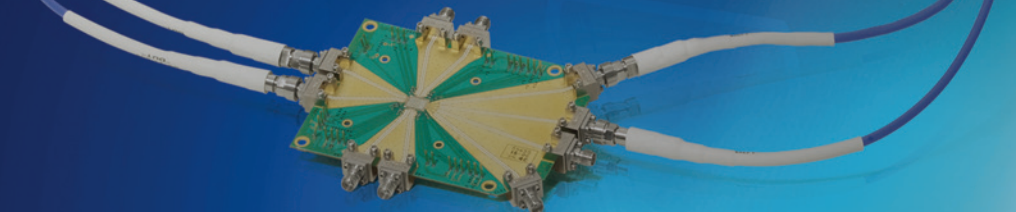# Signal Integrity Network Analyzer

**High-bandwidth,
Multi-port S-parameters**

SPARQ: S-PARAMETERS QUICK

Key Features

- Provides S-parameter measurements up to four-ports

- Measures from DC to 40 GHz

- One-button-press internal OSLT calibration

- Analyzes in both frequency and time domain

- Produces mixed-mode and single-ended simulation-ready S-parameters

- Includes advanced de-embedding features

- Inherent TDR/TDT capability and preview modes for quick checks and debugging

- Available at a fraction of the cost of other network analyzer solutions

The SPARQ™ signal integrity network analyzers connect directly to the device under test (DUT) and to PC-based software through a single USB connection for quick, multi-port S-parameter measurements.

SPARQ is the ideal instrument for characterizing multi-port devices common in signal integrity applications at a fraction of the cost of traditional methods. It is ideal for:

- **Development of measurement-based simulation models**
- **Design validation**
- **Compliance testing**
- **High-performance TDR**
- **PCB testing**
- **Portable measurement requirements**

High-bandwidth, Multi-port S-parameters for the Masses

S-parameter measurements are most often produced by the vector network analyzer (VNA), a difficult instrument that is beyond many budgets. SPARQ is very affordable and simplifies measurements, making S-parameters accessible to all.

PC-based, Small and Portable

Traditional instruments that produce S-parameters are large and fundamentally stationary. The SPARQ, in contrast, is small and weighs less than 20 lbs. It connects to any standard PC through a USB 2.0 interface, allowing SPARQ to run where computing power is easily upgraded.

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S-parameters, Quick

VNA measurements begin with the unpleasant and complex task of calibration. This involves multiple connections that can produce misleading results due to operator error. The SPARQ provides calibrated measurements with a single connection to the DUT and offers simple setup choices. Start and complete the entire measurement with a single button press.

Internal Calibration

SPARQ takes a revolutionary approach to calibration by building in calibration standards. This enables measurements to be made without multiple connection steps and removes the need for additional electronic calibration (ECAL) modules. Calibration proceeds quickly without user intervention, so one can calibrate often without resorting to the use of out-of-date saved calibrations.

THE SIGNAL INTEGRITY TOOLS YOU EXPECT

1. Differential- and common-mode step response at input and output ports

2. Mixed-mode return loss to 40 GHz

3. TDR traces shown during measurement

4. Differential- and common-mode insertion loss to 40 GHz

5. Mode conversion step responses

6. Differential- and common-mode impedance vs. electrical length

7. Rise time normalization for all time domain results

8. Up to 16 measurements can be displayed simultaneously

9. Independent zoom control over each trace

10. Smith chart display alone, or with individual S-parameter plots

The SPARQ signal integrity network analyzer displays time and frequency domain measurement results simultaneously.

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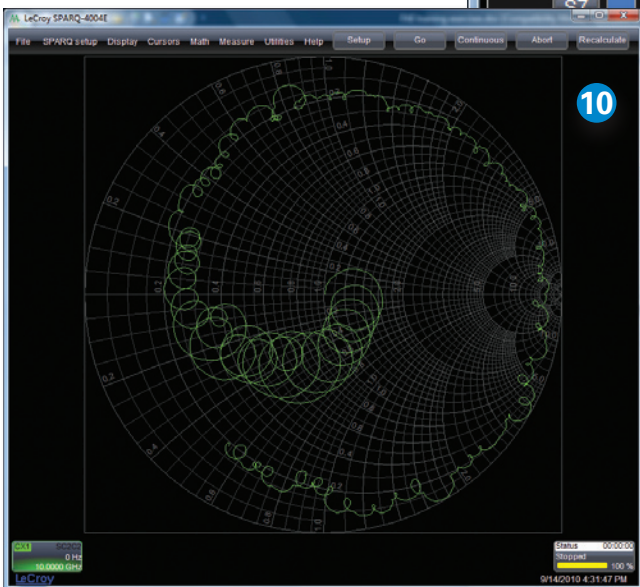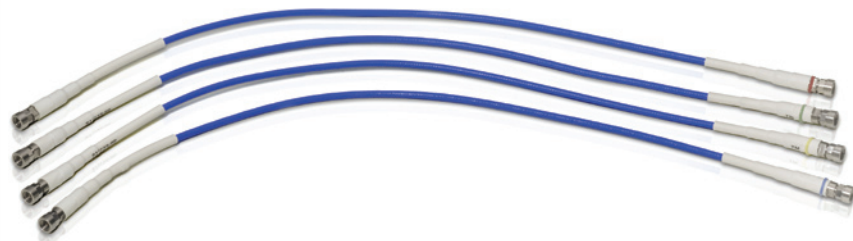
Includes the Tools That You Expect

A signal integrity network analyzer should include well-integrated tools for providing measurement and analysis in both time and frequency domains. Signal integrity requires more than just S-parameters; the time domain offers important insight as it shows the performance of the S-parameter models in simulation.

SPARQ includes standard all of the hardware and software tools needed to make signal integrity measurements right out of the box.

These tools include capabilities that cost extra on most instruments. Mixed-mode S-parameter conversion and port renumbering, passivity, reciprocity and causality enforcement are all standard. Built-in time domain views like impedance, rho, step response and impulse response are included as well. All time domain results can be normalized to your system rise time.

The SPARQ hardware includes calibrated cables for each port, calibrated female 2.92 mm connectors for each port for adapting the connector gender, a universal wrench for holding most popular connector sizes, and a precision torque wrench.

DESIGNED FOR EASE-OF-USE
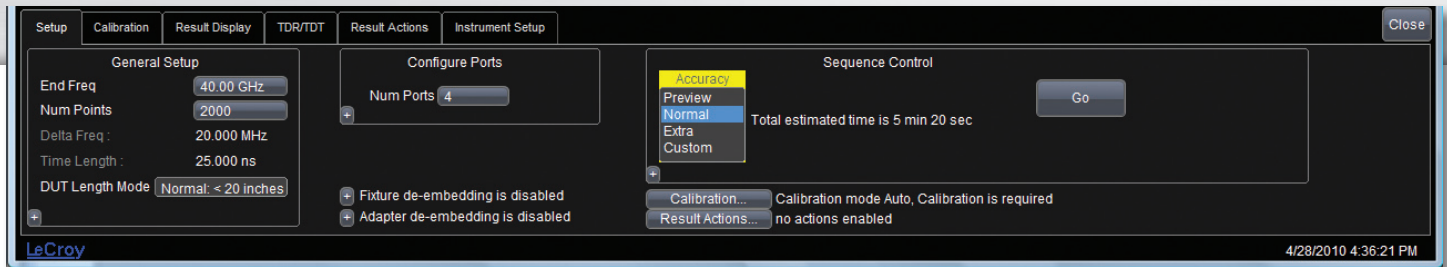
The main SPARQ setup dialog shows all of the information needed to take S-parameter measurements in minutes.

Streamlined Setup

The simple setup shown in the main setup screen above is all that is needed to configure a SPARQ measurement. You provide the frequencies and number of ports and then go. Helper information like time length assist in frequency spacing choices, and DUT length mode choices control the pulser repetition rate for faster measurements. Various measurement sequence control modes allow for trade-offs between precision and speed, and helper information provides an estimate of the measurement time. All measurements proceed automatically without user intervention. Advanced screens are easily accessible for extra capability.

Mixed-mode S-parameters

Measurements encountered in signal integrity applications are often differential-mode or common-mode. SPARQ makes these mixed-mode measurements straightforward through the use of both graphical and tabular displays so there is no doubt about the format of the measurement results.
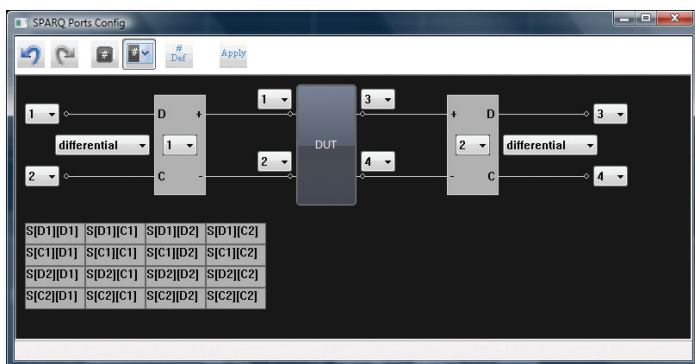
SPARQ easy to understand dialogs ensure that your mixed-mode S-parameters are properly formatted and avoids errors.

The Next Generation of TDR/TDT

The SPARQ is designed with different capabilities than instruments you might have used in the past. The SPARQ's
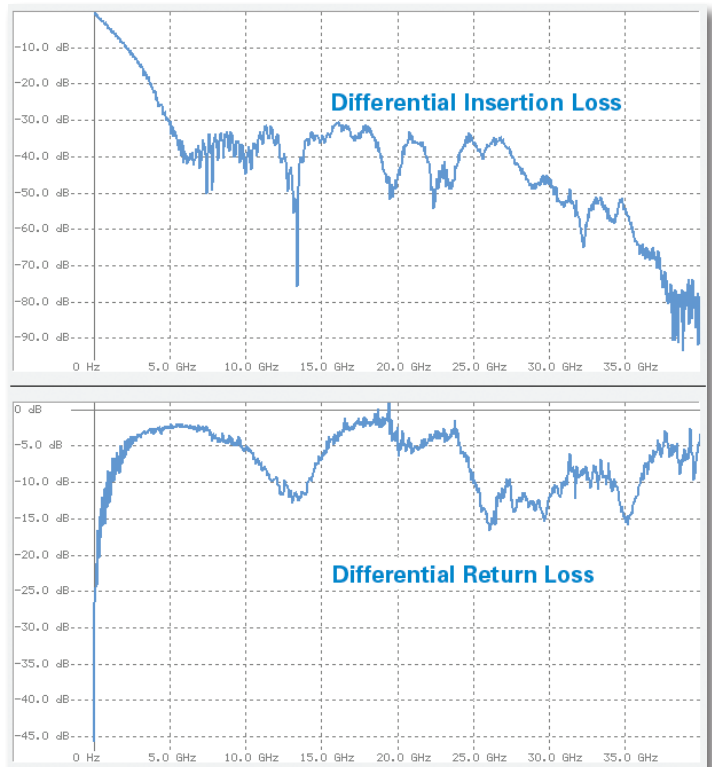
SPARQ mixed-mode measurements are useful for determining the quality of high-speed channels.

built-in calibration makes the measurement easy and fast without trading off calibration accuracy. Older TDR/TDT based instruments claimed to be easier than frequency domain instruments, but sacrificed calibration for ease-of-use.

The SPARQ is designed for high dynamic range with its unprecedented 6 ps pulser rise time and the LeCroy patented coherent interleaved sampling (CIS) time base. This time base removes time base nonlinearity endemic to equivalent time sampling and enables fast averaging that is at least ten times faster than traditional TDR/TDT methods. The result is high-frequency measurements with much higher dynamic range than previously possible.

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From Measurement Directly to Simulation

S-parameters present many difficulties for time domain simulators. These difficulties come from the two ends of the frequency spectrum. Lack of a DC point and truncation of the high frequency content causes simulation problems. Since it is based in the time domain, SPARQ provides a DC measurement point and 40 GHz frequency content so that simulators come up with the right answer. SPARQ provides enforcements of passivity, causality and reciprocity to ensure physical measurement results and provides time domain views so that time domain behavior is verified right at the time of measurement to ensure proper simulation results.
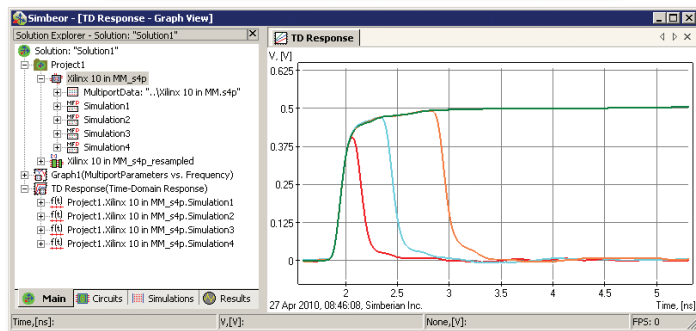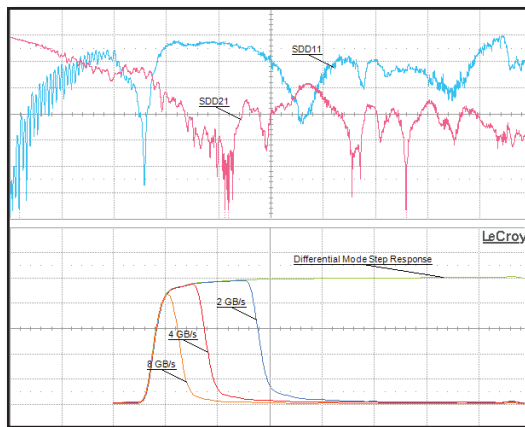
SPARQ based S-parameters show strong correlation with simulations that use these models as shown in the above comparison of SPARQ time domain displays and a Simbeor® simulation. Also shown are the SDD11 and SDD21 measurements acquired by the SPARQ.

Simbeor is a trademark of Simberian® Inc.
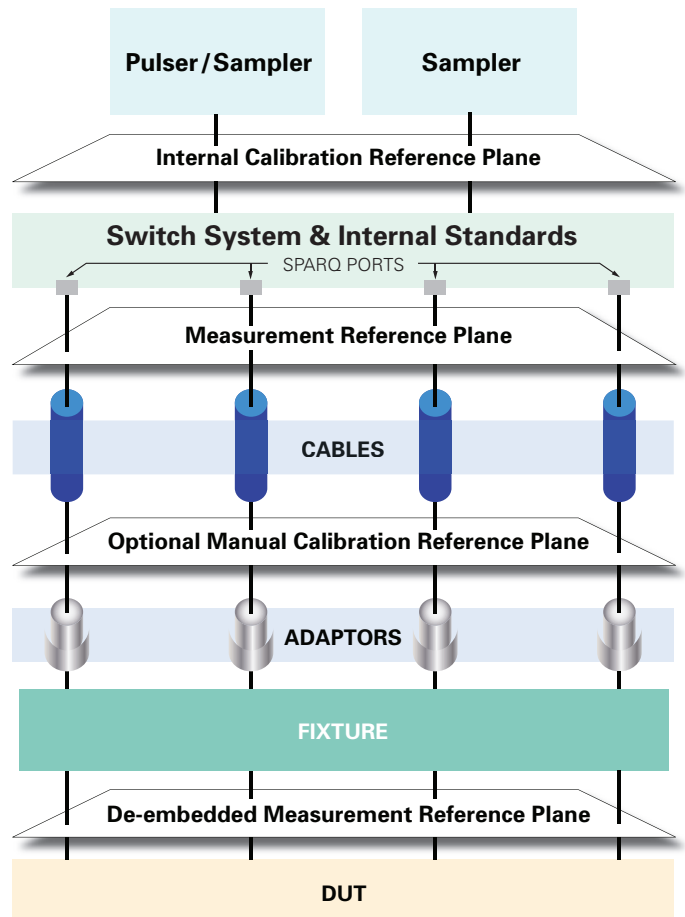
The SPARQ maintains three reference planes – calibration, measurement, and de-embedded DUT. It keeps items that drift with time and temperature behind the calibration reference plane.

Built-in De-embedding

DUT connection and de-embedding present two major, related problems in S-parameter measurements. SPARQ allows the user to de-embed cables, adaptors and fixtures automatically from the measurements to extract the S-paramaters of the DUT. SPARQ utilizes its internal calibration capability and provides fully de-embedded device measurements; no external software tools are required. In situations where direct calibration to a new reference plane is desired, the user can use manual calibration techniques such as open-short-load-thru (OSLT) and save and recall these calibrations.

Advanced Features that Prevent Mistakes and Wasted Time

A frustrating situation is to find that after spending the time to calibrate and take S-parameter measurements, something is wrong either because of a mistake or a poor connection. Sometimes it is hours or days before the problem is detected; that is hours or days of suspect data in use.

Because SPARQ is TDR/TDT based, it can be used to provide basic troubleshooting before you get too far into the measurement. By driving the SPARQ in its native TDR/TDT mode, engineers can pinpoint and isolate intermittent problems quickly.
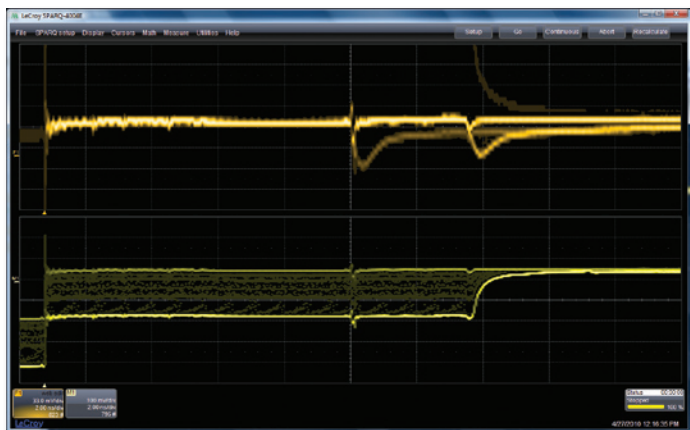
Raw TDR mode persistence showing added near- and far-end capacitance (upper grid) and the effect of wiggling a bad cable (lower grid).

SPARQ also offers preview modes: quick measurement modes that are useful for identification of measurement problems both in the time and frequency domain. A fully calibrated four-port preview measurement takes about three minutes from DUT connection to result display.

"Time-domain measurements" mean that all of the measurement information is contained in acquisitions of step responses taken under various conditions. This is unlike frequency domain instruments which use frequency sweeps. The SPARQ allows the storing and recalling of all of the time-domain acquisitions performed during measurement so that later you can recall the

data and even change the measurement conditions like changing the number of frequency points or configuring for mixed-mode conversions. Results are recalculated based on the saved information without resorting to repeat measurements.

Rugged and Reliable Design

SPARQ utilizes high-frequency, highly reliable internal switches to route signals from pulser/sampler modules to internal calibration standards and to the device under test. SPARQ uses these switches to park the inputs to a 50 Ohm load during down time to help protect against electrostatic discharge (ESD).

SPARQ utilizes precision 2.92 mm connectors at its connection ports. It ships with high phase-stability, low-loss cables to maintain its high dynamic range to 40 GHz. These cables provided with every unit are color-coded and calibrated. Color coding helps you visually keep track of correct cable connection. Of course, the user can use any type of cable or probe desired that connects via 2.92 mm or SMA.

The SPARQ utilizes high-precision 2.92 mm connectors—these can be mated with precision SMA connectors.

Compliance Testing

SPARQ satisfies numerous transmitter, receiver, cable and fixture compliance testing requirements for standards such as:

• SATA TxRx Tests
• PCI Express
• SAS PHY Tests
• Fibre Channel
• USB
• DisplayPort
• HDMI

SPARQ can perform all tests currently made with TDR or VNA instruments—only easier. Some tests that SPARQ performs include:

• Impedance
• Return Loss
• Impedance Imbalance
• Insertion Loss
• Crosstalk (near- and far-end)
• Differential- to common-mode conversion
• Common- to differential-mode conversion
• Intra-pair skew
• Voltage transfer functions

All measurements can be made in differential-mode, common-mode or single-ended, as applicable.

Printed Circuit Board Testing

Specifications for printed circuit boards are moving rapidly higher in frequency. The use of high-speed signaling on many boards involves more demanding tests than in the past. SPARQ measures all high-speed PCB specifications such as:

• Propagation velocity
• Dielectric constant
• Impedance
• Loss
• Skew

It performs all of these measurements for differential- and common-mode as well as single-ended, where applicable. SPARQ is much easier to operate than all other solutions and its 40 GHz upper frequency preserves your investment for many years.
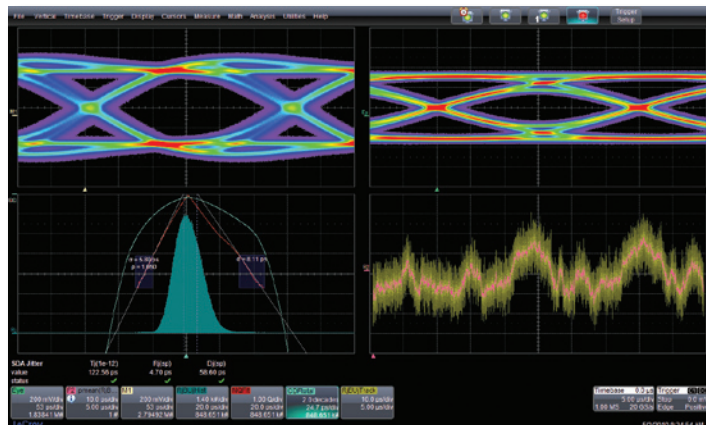
SPARQ produced S-parameters are shown here working with LeCroy oscilloscope based tools like the popular serial data analysis (SDA) and Eye Doctor™ tools in a co-simulation environment to predict the behavior and equalization requirements of a high-speed serial channel.

Seamless Integration with Other Signal Integrity Test and Measurement Tools

LeCroy offers industry leading performance in digital oscilloscopes for signal integrity applications. The Eye Doctor analysis software utilizes S-parameters to de-embed and embed channels, connectors, cables and fixtures in serial data analysis. These tools operate directly on acquired waveforms in real time. When used in conjunction with LeCroy's serial data analysis (SDA) software, the reference plane for eye diagram and jitter measurements can be moved to an ideal location (transmitter output) or to a standardized location for compliance testing (far-end of a compliance test channel). Additionally, SPARQ can aid in the design of transmitter and receiver equalizers by giving the user the ability to emulate the known channel response and simulate the effects of different equalizers.

The LeCroy WavePro® 7 Zi and WaveMaster® 8 Zi oscilloscopes are capable of controlling the SPARQ and the two can be combined to form an end-to-end signal integrity workstation.

Model Specific Specifications

Model	4004E	4002E	4002M
Ports	4	2	2
Calibration	Internal, Automatic	Internal, Automatic	Manual

Ask about 8 and 12 port instruments, available soon

Operating Frequency	DC to 40 GHz
S-parameter Measurements	Single-ended and mixed mode (calculated)
Calibration Method	OSLT
Connector Type	2.92 mm

Standard Measurement Capability

Frequency Domain Displays	Magnitude, Phase, Real and Imaginary
Time Domain Displays	Impulse Response, Step Response, Rho, Z – normalized to specified rise time
Result Displays	Up to 16 measurements displayed simultaneously
Display Modes	Smith Chart, single, dual, tandem, triple, quad, quattro, hex, octal
De-embedding Modes	User cables, adaptors, and optional fixture
File Outputs	Touchstone 1.0
Result Actions	Auto-save and e-mail

Pulser / Sampler and Time base

Step Amplitude	200 mV (nominal top-base, 50 Ω termination)
Rise Time	6 ps 20–80% typical — as measured by sampler
Noise	-50 dBm (no averaging, bandwidth limited to 40 GHz)
Repetition Rate	5 MHz (normal DUT length mode) and 1 MHz (long DUT length mode) @ 30% duty cycle
Hardware Averaging	Fast Averaging at 10 Million Points/Second
Acquisition Rate	Normal DUT Length Mode: 250 acquisitions/second, nominal Long DUT Length Mode: 50 acquisitions/second, nominal
Acquisition Duration	Normal DUT Length Mode: 50 ns; Long DUT Length Mode: 200 ns
Dynamic Range	$77 + 0.272\,f - 0.931\,\sqrt{(f)} - 20\,\mathrm{Log}(f)$; (typical, f in GHz; > 50 dB at 40 GHz in `Normal´ sequence control mode)

Time Base Type	Coherent Interleaved Sampling (CIS)
Equivalent Time Sample Rate	204.8 GS/s
Jitter	≤ 300 fs rms

Internal Switching Relays

Frequency Rating	40 GHz
Rated Life	2 million actuations per contact
Insertion Loss	< 1.1 dB at 40 GHz
VSWR	< 1.8 @ 40 GHz
Switching Variation	Insertion loss: 0.05 dB, 0.9 °, VSWR 0.087 @ 40 GHz
Single Relay Port-port Isolation	> 50 dB @ 40 GHz (pulser / sampler port-port isolation > 100 dB @ 40 GHz)

Environmental

Temperature (Operating)	5 °C to 40 °C (Internal Calibration valid 20 °C – 30 °C)
Humidity (Operating)	Maximum relative humidity 80% for temperatures up to 30 °C, decreasing linearly to 50% relative humidity at 40 °C
Altitude (Operating)	Up to 10,000 ft (3,048 m) at or below 30 °C

Physical Dimensions

Dimensions	7" H x 13" W x 13" D (178 x 330 x 330 mm)
Weight	17 lbs. (7.711 kg)
Shipping Dimensions	12" H x 25" W x 20.5" D (305 x 635 x 521 mm)
Shipping Weight	29 lbs. (13.17 kg)

Power Requirements

Voltage	100 to 240 VAC (±10%) at 50/60 Hz; Automatic AC voltage selection
Max. Power Consumption	80 W (80 VA) (Operating Mode), 7 W (Standby)

Minimum PC Requirements

Operating System	Microsoft Windows® XP (32-bit), Vista® and Windows 7 (32-bit and 64-bit)
Processor	Intel Core 2 Duo @ 2.4 GHz or better
Memory	2 GB RAM minimum
Hard Disk	150 MB available free space
Display Resolution	Minimum 1280 x 780
Connectivity	USB 2.0 High-speed

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ORDERING INFORMATION

Product Description	Product Code

Signal Integrity Network Analyzers

40 GHz, 4-port, Internal Calibration, Signal Integrity Network Analyzer	SPARQ-4004E
40 GHz, 2-port, Internal Calibration, Signal Integrity Network Analyzer	SPARQ-4002E
40 GHz, 2-port, Manual Calibration, Signal Integrity Network Analyzer	SPARQ-4002M

Options and Accessories

2 x 40 GHz Cables	SPARQ-C402
4 x 40 GHz Cables	SPARQ-C404
Manual Calibration Kit	SPARQ-OSLT
Soft Carrying Case	SPARQ-SFTC

Included with Standard Configuration

2 or 4 Color-coded, serialized, calibrated cables (depending on model)

Accessory Kit including four female 2.92 mm adaptors, universal wrench, torque wrench, and USB memory stick containing software and calibration data

Calibration and Performance Certificate

Power Cord (country appropriate)

USB Cable

Soft Carrying Case

Warranty and Service

3-year Warranty Under Terms of Instrument Use

Customer Service

LeCroy instruments are designed, built and tested to ensure high reliability. In the unlikely event you experience difficulties our instruments are warranted for three years under normal usage conditions.

LeCroy provides optional services to keep your SPARQ providing accurate measurements year after year.

This warranty includes:
- No charge for return shipping
- Long-term 7-year support
- Upgrade to latest software at no charge
- Optional service contracts for SPARQ calibration and extended warranty
- Economically priced upgrades to higher port-count models

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