Keysight Technologies

Accelerate Your PXI Test Development and Test System Speed

Application Note

Unlocking Measurement Insights

Save Money By Speeding Up Your Test System

The old axiom, time is money, can be applied to test. Speeding up your test system will likely reduce the overall production cost of the device. This application note provides recommendations and examples for optimizing PXI test system speed in each of the following test system stages:

- Instrument selection
- Measurement set up
- Data acquisition
- Data processing
- Returning the measurement results

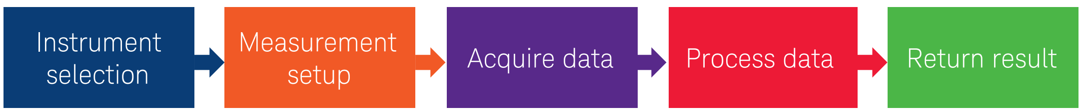


Figure 1. Stages in a typical test system.

Achieving faster test system throughput starts with the selection of hardware and software. For example, using PXI instruments with the latest and fastest communications specifications is an ideal way to achieve fast data transfers between instruments. Selecting modules and software that enable on-board processing, integrated measurements, peer-to-peer communications, data reduction or simultaneous measurements will also increase the speed of a PXI test system. Understanding these and other similar time saving features is important as engineers begin development of PXI test systems.

Instrument Selection

There are several PXI instrument vendors offering different instrument features, specifications and instrument drivers to choose from. Surprisingly, not all PXI instruments adhere to the PXI hardware and software standards, agreed to and supported by the PXI System Alliance (PXISA). Selecting PXI components that do not adhere to the PXI hardware and software standards can cause problems with the test system's power and cooling, module interoperability, triggering, and more. A PXISA certification process ensures standards compliance and equipment vendors can provide evidence of compliance, upon request.

PXI is based on the widely-used, leading-edge, and high performance PCI architecture which is part of the PXISA standard. PXISA continually uses the most recent PCI technology available and has progressed from PCI with a shared bus technology to PCI Express (PCIe) using a point-to-point bus topology for faster data bus transfers. Using PXI instruments with the latest PCIe communications specifications is an ideal way to achieve fast data transfers within the test system. As a member of the PXISA, Keysight works with other modular instrument manufacturers to update and revise the international standards.

Developing a PXI test system with optimal test execution speeds requires a system infrastructure that is up to the task. PXI system components are connected through the PCIe backplane using links (Figure 2). A link is a point-to-point communication channel between two PCI Express ports enabling them to send and receive PXI commands for activities such as configuration, I/O or memory read/writes. Each set of wires used to carry a signal in the link is called a lane. A link can be designed with a single lane, for slower devices or, with up to 16 lanes for wider and faster communications. A "by one" (x1) connection, the smallest PCIe connection, has one lane, consisting of 4 wires. It carries one bit per cycle in each direction. A "by two" x2 link contains eight wires and transmits two bits at once, a x4 link transmits four bits as the same time and so on. Other configurations are x12, x16 and x32. A x16 connection can easily handle, for example, powerful graphics adapters that require high data transfer rates.

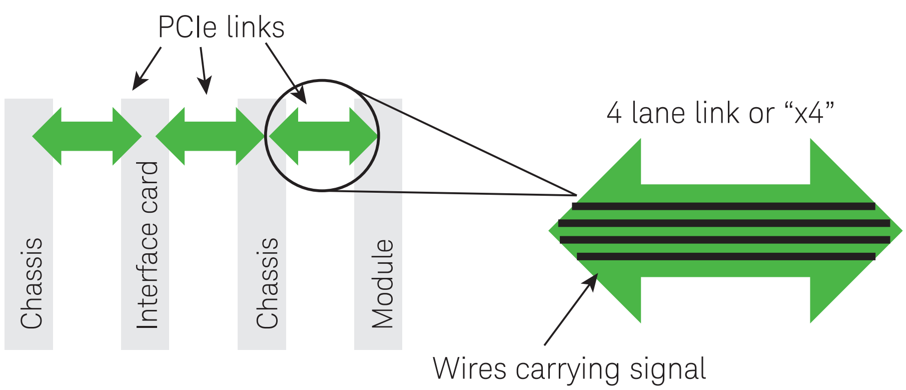


Figure 2. PCIe connections including links and lanes.

Data transfer rates for single (x1) lane links, and (x16) lane links are:

PCI version	Single (x1) lane links	X16 lane links
Gen 1.1	250 MB/s	Up to 4 GB/s
Gen 2	Twice as fast with 500 MB/s	Up to 8 GB/s
Gen 3	Fastest with 985 MB/s	Up to 16 GB/s

To configure a system that will achieve higher data rates for faster communications, you will want to select system components, chassis and modules, that are Gen 2 or newer.

PXI system development begins with selecting a chassis, interface cards and a CPU/controller that are capable of high speed data transfers. The fastest speeds are currently achieved with Gen 3 PXI hardware. Data transfer rates, starting from the instrument, through the backplane, to the interface card and PC or embedded controller, are limited by the slowest component within the link. For example, in a configuration that includes a Gen3 chassis, interface card and PC and a Gen2 instrument, the fastest achievable data rates, from instrument to PC will be Gen2.

PCIe data transfer rates are very important to consider when selecting components. Many engineers are choosing to develop new systems using Gen 3 chassis and interface cards to achieve optimal data rate speeds as more Gen 3 instruments become available.

Software Driver Considerations

PXI instruments typically come with several drivers so you can easily use the module, with a specific driver type, in your choice of programming environment. As you select PXI system components review the list of instrument drivers available, and verify that they will work in your programming environment. IVI-C instrument drivers are often provided and are best used in MATLAB, Excel, Python or LabWindows. Newer PXI instruments include IVI.NET drivers that can be used in 64-bit programming. Keysight PXI products provide a selection of drivers, including IVI.NET, IVI.COM and LabVIEW drivers, so you can control the instrument using the software of your choice.

Application Software Considerations

Readily available application software offers time-saving advantages like providing optimal configurations and measurements, that can help you to achieve results faster. Many test applications can be integrated into system software and used alongside other instrument control and measurement routines. An X-Series Measurement Application (X-App) is one type of software that can be integrated into a test program. An X-App easily integrates into a test program using SCPI commands, and is able to provide pass/fail types of test for design verification and manufacturing. Application specific software can be very helpful to quickly achieve measurement results.

Measurement Set Up and Acquisition of Data

Many PXI test instruments include advanced features that enable the test system to be quickly configured. Being familiar with the features that increase test throughput is important when selecting instruments for a test system. A few examples of instrument features designed to expedite measurement set up and acquire data more quickly include list mode, digital down conversion and FFT.

List mode

List mode, similar to an event-by-event data acquisition, (Figure 4) is used by signal analyzers and signal generators to execute a list of specific commands in a pre-determined order. With list mode, engineers are able to preload the configuration changes for frequency, power level, triggers and more, prior to the test execution which provides fast changes from one configuration to the next. The use of list mode by vector signal analyzers and vector signal generators is considerably faster than sending individual commands from the controller via GPIB or Ethernet to change the instruments' configuration settings. Since the list of RF configurations is created prior to the test execution, the instrument can quickly execute the list without any system overhead to update the configuration.

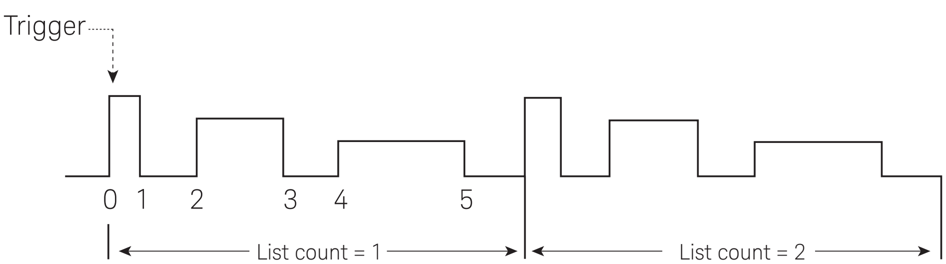


Figure 4. Example of a simple list mode configuration.

Digital down conversion

Some oscilloscope or digitizers can sample at 20 GS/s, which for a long acquisition, will result in lot of data. Engineers might be interested in analyzing only a subset of that data. In frequency domain applications, digital down conversion allows engineers to focus on a specific part of the signal using a higher resolution, and transfer only the data of interest to the controller. The digital down conversion process begins with an RF signal which is converted down to a baseband frequency, or lower frequency, removing unwanted signal components. The sample rate can then be reduced to a rate appropriate with the new bandwidth. This reduces the amount of data required for a measurement which, in turn, greatly reduces the amount of data to transfer. Digital down conversion of a signal allows for shorter data readout and post-processing time, leading to overall faster test result.

FFT mode

The Fast Fourier Transform (FFT) mode, of a digital oscilloscope, saves significant measurement time by acquiring wide bands of data in fewer measurements. The FFT algorithm transforms data from the time domain to the frequency domain (Figure 5). Many calculations are executed during the transformation which requires a CPU or integrated on-board microprocessor to calculate accurate results. PXI modules that include FFT capability can provide wide bands of data at optimal speeds.

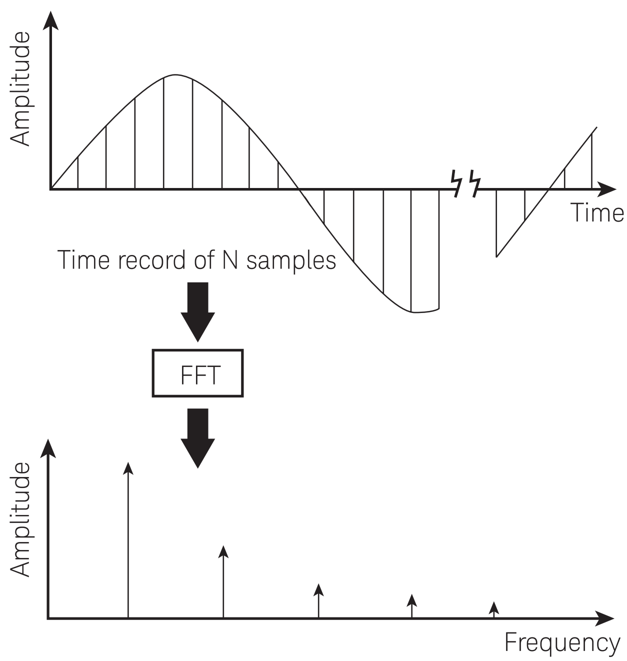


Figure 5. Data reduction using FFT function.

Processing Data and Results

Reducing test time while maintaining repeatability is essential to component manufacturers. Instrument features such as on-board processing and peer-to-peer data transfers enable modules to communicate with each other and perform other functions without using the system controller. Examples include apply functions, or data filters used without the overhead associated with transferring, processing and storing data using the system controller. The ability to run independently from the system controller also allows these modules to run simultaneous to other processes in the test system, reducing the overall test time even more.

Peer-to-peer communications

Peer-to-peer communication uses the PCIe backplane for direct point-to-point transfers between multiple modules within an instrument or between instruments without sending data through the PC or system controller (Figure 6). The system controller is not involved in the actual transfer of data between the modules or instruments. The modules can share information directly rather than use other system resources and can execute much faster. Module-to-module communication is used within multi-module instruments to accelerate measurements. Instrument peer-to-peer is commonly used to execute a direct data transfer to an FPGA co-processor or storage device.

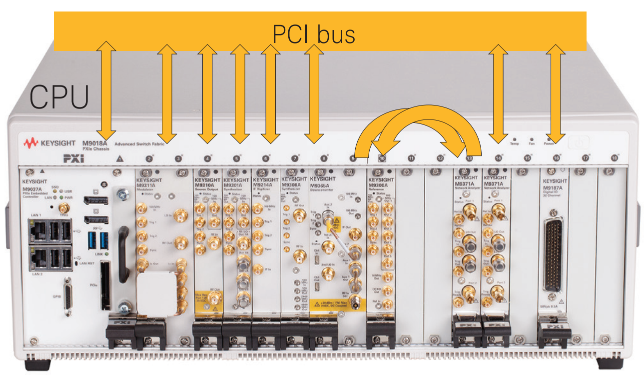


Figure 6. Peer-to-peer communications between PXI modules.

On-board processing

Typically, measurements and other data acquired by PXI instruments and software are transferred to the system controller for processing and storage. A module with on-board signal processing (Figure 7), can manage specific data processing itself, without the need to transfer data to the controller.

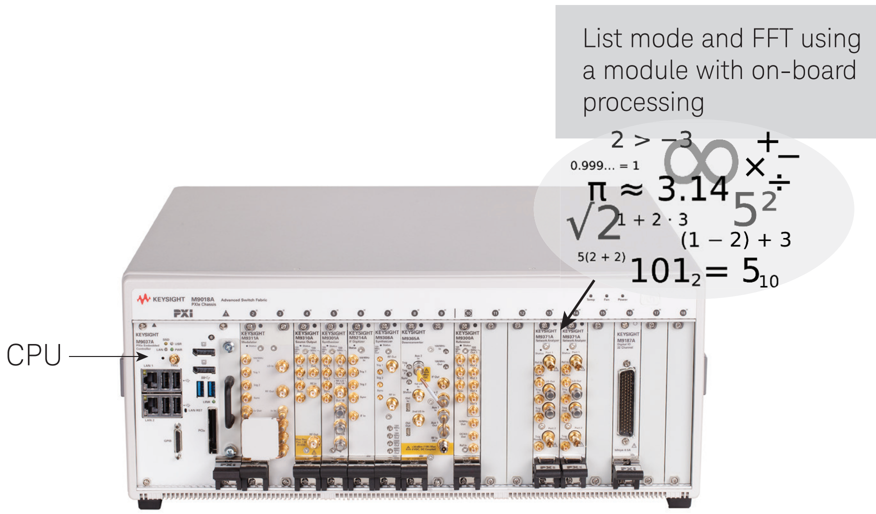


Figure 7. PXI modules with on-board processing capabilities.

PXI instruments with on-board Field Programmable Gate Arrays (FPGAs) enable customization including user-defined software. The user-defined software may include sequencing, or on-board calculation for real-time decision making within the instrument for tasks like tuned measurements, specialized tests and measurement coverage.

An example of on-board processing to make faster measurements can be demonstrated when making a wide band measurement. Power and FFT measurements require a lot of test time as they acquire a large number of measurements and then, process the data for final results. Data transfers between the PXI instrument and PC controller, in addition to large sets of data processing, consumes even more test time. Swept measurements, like wideband FFTs, take a fair amount of time as data is sequentially collected across a selected bandwidth. An approach to make these time-consuming measurements more quickly is to capture digital measurements for segments (multiple FFTs) across a spectrum using list mode. Using on-board module processing, the captured data can be compiled in parallel with other controller processes, quickly providing the data needed for wideband analysis including harmonics and spur measurements. The time to perform this type of FFT is similar to performing a single measurement.

Power amplifier application example

The benefits of both time-saving capabilities, peer-to-peer and on-board processing, can be demonstrated in this power amplifier (PA) test and characterization example (Figure 8). For PA test, a big concern is to balance the time it takes to perform the test as well as ensure repeatability across all the units under test. Generally, as test speed increases, test repeatability decreases.

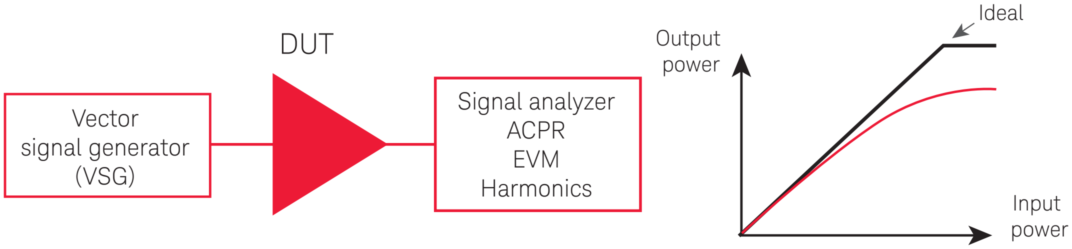


Figure 8. Setting the device output power level in a power amplifier test system.

The key challenge for a PA test is to quickly adjust a power servo loop using a “test and adjust” process to achieve a specific device under test (DUT) output power level. During the adjustment process, a vector signal generator’s level is iteratively adjusted until the specified DUT output power is met, and this process is usually a significant amount of the overall test time. A solution to reduce the power measurement time is to use real time, on-board signal processing. This is achieved by using a VSG’s power level which can switch faster with better linearity, resulting in a reduced number of required iterations required by using on board processing. The VSG’s use of on-board signal processing allows it to perform digital baseband power level changes and frequency offsets, while maintaining amplitude and phase calibrated accuracy without the use of the system controller. Peer-to-peer connectivity is used for data transfers between the PXI VSAs and VSGs in the PA test system which achieves faster data transfer speeds without sacrificing performance.

Wireless component test application example

This is an example of on-board processing used in a wireless product application (Figure 9). Technical advancements of wireless technologies are driving the need for very high volume manufacturing of passable components for mobile handsets as well as components such as antennas, filters, cables and more. To address this need, multiple devices need simultaneous measurements using a single test station to reduce the cost of test by increasing throughput. A PXI vector network analyzer (VNA) with multi-site capability provides the needed test solution. The multi-site VNA enables stimulus setup and generation of frequency, power level, and intermediate frequency bandwidth (IFBW) or a number of points, while simultaneously making measurements for different devices or channels. The test system uses on-board processing with peer-to-peer communication between the VNA modules to make simultaneous measurements in a minimal amount of time.

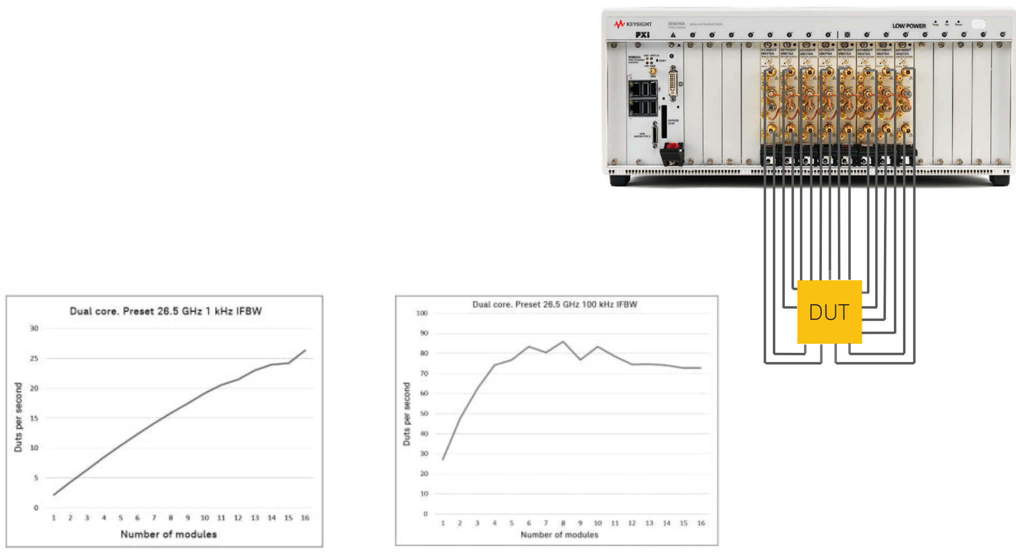


Figure 9. Minimal effect of an increasing number of VNA modules, for more simultaneous measurements, in a system.

Summary

Opportunities to optimize a PXI test system's throughput by selecting specific PXI hardware and software with the right characteristics and features to save time in your measurement setup, when acquiring data, processing data and finally, achieving final measurement and performance results. Test systems can be faster with Gen 2 or newer (Gen 3) system components including the chassis, interface and instrument modules. Remember, the slowest component in the communication link determines the fastest achievable data rate.

Depending on your application needs, you may be able to use instruments with feature like list mode, digital down conversion and FFT to optimize fast measurement setup and data acquisition. There are many PXI instruments that provide on-board processing, peer-to-peer communication and multi-site or parallel processing for faster results. You can achieve fast and efficient test execution by selecting and using PXI instruments and software that include these (Figure 10), and similar, speed optimizing characteristics.

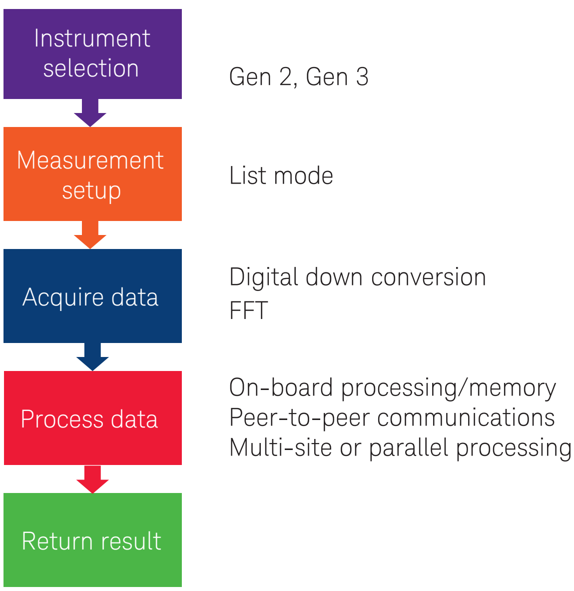


Figure 10. Summary of recommended features for increased test system throughput

Related Literature

Multiport and Multi-site Test Optimization Techniques, Application Note, literature number 5992-0681EN

Solutions for RF Power Amplifier Test, Application Note, literature number 5991-4607EN

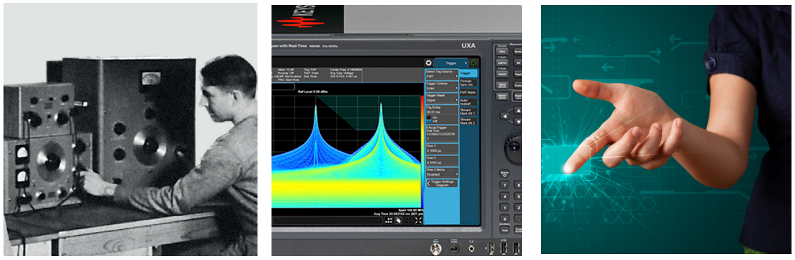
PXIe Measurement Accelerator Speeds RF Power Amplifier Test, Microwave Journal Article Reprint, literature number 5992-1229EN

RF PA/FEM Characterization & Test, Reference Solution, Solution Brochure, literature number 5992-0071EN

Increase Power Amplifier Test throughput with the Keysight PXIe Vector Signal Analyzer and Generator, Application Note, literature number 5991-0652EN

Evolving

Our unique combination of hardware, software, support, and people can help you reach your next breakthrough. We are unlocking the future of technology.



From Hewlett-Packard to Agilent to Keysight

myKeysight

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

KEYSIGHT SERVICES
Accelerate Technology Adoption. Lower costs.

Keysight Services
www.keysight.com/find/service
Our deep offering in design, test, and measurement services deploys an industry-leading array of people, processes, and tools. The result? We help you implement new technologies and engineer improved processes that lower costs.

Three-Year Warranty
www.keysight.com/find/ThreeYearWarranty
Keysight's committed to superior product quality and lower total cost of ownership. Keysight is the only test and measurement company with three-year warranty standard on all instruments, worldwide. And, we provide a one-year warranty on many accessories, calibration devices, systems and custom products.

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

www.keysight.com/find/modular

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

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
(BP-11-29-16)

DEKRA Certified
ISO9001 Quality Management System

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

KEYSIGHT TECHNOLOGIES
Unlocking Measurement Insights

Published in USA, May 25, 2017
5992-2149EN
www.keysight.com