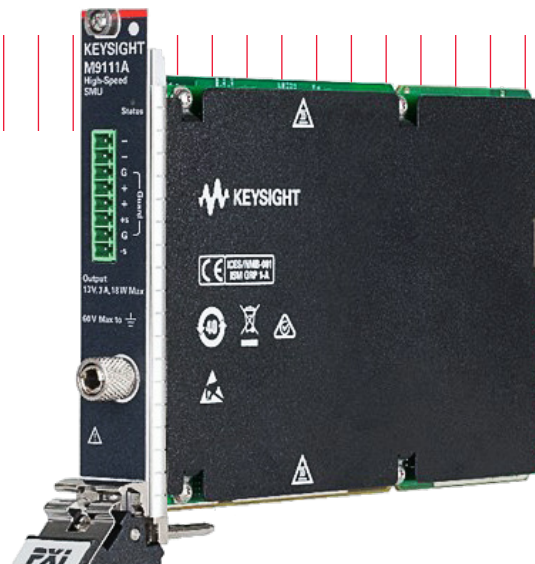


Keysight Technologies

M9111A PXIe High-Speed Source/Measure Unit

13 V,  $\pm 1$  A or 6 V,  $\pm 3$  A, 18 W

Data Sheet



## Source Faster, Measure Faster

### Change voltage, stabilize, and make accurate measurements in less than 1 ms!

In automated test environments, the adage “time is money” is never more prevalent. Thus, speed of test is critical. The faster you are able to test a device, the more money you will save. Keysight’s M9111A PXIe High-Speed Source/Measure Unit (SMU) was specifically designed for this environment. It helps you achieve high-throughput, while maintaining measurement quality in design validation and production test of power amplifiers. The M9111A can change its output voltage, stabilize that voltage, and accurately measure current from Amps down to micro-Amps all in less than 1 ms so that you can move on to the next test as quickly as possible.

As part of Keysight’s RF PA/FEM Characterization and Test Reference Solution, this combination provides exceptional performance for the demanding requirements of testing modern power amplifiers (PAs) and front-end modules (FEMs).

## Overview

The M9111A is a 1-slot, 2-quadrant PXIe module that delivers up to 13 V,  $\pm 1$  A or up to 6 V,  $\pm 3$  A, 18W. The M9111A SMU combines the capabilities of a voltage source, a current source, an ammeter and a voltmeter to provide stable, glitch-free sourcing and sinking, and high accuracy measurements. It offers:

- High-speed changes in voltage with fast settling times
- High-speed recovery and low-voltage droop when the DUT pulls fast slewing current pulses
- High-speed, accurate low level-current measurements, such as leakage current

### Speed up test with high speed SMU output

When it comes to speed, the M9111A PXIe High-Speed Source/Measure Unit achieves performance unlike a typical DC power supply; it’s up to 20x faster than previous generation Keysight SMUs. The M9111A quickly changes voltage in 10-50 microseconds depending on capacitance of the device under test (DUT), and that voltage quickly settles to its programmed value to quickly provide a stable output. Decrease test time by minimizing the wait time for a power supply voltage to settle with the M9111A, so the rest of the test system can continue to do its job.

## Stable Voltage even with Dynamic or High Capacitive Loads

Power amplifiers and other components present a unique testing challenge: they draw rapid pulses of current. By offering superior transient performance, the M9111A SMU dramatically reduces the transient voltage drop due to pulsed loading and recovers quickly to its program voltage (even with capacitances of up to 150  $\mu\text{F}$ ).

The M9111A provides industry-leading output stability under extreme, dynamic load conditions so that you never have to worry about your power source interfering with your measurements. The M9111A SMU's glitch-free operation ensures that during programmed output or measurement ranges changes, the M9111A's output voltage and current remain steady and the DUT remains unaffected. Further, to provide this output stability, the M9111A SMU has user-selectable compensation modes that improves usability and productivity by instantly configuring the SMU's feedback loop to match the impedance of the system (DUT and wiring paths).

## Accurately Measure Leakage and Dynamic Currents

Measuring static current accurately can be a challenge. Measuring dynamic currents from  $\mu\text{A}$  level to A is an even greater challenge. Depending on the level of current, a different precision measurement resistor must be used, representing a measurement range in the SMU. The three current measurement ranges (3 A, 1 mA, and 100  $\mu\text{A}$ ) of the M9111A makes it tuned to quickly and accurately measure the different operating states and power consumption of a device. The built-in measurement system enables fast measurement of low currents down to  $\mu\text{A}$ , even if the DUT has a large capacitor (up to 150  $\mu\text{F}$ ) and the built-in high-speed digitizer measures voltage and current every 5.12  $\mu\text{s}$  (~200 ksamples/s).

## Triggering

The M9111A PXIe SMU utilizes the PXI chassis backplane trigger-in to receive triggers to start a measurement.

## Drivers and Soft Front Panel

To simplify system development, the M9111A comes with IVI.COM and IVI.C drivers for 32-bit and 64-bit Windows OS.

The soft front panel interface provides an easy way to monitor, configure, and control the M9111A SMU.

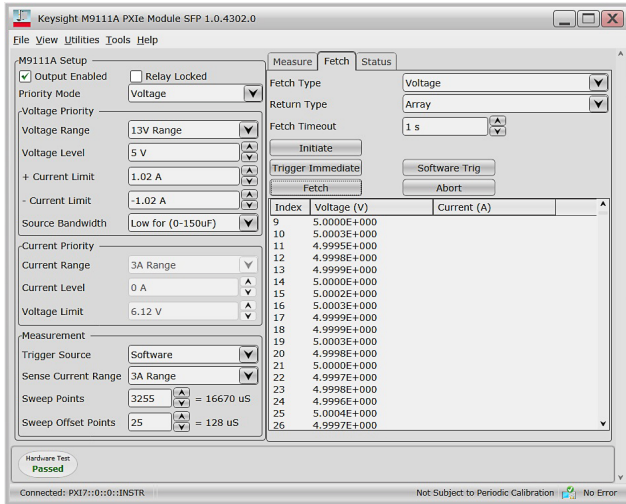


Figure 1. Soft front panel

## Address RF PA/FEM Test Challenges with a Reference Solution

The M9111A PXIe High-Speed SMU is a part of the Keysight RF Power Amplifier/Front End Modules (PA/FEM) Characterization and Test Reference Solution. This reference solution enables rapid, full characterization of next-generation power amplifier modules such as PAD devices, including S-parameter, demodulation, power, adjacent channel power and harmonic distortion measurements.

Use the reference solution to rapidly evaluate new test configurations or augment your existing test system with open source shortcuts. Get a running start the RF PA/FEM reference system, to learn more, please see: [www.keysight.com/find/solution-padvt](http://www.keysight.com/find/solution-padvt)

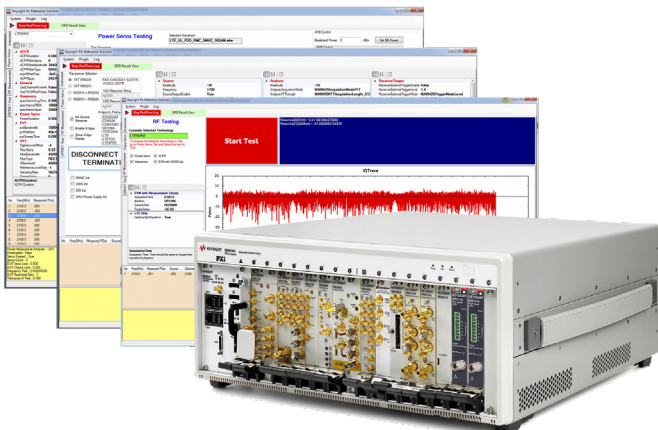


Figure 2. RF PA/FEM Characterization & Test Reference Solution

## Performance Specifications

Unless otherwise noted, specifications warranted over the ambient temperature range of 0 to 45 °C after a 30-minute warm-up period.

### M9111A

#### DC ratings:

Voltage	13 V/6 V
Current	$\pm 1$ A/ $\pm 3$ A
Power	13 W/18 W

#### Output voltage ripple and noise (PARD) from 20 Hz – 20 MHz:

Measured at the output terminals, under all load conditions, in voltage priority mode with output bandwidth setting = low

CV peak-to-peak	15 mV
CV rms	1.5 mV

#### Load effect (load regulation):

For any load change, with a load drop of up to 1.0 V. The load load drop reduces the maximum available voltage at the load.

Voltage	500 $\mu$ V
Current, 3 A range	200 $\mu$ A
Current, 1 mA range	250 nA

#### Programming accuracy @ 23 °C $\pm$ 5 °C:

Applies from minimum to maximum programming range at any load.

Voltage, 13 V and 6 V ranges	0.025% + 1 mV
Current, 3 A range	0.05% + 1 mA
Current, 1 mA range	0.05% + 500 nA

#### Measurement accuracy @ 23 °C $\pm$ 5 °C:

Applies when measuring the default value of 3255 data points with a 5.12  $\mu$ s time interval.

Voltage, 13 V and 6 V ranges	0.05% + 1 mV
Current, 3 A range	0.05% + 300 $\mu$ A
Current, 1 mA range	0.05% + 100 nA
Current, 100 $\mu$ A range	0.05% + 10 nA

#### Load transient response time in voltage priority mode:

Time to recover to within the settling band.

With 150  $\mu$ F cap (ESR = 50 m $\Omega$ ) at load, remote sensing at cap, 4.25' twisted pair load leads.

Rise time (10% to 90%)	$\geq 10$ $\mu$ s
Settling band	
6 V range with a 1.4 A load step	$\pm 20$ mV
Recovery time	$\leq 35$ $\mu$ s

## Supplemental Characteristics

### M9111A

#### Minimum current and voltage compliance limits:

13 V and 6 V ranges current priority mode	20 mV
3 A range voltage priority mode	± 20 mA
1 A range voltage priority mode	± 10 mA

#### Programming range and resolution:

Voltage, 13 V range	0 to 13.26 V; 260 $\mu$ V
Voltage, 6 V range	0 to 6.12 V; 260 $\mu$ V
Current	-3.06 A to 3.06 A; 100 $\mu$ A

#### Programming accuracy temperature coefficient per °C:

Voltage, 13 V and 6 V ranges	0.0025% +200 $\mu$ V
Current	0.0025% +60 $\mu$ A

#### Measurement resolution:

Voltage	120 $\mu$ V
Current, 3 A range	25 $\mu$ A
Current, 1 mA range	13 nA
Current, 100 $\mu$ A range	1.4 nA

#### Measurement accuracy temperature coefficient per °C:

Voltage	0.003 % + 75 $\mu$ V
Current, 3 A range	0.002% + 110 $\mu$ A
Current, 1 mA range	0.002% + 5 nA
Current, 100 $\mu$ A range	0.002% + 500 pA

#### Voltage programming speed and settling time: (at the specified bandwidth)

With slew rate set to maximum; with high 2 output capacitor = 1  $\mu$ F; with high 3 output capacitor = 7  $\mu$ F

Compensation setting	Low	High 1	High 2	High 3
Rise time from 10% to 90% of step 13 V and 6 V ranges with a 0-4 V step	300 $\mu$ s	12 $\mu$ s	15 $\mu$ s	40 $\mu$ s
Settling time to 0.1% of step 13 V and 6 V ranges with a 0-4 V step	1.2 ms	40 $\mu$ s	50 $\mu$ s	120 $\mu$ s

#### High frequency output voltage noise: (at the specified bandwidth)

With high 2 setting, output capacitor = 1  $\mu$ F; with high 3 setting, output capacitor = 7  $\mu$ F

Compensation setting	Low	High 1	High 2	High 3
CV peak-to-peak from 20Hz - 20MHz 13 V and 6V ranges with any load	15 mV	15 mV	3 mV	3 mV
CV rms from 20Hz - 20MHz 13 V and 6 V ranges with any load	1.5 mV	1.5 mV	0.4 mV	0.3 mV

#### Voltage measurement noise: (peak value)

13 V range	2.9 mV
------------	--------

#### Voltage measurement settling time: (settling band of 0.1% of step - 10mV)

Settling time	35 $\mu$ s
---------------	------------

#### Voltage measurement small signal bandwidth:

-3 db	DC to 30 kHz
-1 db	DC to 17 kHz

## Supplemental Characteristics (continued)

### M9111A

#### Voltage priority transient characteristic: (time to recover to within the settling band)

At the specified bandwidth, 6 V range only, with remote sensing at load cap, 4.25' twisted pair load leads.

Compensation setting	Low	High 1	High 2	High 3
Settling band.	40 mV	50 mV	30 mV	20 mV
CC load step	0.2 A	0.2 A	0.5 A	1.4 A
Rise time from 10% to 90% of step	10 $\mu$ s	5 $\mu$ s	5 $\mu$ s	10 $\mu$ s
Recovery time				
with no load cap	40 $\mu$ s	12 $\mu$ s	–	–
with 1 $\mu$ F load cap (ESR = 50 m $\Omega$ )	–	20 $\mu$ s	12 $\mu$ s	–
with 6.8 $\mu$ F load cap (ESR = 50 m $\Omega$ )	–	–	14 $\mu$ s	15 $\mu$ s
with 150 $\mu$ F load cap (ESR = 50 m $\Omega$ )	150 $\mu$ s	–	–	35 $\mu$ s
Maximum peak voltage				
deviation with no load cap	250 mV	260 mV	–	–
with 1 $\mu$ F load cap (ESR = 50 m $\Omega$ )	–	290 mV	140 mV	–
with 6.8 $\mu$ F load cap (ESR = 50 m $\Omega$ )	–	–	140 mV	60 mV
with 150 $\mu$ F load cap (ESR = 50 m $\Omega$ )	65 mV	–	–	45 mV

#### Over-voltage protection:

Range	0 to 15 V
Accuracy	0.05% + 5 mV
Response time <sup>1</sup>	< 40 $\mu$ s

#### Current programming speed and settling time:

Rise time from 10% to 90% of step	
3 A range with a 0-1.5 A step	3 $\mu$ s
1 mA range with a 0- 0.5mA step	1 ms
Settling time to 0.1% of step	
3 A range with a 0-1.5 A step	20 $\mu$ s
1 mA range with a 0-0.5 mA step	7 ms

#### High frequency output current noise: ( CC rms from 20 Hz - 20 MHz )

3 A range	1 mA
1 mA range	1 $\mu$ A

#### Current programming small signal bandwidth:

-3 dB	
3 A range	DC to 100 kHz
1 mA range	DC to 1 kHz

#### Current measurement noise: (peak value)

3 A range	305.2 $\mu$ A
1 mA range	1.1 $\mu$ A
100 $\mu$ A range	25 nA

#### Current measurement settling time: (to 1% of the specified step with no range change)

3 A range with a 0.5-1 A step	35 $\mu$ s
1 mA range with a 0.5-1 mA step	120 $\mu$ s
100 $\mu$ A range with a 50-100 $\mu$ A step	300 $\mu$ s

(to 1% of the specified range with down-ranging)

Down-ranging from 3 A range to:

1 mA range	200 $\mu$ s
100 $\mu$ A range	2 ms

1. Response time applies from the occurrence of the over-voltage condition to the start of output shutdown.

## Supplemental Characteristics (continued)

### M9111A

#### Current measurement small signal bandwidth:

-3 dB	
3 A range	DC to 28 kHz
1 mA range	DC to 10 kHz
100 $\mu$ A range	DC to 1 kHz

-1 dB	
3 A range	DC to 16 kHz
100 mA range	DC to 6 kHz
100 $\mu$ A range	DC to 800 Hz

#### Current priority transient characteristic: (with 4.25' twisted pair load leads)

3A range with a 1.5-3.5 V step	
Current settling band	40 mA
Recovery time	5 $\mu$ s

#### Common mode current from 20 Hz - 20 MHz: (with negative output connected to chassis)

CC peak-to-peak	< 1 mA
CC rms	< 75 $\mu$ A

#### Remote sense capability:

Outputs can maintain specifications with up to a 1-volt drop per load lead. The load lead drop reduces the maximum available voltage at the load.

#### Measurement digitizer:

Digitize voltage and current at ~200 ksamples/s, 1M readings

#### Regulatory compliance:

EMC	Complies with European EMC Directive 2014/30/EU <ul style="list-style-type: none"> <li>- IEC/EN 61326-1</li> <li>- CISPR 11, Group 1, class A</li> <li>- AS/NZS CISPR 11</li> </ul> Complies with South Korea KC mark This ISM device complies with Canadian ICES-001. Cet appareil ISM est conforme à la norme NMB-001 du Canada.
Safety	Complies with European Low Voltage Directive 2014/35/EU.

#### Environmental conditions:

Temperature range	0°C to 45°C
Relative humidity	Up to 95% (non-condensing)
Altitude	Up to 2000 meters
Storage temperature	-40°C to 70°C

#### Output terminal isolation:

Maximum rating No output terminal may be more than 60 VDC from any other terminal or chassis ground.

#### Net weight:

0.41 kg (0.90 lbs)

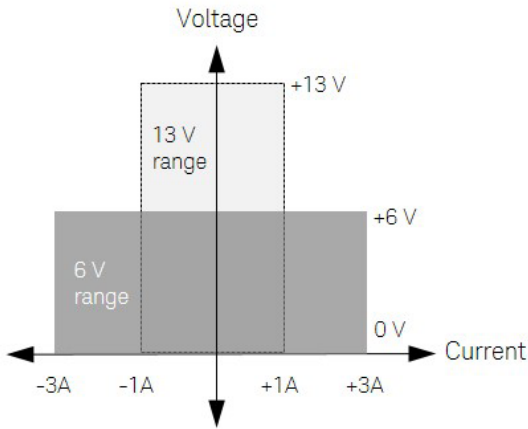
#### Dimensions:

3U, 1-slot, PXIe module  
19.9 mm W x 128.4 mm H x 212.6 mm D (0.784 in. x 5.06 in. x 8.37 in.)

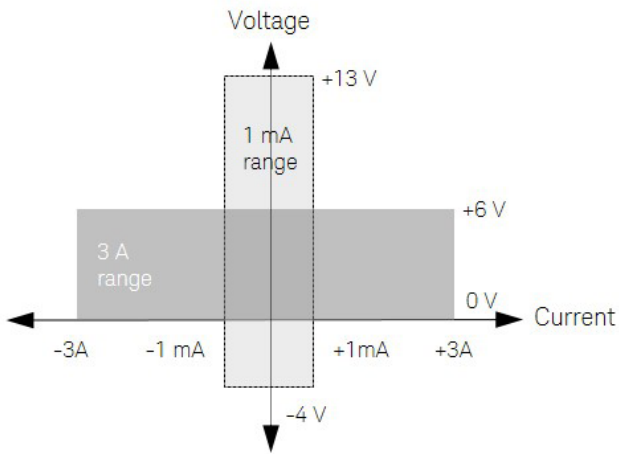


## Output Quadrant Characteristic

### Voltage Priority Mode



### Current Priority Mode

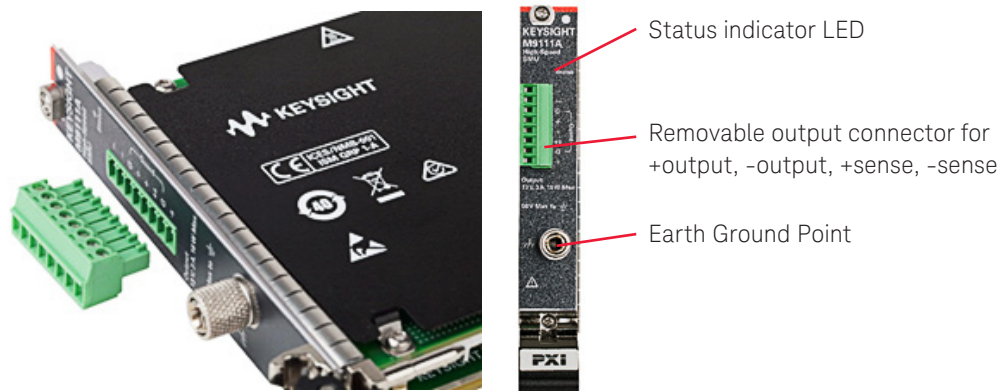


## Measurement Accuracy and Resolution (with shorter measurement intervals)

The following table shows changes to the short-term measurement accuracy and resolution with various number of power line cycle (NPLC) measurement settings. Changes are due to the A-to-D converter's noise performance. The table's baseline is 1 NPLC with no added noise. To determine the measurement accuracy at shorter averaging intervals, simply add the noise value to the fixed accuracy value in the specification table.

<b>NPLC @ 60 Hz:</b>	0.0003	0.003	0.006	0.010	0.031	0.06	0.1	0.6	1
<b>Time:</b>	5.1E-6	51.2E-6	102.4E-6	169E-6	512E-6	998.4E-6	1.7E-3	10E-3	16.7E-3
<b>Averaged points:</b>	1	10	20	33	100	195	325	1953	3255
<b>3A range noise:</b>	305.2E-6	119.5E-6	73.8E-6	72.8E-6	34.8E-6	30.3E-6	19.2E-6	7.8E-6	7.6E-6
<b>Resolution (bits):</b>	13.3	14.6	15.3	15.3	16.4	16.6	17.3	18.5	18.6
<b>1mA range noise:</b>	1.1E-6	290.6E-9	193.0E-9	191.0E-9	45.8E-9	28.7E-9	18.0E-9	3.2E-9	2.9E-9
<b>Resolution (bits):</b>	9.8	11.7	12.3	12.4	14.4	15.1	15.8	18.3	18.4
<b>100 uA range noise:</b>	25.0E-9	20.9E-9	17.0E-9	10.3E-9	5.9E-9	3.2E-9	2.3E-9	547.5E-12	417.9E-12
<b>Resolution (bits):</b>	12.0	12.2	12.5	13.2	14.1	14.9	15.4	17.5	17.9

## Front Panel Details



## Ordering Information

Model	Description
M9111A	PXIe high-speed source/measure unit

## Related Products

Model	Description
M9018A	PXIe 18-slot chassis
M9037A	PXIe high performance embedded controller

## Web Resources

Visit our web sites for additional product information and literature.

M9111A PXIe High-Speed Source/Measure Unit  
[www.keysight.com/find/M9111A](http://www.keysight.com/find/M9111A)

RF PA/FEM Characterization & Test, Reference Solution  
[www.keysight.com/find/solution-padv](http://www.keysight.com/find/solution-padv)

## Evolving Since 1939

Our unique combination of hardware, software, services, and people can help you reach your next breakthrough. We are unlocking the future of technology.  
 From Hewlett-Packard to Agilent to Keysight.



For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: [www.keysight.com/find/contactus](http://www.keysight.com/find/contactus)

### Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

### Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 11 2626
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

### Europe & Middle East

Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
Switzerland	0800 805353
	Opt. 1 (DE)
	Opt. 2 (FR)
	Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:  
[www.keysight.com/find/contactus](http://www.keysight.com/find/contactus)  
 (BP-9-7-17)

**DEKRA Certified**  
ISO 9001 Quality Management System

[www.keysight.com/go/quality](http://www.keysight.com/go/quality)  
 Keysight Technologies, Inc.  
 DEKRA Certified ISO 9001:2015  
 Quality Management System

This information is subject to change without notice.  
 © Keysight Technologies, 2018  
 Published in USA, February 21, 2018  
 5992-1541EN  
[www.keysight.com](http://www.keysight.com)

### myKeysight

#### myKeysight

[www.keysight.com/find/mykeysight](http://www.keysight.com/find/mykeysight)

A personalized view into the information most relevant to you.

[http://www.keysight.com/find/emt\\_product\\_registration](http://www.keysight.com/find/emt_product_registration)

Register your products to get up-to-date product information and find warranty information.

### KEYSIGHT SERVICES

*Accelerate Technology Adoption.  
 Lower costs.*

#### Keysight Services

[www.keysight.com/find/service](http://www.keysight.com/find/service)

Keysight Services can help from acquisition to renewal across your instrument's lifecycle. Our comprehensive service offerings—one-stop calibration, repair, asset management, technology refresh, consulting, training and more—helps you improve product quality and lower costs.



#### Keysight Assurance Plans

[www.keysight.com/find/AssurancePlans](http://www.keysight.com/find/AssurancePlans)

Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

#### Keysight Channel Partners

[www.keysight.com/find/channelpartners](http://www.keysight.com/find/channelpartners)

Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

