# S400DC/RF

# DC/RF Test Systems

- Combines DC and RF measurement functions in a single tester/prober combination
- Independent DC and RF test execution on separate probes
- Incorporates technology-leading Vector Network Analyzers and DC/RF probe cards
- Utilizes existing UNIX-based S400 systems

## The Industry's First Single-Insertion RF and DC Test Solution

Keithley's S400DC/RF Test Systems are the first of a line of testers designed to speed and simplify measuring RF parameters in sequence with DC parametric testing. No other systems on the market integrate DC and RF parametric testing capabilities in a single automated tester, allowing independent DC and RF test execution when used with a suitable test structure layout. The S400DC/RF systems add 2-port s-parameter measurement capabilities to Keithley's UNIX-based S400 Automated Parametric Test System, one of the most versatile and widely accepted DC test platforms available.

The measurement capabilities built into the S400DC/RF systems were defined in cooperation with leading manufacturers of telecommunications components, many of whom already employ S400UX systems in their wafer fabrication facilities. To meet these requirements, Keithley has formed working partnerships with two companies at the cutting edge of RF test technology—Anritsu Corporation, a leading producer of Vector Network Analyzers (VNAs), and GGB Industries, Inc., the foremost maker of combined DC/RF probe cards.

As the first offerings from Keithley's DC/RF tester line, these systems are targeted at the technology development testing needs of a fab's modeling and process integration engineering departments. Three different system configurations are available; all offer an economical wafer level testing approach to handling the growing demand for chips for telecommunications devices such as mobile phone components and base station components.

## Dramatic Reductions in COT

The S400DC/RF Systems offer fabs producing components for telecommunications manufacturers a variety of ways to reduce their Cost of Test at the wafer level. The most obvious advantage is the extended use of existing S400UX testers. By re-purposing these testers, fabs can continue to get returns on their original investments while adding RF testing functionality. Combining RF and DC parametric testing capabilities in a single existing system eliminates the high cost and significant floor space required for a separate RF tester and prober. The S400DC/RF is compatible with many popular probers, including many of those used with existing S400UX testers.

Throughput improvements also allow S400DC/RF users to reduce their testing costs dramatically; depending on the system configuration chosen, S400DC/RF testers can offer up to ten times faster throughput than other RF testing approaches. This speed increase is made possible through the use of Anritsu's self-calibrating Vector Network Analyzer and GGB's DC/RF probe cards and calibration substrates. These system components work in cooperation with the rest of the tester hardware to reduce measurement calibration time to less than two minutes. The S400DC/RF testers employ a full Short-Open-Load-Through (SOLT) system-level measurement calibration process. By giving users improved confidence in the integrity of their test results, this calibration technique, which includes enhanced reflection standards, helps eliminate the need for time-consuming reprobing.

The system software includes a library of test macros that allow users to reduce 2-port s-parameters (transmission and reflection) to RF parameters rapidly and automatically. These parameters include maximum frequency, transit time as a function of current, base resistance of the bipolar transistor, and inductor quality. The repeatable, reliable measurements produced by the S400DC/RF tester correlate to any properly configured benchtop or rack solution.

## Ultra-Low-Loss Interconnect

The S400DC/RF's measurement accuracy is specified as a complete system—VNA, interconnects, probe card adapter, probe card, and the calibration substrate—right to the probe tips. The S400DC/RF's high accuracy is a sharp contrast to the typical rack-and-stack RF testing approach, the accuracy of which depends largely on the skill of the engineer assembling the system and the care with which it is maintained and operated.

Integrated DC and RF parametric testing capabilities

SEMICONDUCTOR

Integrated DC and RF parametric testing capabilities

# S400DC/RF

- 12 term SOLT calibration or user-defined calibration algorithm
- 1pA/10µV DC resolution
- 1Hz RF frequency resolution
- Compatible with 200mm and 300mm probers
- Supports "lights out" factory automation
- Adapts easily and economically to new processes and applications

## Ordering Information

| | |
|---|---|
| 9400-20GM | Multi-DUT tester with 20GHz VNA with 6x6 RF Switch (Keithley Model 41) |
| 9405-20G | Single-DUT tester with 20GHz VNA without RF switch |
| 9410-40G | Single-DUT tester with 40GHz VNA without RF Switch |

These products are available with an Extended Warranty.

**APPLICATIONS**

**Wafer level s-parameter testing for:**

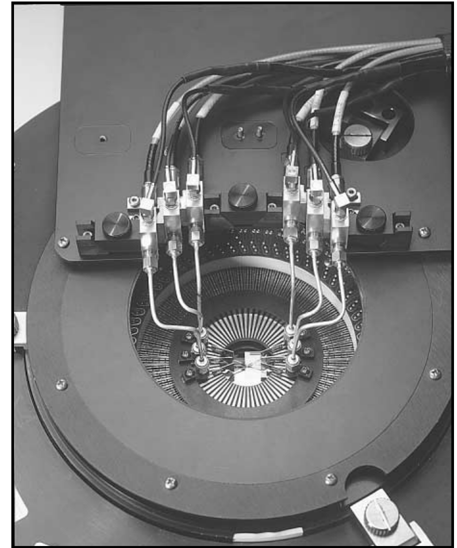
- Device modeling (data compatible with popular packages such as BSIMPro, IC-CAP, UTMOST)
- Process monitoring (with test macros for converting s-parameters to RF parameters such as fmax, ft, Rbb, and Q)
- General analysis of complex signals, including user-defined combinations of a1, a2, b1, and b2

# DC/RF Test Systems

### High DC and RF Measurement Accuracy

Several aspects of system design contribute to the S400DC/RF systems' high DC and s-parameter measurement accuracy.

- Keithley has developed a special hardware calibration kit for in-situ preventive maintenance, so there's no need to pull the VNA out of the cabinet for yearly recalibration, eliminating the need to connect and disconnect cabling, which might degrade the system's performance.
- Hardwired, mechanically stable interconnects are used between the probe tips and the VNA, so the system calibration is not affected by vibration.
- The high speed, 12 term SOLT measurement calibration process Keithley and Anritsu have implemented for these testers slashes the required calibration time prior to each wafer lot. GGB's calibration substrate reduces the need for calibration shortcuts that can impact accuracy. The software also includes support for user-defined calibration techniques.



Electrical precision and mechanical stability ensure highly repeatable RF parametric measurements.

- The S400DC/RF's 1kHz frequency resolution makes it far easier to "dial in" the desired frequency than with typical rack-and-stack RF systems, which usually offer less frequency resolution.
- Unlike rack-and-stack or benchtop systems, the S400's inherent 1pA/10µV DC precision isn't compromised by the addition of the RF measurement circuitry.
- The optional SofTouch package ensures good electrical contact between the probe tip and the device pad. A burnishing algorithm in the Probe Tip Cleaning utility allows automated cleaning of the probe tips, based on the probe needle type, for greater measurement accuracy.
- The de-embedding software provided supports measuring the signal components specific to the DUT and correcting the measurement for them.

### Broad Data Analysis Flexibility

The S400DC/RF systems offer users support for a variety of methods of data analysis. The software provided with the system includes Keithley USERLIB macros for reduction of s-parameters to RF parameters. These macros are consistent with industry standards for this analysis. The Keithley Test Environment also allows users to create their own test macros to define their own combinations of a1, a2, b1, and b2 for general analysis of complex signals. Test results can be exported readily to a variety of popular device modeling packages for more in-depth analysis.

### Choice of System Configurations

Fabs can choose from three different S400DC/RF system configurations to match their specific testing needs. The Model 9400-20GM is a multi-DUT tester with a 20GHz VNA and a Keithley Model 41 6×6 RF Switch. This configuration supports testing up to three devices per prober touchdown. The Model 9405-20G and Model 9410-40G are single-DUT testers with 20GHz and 40GHz VNAs respectively; neither model includes RF switching. The Model 9410-40G supports manual probing. The architecture of all three systems has been designed with upward mobility in mind. As new devices and applications that require higher frequency testing are developed, Anritsu's modular VNA design makes it simple and economical to upgrade a system's RF measurement instrumentation from 20GHz to 40GHz or beyond.



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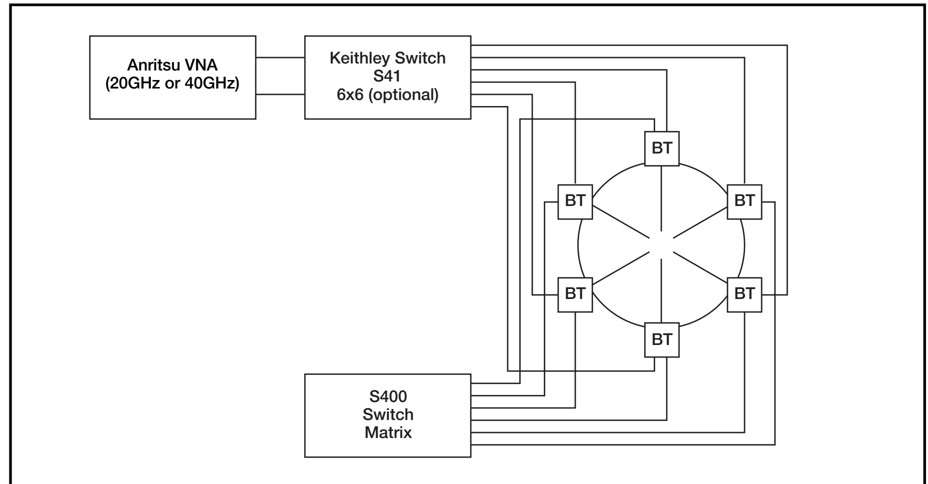
# S400DC/RF DC/RF Test Systems

## Fully Supported Test Environment

Unlike existing rack-and-stack approaches to RF parametric testing, which are often difficult to maintain or expand as needs change, the S400DC/RF testers are based on a standard test environment, the latest release of the Keithley Test Environment. All currently marketed Keithley testers can be operated in this same testing environment, which shortens the learning curve associated with new systems or applications significantly. Just as important, KTE provides the foundation for a growing line of operational productivity tools from Keithley. These optional tools include:




The extensibility of the Keithley tester architecture supports RF integration easily.

- The new WaferMap Software Option, which enables test engineers and operators to do rapid on-tester visualization, plotting, and analysis of parametric test data at the site, die, wafer, and cassette levels. It includes tools for visualizing and analyzing both live test data (dynamic results displayed in real time from tests in progress) and stored test data.
- SofTouch Probing Solution. Unlike aluminum pads, probing copper pads typically doesn't produce scrub marks, which are used to verify contact. The SofTouch probing solution automates detecting probe-to-pad contact on copper pads. It minimizes overdrive while maximizing contact.
- Probe Tip Cleaning Option. Probing copper pads requires more frequent cleaning than the traditional aluminum pads. The automated Probe Tip Cleaning technique tracks probe tip usage, allowing tips to be cleaned before data integrity can be compromised. Tips are cleaned automatically when cleaning is required, and the system returns to testing without the need for operator intervention. This solution is compatible with most major automatic wafer probers.
- Keithley Recipe Manager Option. This package helps test program developers generate valid test plans quickly by allowing them to modify existing test plans easily for reuse. By providing the version control tools needed to prevent unintentional, undesired, or undocumented code changes, it also ensures only approved test sequences are released to production.
- Copper Analysis Algorithm Library. To help fabs address new process monitoring challenges, Keithley has bundled a library of copper process analysis algorithms and test structures with other utilities designed to speed and simplify copper process monitoring.
- Adaptive Testing enhances throughput, yield, and process control by enabling the test system to make automatic changes to the test plan for each wafer being tested. These changes may be based on pre-defined zones or patterns contained in the wafer definition file. The software also supports result-based testing, which changes the sites and/or tests to be used based on the results of previous site tests.
- A SECS-II/GEM interface for easy tester integration into fab-wide automation/control systems.

In addition to these capabilities, KTE offers test engineers the flexibility of User Access Points (UAPs), which simplify integrating fab-specific functionality into the overall test environment. Backed by Keithley's worldwide technical and applications support network, KTE eliminates the time-consuming and cumbersome programming of new test functions associated with older RF test hardware. There's no need for the device modeling engineer to "babysit" a problematic test setup, so he can spend time analyzing reliable data because all aspects of system automation and program generation are part of a standard, well-supported test environment.

### S400DC/RF SYSTEM BENEFITS

**The S400DC/RF test solution offers fabs' modeling and process integration engineering departments capabilities and advantages never before available:**

- **Up to 10 times faster throughput than other RF approaches.**
- **Integrated single-insertion DC/RF test solution.**
- **Complete–high speed 12 term SOLT calibration process and supporting substrates.**
- **Fully integrated package with ultra-low-loss interconnections for high accuracy measurements.**
- **Full range of DC measurements to provide complete DC and RF characterization and monitoring.**
- **A full package of RF extraction library routines to provide industry standard analysis.**
- **Support for user extensions of extraction library to provide company specific analyses.**
- **Complete KTE support for development and operational tools that are easy to use.**

## 9400-20GM: 20GHz VNA with Keithley S41 6x6 Switch Matrix

**RF PARAMETERS:**

**FREQUENCY:** 40MHz–20GHz.

**SWITCH CONFIGURATION:** Non-blocking coaxial matrix with six inputs and six outputs.

**IMPEDANCE:** 50Ω.

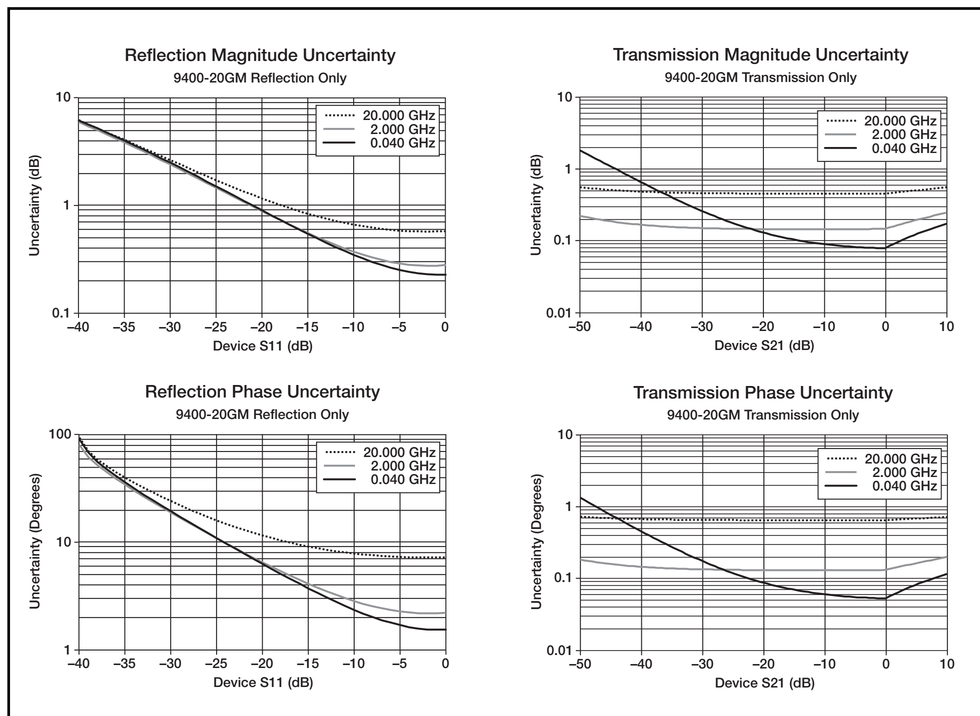
**PROBE CARD:** Coplanar Probes – Ground, Signal, Ground.

**CALIBRATION SUBSTRATE:** Manufactured for probe card design.

**DC BIAS:** 16V max., 100mA max.[1]

**MEASUREMENT UNCERTAINTY[2]:**

The graphs give measurement uncertainty after 12-term vector error correction. The errors are worst case contributions of residual directivity, load and source match, frequency response, isolation, network analyzer dynamic accuracy, and connector repeatability. In preparing the graphs, 10Hz IF bandwidth and averaging of 512 points were used. Changes in the IF bandwidth or averaging can result in variations at low levels.
0dB = –7dBm.




## 9405-20G: 20GHz VNA without Switch Matrix

**RF PARAMETERS:**

**FREQUENCY:** 40MHz–20GHz.

**IMPEDANCE:** 50Ω.

**PROBE CARD:** Coplanar Probes – Ground, Signal, Ground.

**CALIBRATION SUBSTRATE:** Manufactured for probe card design.

**DC BIAS:** 16V max., 100mA max.[1]

**MEASUREMENT UNCERTAINTY[2]:**

The graphs give measurement uncertainty after 12-term vector error correction. The errors are worst case contributions of residual directivity, load and source match, frequency response, isolation, network analyzer dynamic accuracy, and connector repeatability. In preparing the following graphs, 10Hz IF bandwidth and averaging of 512 points were used. Changes in the IF bandwidth or averaging can result in variations at low levels.
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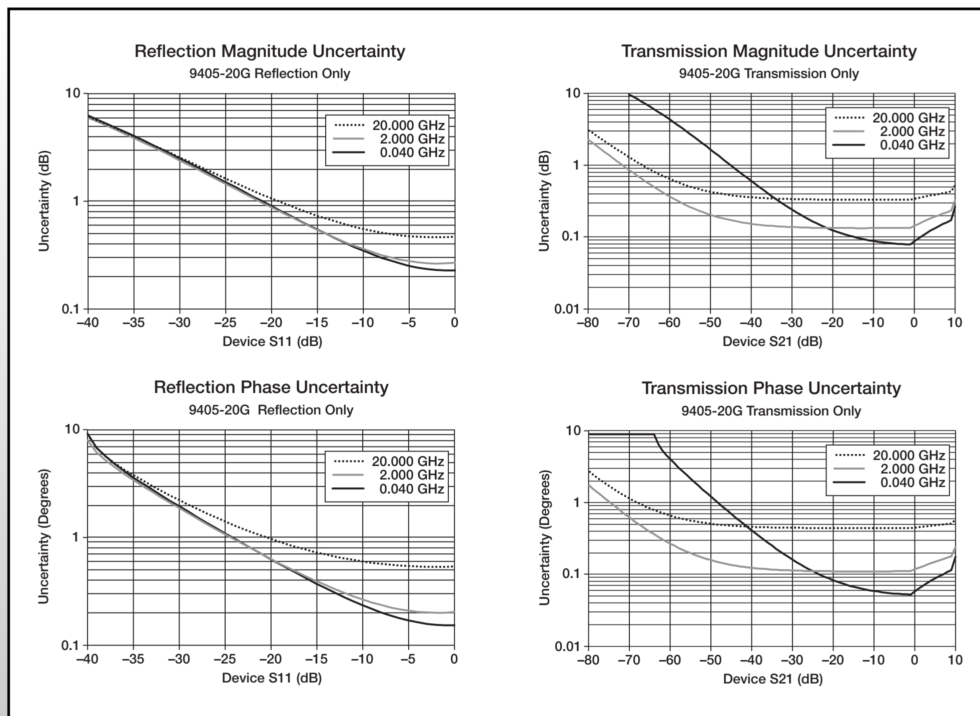




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## 9410-40G: 40GHz VNA without Switch Matrix

**RF PARAMETERS:**

**FREQUENCY:** 40MHz–40GHz.

**IMPEDANCE:** 50Ω.

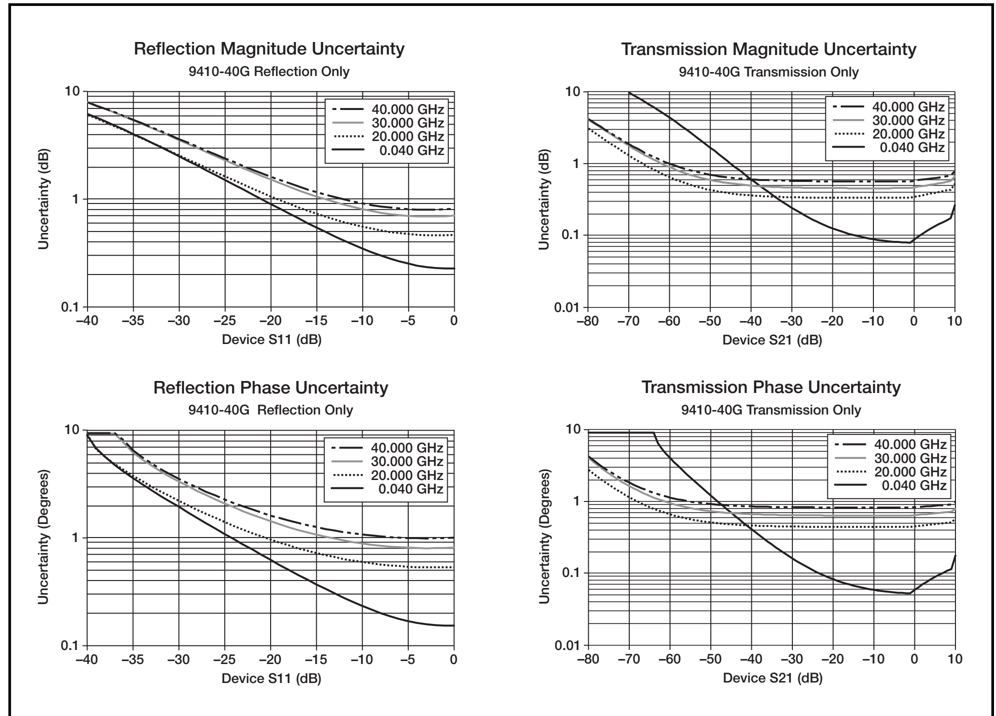
**PROBE CARD:** Coplanar Probes – Ground, Signal, Ground.

**CALIBRATION SUBSTRATE:** Manufactured for probe card design.

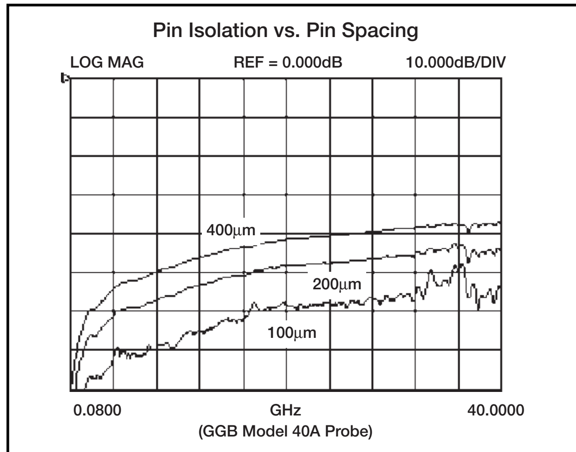
**DC BIAS:** 16V max., 100mA max.[1]

**MEASUREMENT UNCERTAINTY[2]:**

The graphs give measurement uncertainty after 12-term vector error correction. The errors are worst case contributions of residual directivity, load and source match, frequency response, isolation, network analyzer dynamic accuracy, and connector repeatability. In preparing the following graphs, 10Hz IF bandwidth and averaging of 512 points were used. Changes in the IF bandwidth or averaging can result in variations at low levels. 0dB = –7dBm.




## 9400-20GM, 9405-20G, 9410-40G




Crosstalk performance of two Model 40A-GSG-150-P Picoprobes while contacting a bare sapphire substrate with spacings of 100, 200, and 400 microns.

### GENERAL

**SAFETY:** Conforms with European Union Directive 73/23/EEC: EN61010-1.

**EMC:** Conforms with European Union Directive 89/336/EEC: EN61326.

**ENVIRONMENT:**
**Operating:** 21°C to 25°C, <50% relative humidity.
**Storage:** –25°C to +65°C.

### NOTES:

1. The S400 system is capable of outputting higher voltages and currents than the bias tees are rated. The user must take this into consideration when programming the test routines by limiting voltage and current levels.
2. All RF specifications listed are based on a 24 hour calibration with appropriate calibration substrate. Changing of probe card, breaking and reconnecting interconnect cables, and 24 hours elapsed time from calibration requires that the system be recalibrated.

Specifications are subject to change without notice.
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