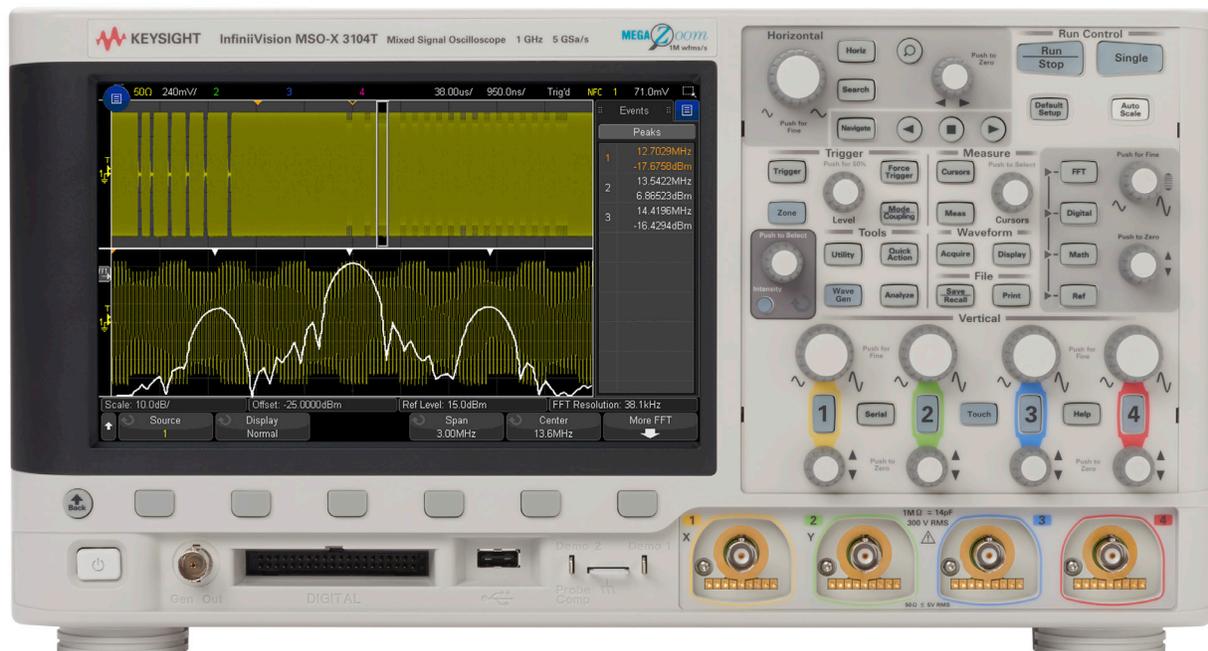


Keysight Technologies

NFC-A and -B Sideband Measurements

Using Keysight InfiniiVision X-Series Oscilloscopes

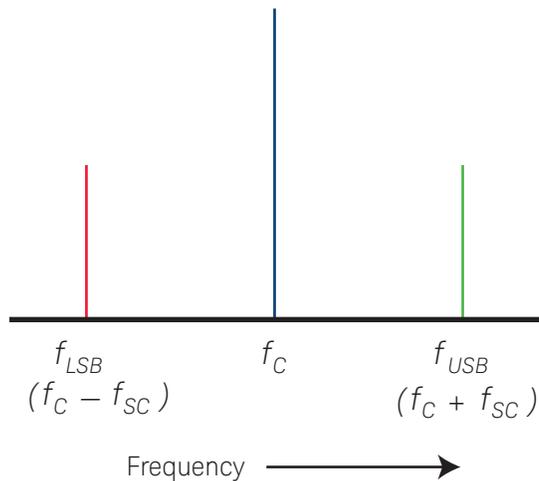
Application Note



Unlocking Measurement Insights

Introduction

Load modulation of NFC-A and NFC-B target/listener devices is based on a 13.56 MHz carrier frequency (f_C) with a subcarrier at 848 kHz (f_{SC}). This creates an upper sideband frequency (f_{USB}) at 14.41 MHz and a lower sideband frequency (f_{LSB}) at 12.71 MHz. Although characterizing load modulation is more often performed in the time domain using an oscilloscope or a one-box NFC tester, engineers that develop the RF technology blocks of NFC devices often prefer to perform load modulation measurements in the frequency domain. This is the natural measurement domain of spectrum analyzers, as well as that of most RF engineers. But there are several advantages in using a Keysight InfiniiVision X-Series oscilloscope to not only view and measure NFC signals in the time domain, but to also perform NFC-A and -B sideband measurements in frequency domain – simultaneously. This allows for cross-correlation between time-domain and frequency-domain measurements. One of the advantages of using an oscilloscope for frequency-domain measurements is the scope's ability to synchronize acquisitions on sequences of complex RF communication with optional NFC triggering. Another advantage is “gated” FFT measurements. Gated FFT measurements allow you to isolate frequency-domain measurements onto specific bursts of subcarrier-generated load modulation for more accurate sideband measurements.



This application note focuses on showing you how to properly window-in on a portion of NFC-A and NFC-B load modulation, perform a gated FFT measurement, and then use the FFT peak search capability of a Keysight InfiniiVision X-Series oscilloscope to measure the amplitude (power levels) and frequency of NFC sidebands, subcarrier, and carrier.

Capturing and Displaying NFC Communication on the Oscilloscope

One method of capturing and displaying NFC listener load modulation is to use a reference polling antenna, such as Keysight's N2116A 3-in-1 programmable NFC antenna, along with applied poller stimulus to initiate communication with a listening device under test. Keysight's automated NFC test software can be used to program the antenna along with an external AWG to generate the appropriate poller antenna stimulus. The Keysight NFC test software also sets up the scope to trigger on and repetitively capture specific sequences of NFC communication. One of the big advantages of using a scope with NFC measurement capability over an NFC one-box tester is that it allows you to view repetitive acquisitions of dynamic NFC communication.

Another method is to simply “sniff out” RF communication in the air between two non-reference devices (poller and listener) using an NFC calibration coil as shown in Figure 1.



Figure 1. Sniffing out NFC communication between a mobile phone (poller) and a tag (listener) using an NFC calibration coil.

Capturing and Displaying NFC Communication on the Oscilloscope (Continued)

Setting up the scope to trigger on NFC communication is easy if the scope has an NFC trigger option. Figure 1 shows an example of a Keysight oscilloscope triggering repetitively on an ALL_REQ command generated by an NFC-A polling device. To learn more about capturing and triggering on NFC communication, refer to Keysight's application note titled, "NFC Device Turn-on & Debug" listed at the end of this document.



Figure 2. Triggering on NFC-A communication.

Setting Up the Sideband Measurement Window

FFT measurements on oscilloscopes are typically performed across the entire acquisition window, which in most cases is the same as the display window. For the example shown in Figure 1 where we triggered on and captured both poller modulation and listener load modulation at 50 $\mu\text{s}/\text{div}$, the acquisition window is 500 μs (50 $\mu\text{s}/\text{div}$ X 10 divisions). This is too long of an acquisition window for proper FFT sideband measurements on the load modulation of a listening device. One solution is to simply zoom in to a tighter window in a specific location. Another solution is to use the scope's zoom timebase along with a gated FFT.

Figure 3 shows an example of using the scope's zoom timebase set at 5 $\mu\text{s}/\text{div}$ (lower display window) and horizontally positioned to display a portion of the listening device's load modulation near the beginning of the response. The zoom timebase display is basically an expansion of a user-defined portion of the main timebase.

A gated FFT – which we will eventually get to – will perform an FFT operation only on acquired data during the zoom timebase window. But we don't yet have the zoom timebase set up properly. So where should the zoom timebase be set for a proper gated FFT sideband measurement?

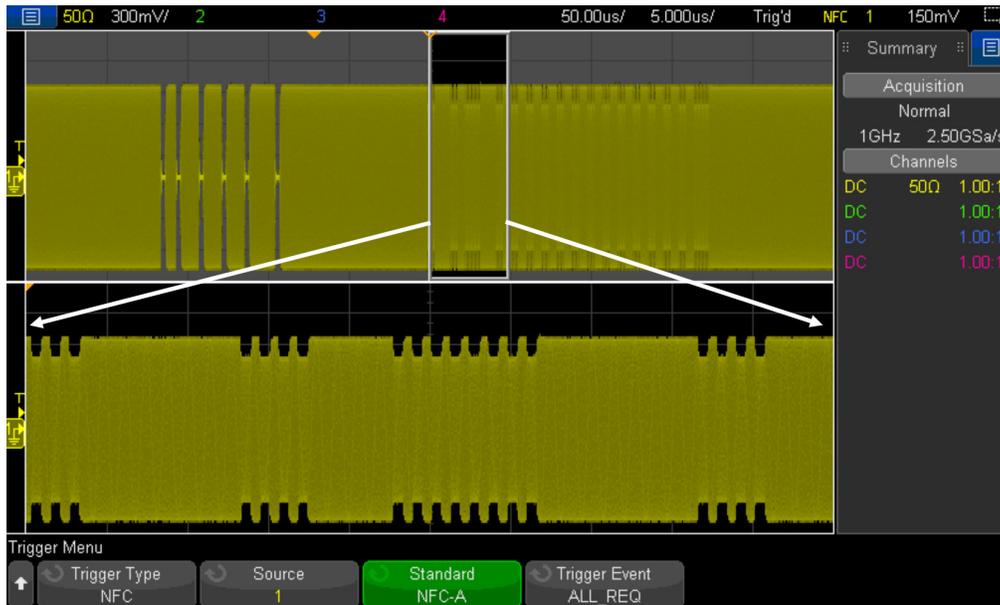


Figure 3. Using the scope's zoom timebase mode to view bursts of NFC-A ASK modulation.

Setting Up the Sideband Measurement Window (Continued)

If you look closely at NFC-A listener amplitude-shift keying (ASK) modulation, you will notice that the modulation appears to come in bursts. For NFC-A, the maximum number of cycles of modulation in one or more of these bursts is eight. Windowing around one of these 8-cycle bursts is where the zoom window should be centered (using the position/delay knob) for the gated FFT sideband measurement. Note that if you demodulate the captured waveform (using the scope's "envelope" waveform math function) and measure the frequency of modulation during one of these bursts, it should measure approximately 848 kHz, which is the subcarrier frequency (f_{sc}).

Eight cycles of 848 kHz is 9.43 μ s. Therefore, the zoom timebase should be set at 943 ns/div (9.43 μ s/10 divisions) with the horizontal position/delay set to center on the modulated burst of pulses so that exactly eight cycles of modulation are displayed in the lower zoom display as shown in Figure 4. Note that with most other vendor's oscilloscopes, it is not possible to establish a precision FFT acquisition window. Once the zoom timebase has been set up properly, it is now time to perform some frequency-domain sideband measurements.

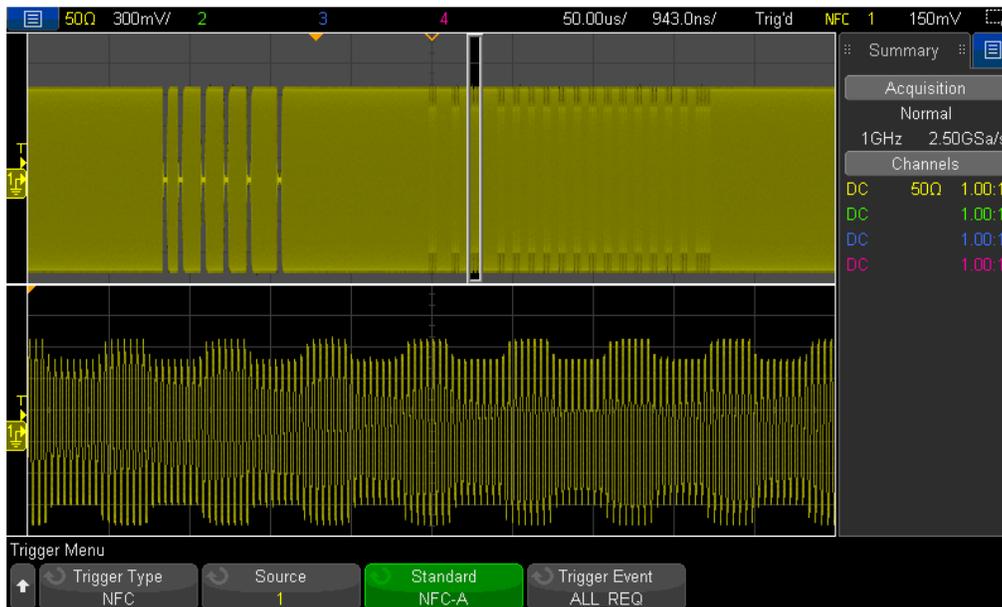


Figure 4. Windowing on exactly eight cycles of modulation.

Using Gated FFT to Display the Sidebands

InfiniiVision X-Series oscilloscopes can be set up to perform an FFT operation on the entire acquisition record or a gated (or selective) portion of the acquisition. If the zoom timebase mode is turned on and if a gated FFT has been selected, then the FFT is performed only on acquired data during the zoom window. Figure 5 shows a gated FFT measurement on the zoom window with FFT display scaling set at a center frequency of 13.56 MHz and a span of 3 MHz. In this screen image we can clearly see the carrier frequency (f_c) at center screen and the lower sideband (f_{LSB}) and upper sideband (f_{USB}) on each side.

With just eight cycles of NFC-A modulation for which to perform this FFT operation on, FFT frequency resolution is limited (wide lobes). Although it may be tempting to expand the zoom timebase to a larger window to improve frequency resolution and accuracy, the peak amplitudes of the sidebands will decrease and become less accurate. If you zoom in to less than eight cycles of NFC-A modulation, peak amplitudes will remain relatively flat and accurate, but you will lose frequency resolution (lobes get even bigger and will begin to merge). If you open up the FFT display span (beyond 3 MHz) while keeping the FFT acquisition window at exactly 943 ns, you'll be able to identify and measure harmonics of the sidebands if desired.

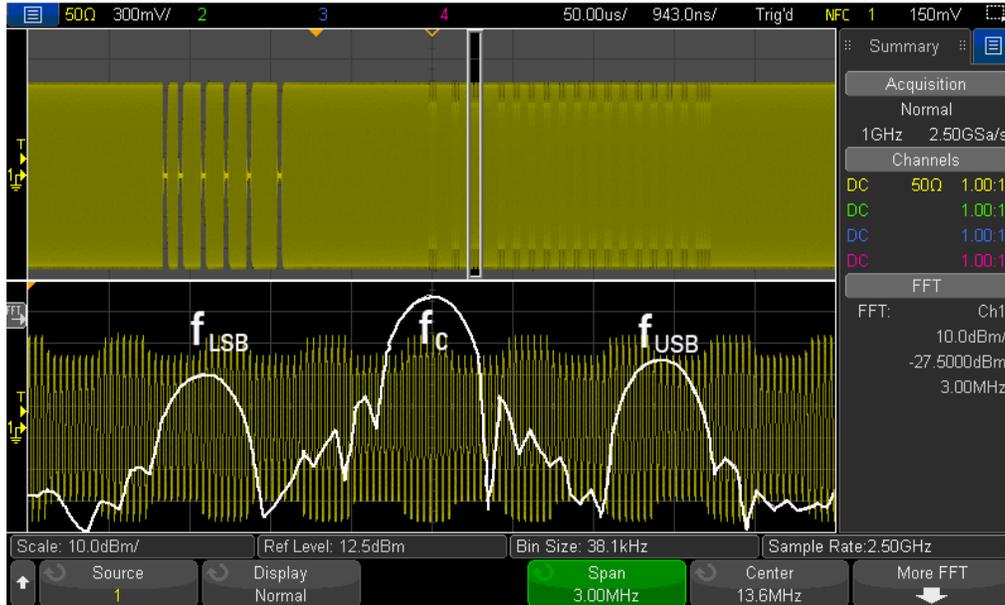


Figure 5. Performing a gated FFT measurement on NFC-A load modulation.

Carrier and Sideband Measurements

One method of measuring amplitude and frequency of various frequency peaks is to use the scope's cursors (markers) slaved to the FFT plot. Another and more automatic method is to use the scope's FFT peak search capability. Figure 6 shows the measurement results of an automatic FFT peak search. The white triangles at the top of the lower zoom display show that the scope found three frequency peaks (spurs) that were within the FFT peak search threshold and excursion settings. The amplitude and frequency of each of these three peaks are shown in the peak measurement window in the upper right-hand corner of the scope's display (highlighted in the red box). Peak #1, which is the lower sideband (f_{LSB}), measured -17.31 dBm at 12.703 MHz. Peak #2, which is the carrier (f_c), measured 7.515 dBm at 13.542 MHz. The difference between the carrier frequency and either the lower or upper sideband frequency is the subcarrier frequency (f_{SB}). Based on the lower sideband, we measure a subcarrier frequency of 840 kHz.



Figure 6. Using the scope's automatic FFT peak search capability to measure sideband and carrier amplitudes and frequency.

Carrier and Sideband Measurements (Continued)

Figure 7 shows an example of performing a gated FFT sideband measurement on NFC-B load modulation. With NFC-B's BPSK modulation, there are many more repeating cycles of the subcarrier for which to perform this frequency-domain measurement. This provides us significantly higher frequency resolution than with NFC-A, as evidenced by the narrower frequency peaks in the FFT plot, as well as a more accurate determination of the sideband, subcarrier, and carrier frequencies.

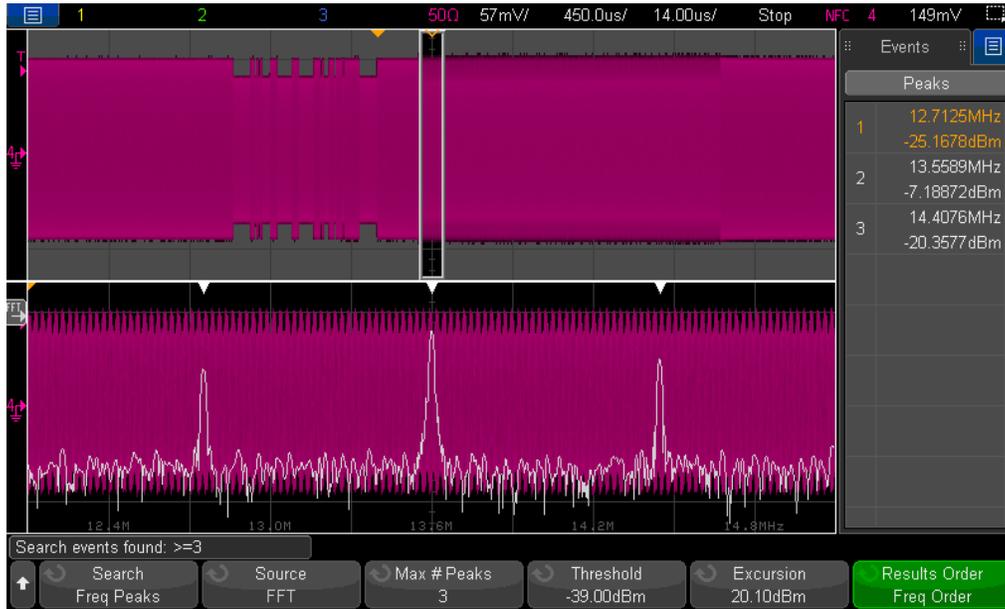


Figure 7. Performing a gated FFT sideband measurement on NFC-B load modulation.

Summary

Performing NFC sideband measurements in the frequency domain is possible when using an oscilloscope with NFC triggering, gated FFT, and FFT peak search capability, such as Keysight's InfiniiVision X-Series oscilloscopes. In this application note we showed how to window-in on repeating patterns of NFC-A and NFC-B listener (target) load modulation, perform a gated FFT measurement, and then measure amplitude and frequency of the upper and lower sidebands, as well as the carrier.

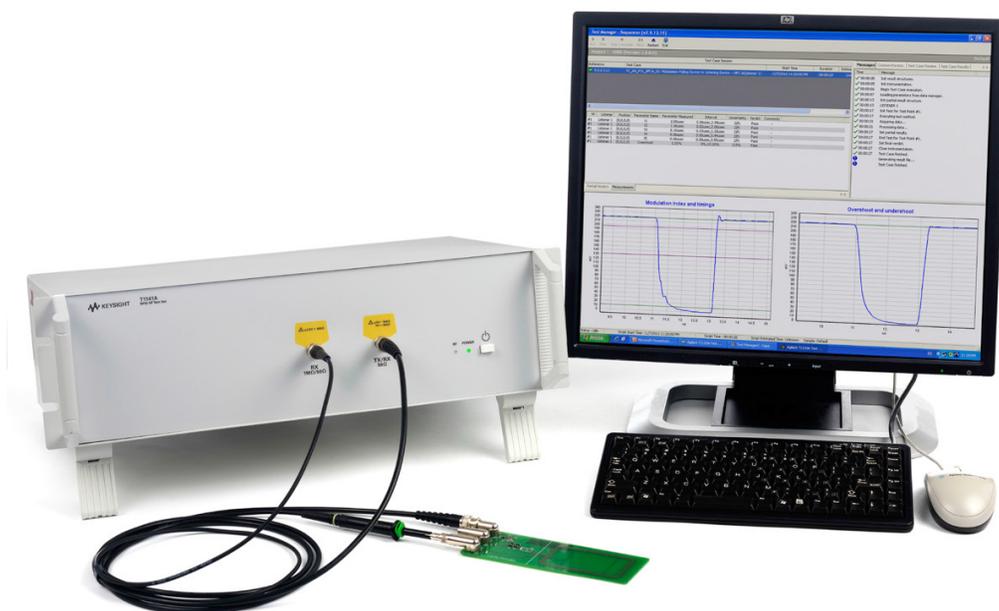
To learn more about how to make various benchtop time-domain NFC measurements, including how to demodulate a captured waveform in order to perform parametric timing measurements, refer the application note titled, "NFC Device Turn-on & Debug" listed at the end of this document.

To learn more about automated pass/fail NFC testing based on NFC published specifications using Keysight's NFC automated test software along with the N2116A programmable 3-in-1 NFC reference antenna (poller-3 equivalent coil, listener-3 equivalent coil, and resonant frequency test coil), refer to the data sheet on this product solution listed at the end of this document.

Related Products

For full/complete NFC conformance testing, Keysight recommends the T3111S.

- Supports analog RF and digital protocol parts of NFC, EMV™ and ISO test specifications
- Platform supports R&D, pre-conformance and conformance testing
- Fully qualified by NFC Forum certification program
- Qualified for EMV Level 1 test including PICC/Mobile and PCD
- Software-upgradeable, integrated, automated, extensible test platform
- Available with automatic positions robots for accurate antenna location
- Easy-to-use test manager for execution and results analysis



Related Literature

Publication title	Publication number
DSOXT3NFC/DSOX4NFC Automated NFC Test Software, N2116A/N2134A/N2135A Programmable NFC 3-in-1 Antenna - Data Sheet	5992-1593EN
InfiniiVision 3000T X-Series Oscilloscopes - Data Sheet	5992-0140EN
InfiniiVision 4000 X-Series Oscilloscopes - Data Sheet	5991-1103EN
T3100S Series NFC Test Systems - Technical Overview	5992-0188EN
NFC Device Turn-on and Debug - Application Note	5992-2066EN
NFC Testing Using an Oscilloscope - Part 1: R&D benchtop testing	Youtube.com
NFC Testing Using an Oscilloscope - Part 2: Automated testing	Youtube.com



www.axistandard.org

AdvancedTCA® Extensions for Instrumentation and Test (AXIe) is an open standard that extends the AdvancedTCA for general purpose and semiconductor test. The business that became Keysight was a founding member of the AXIe consortium. ATCA®, AdvancedTCA®, and the ATCA logo are registered US trademarks of the PCI Industrial Computer Manufacturers Group.



www.lxistandard.org

LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. The business that became Keysight was a founding member of the LXI consortium.

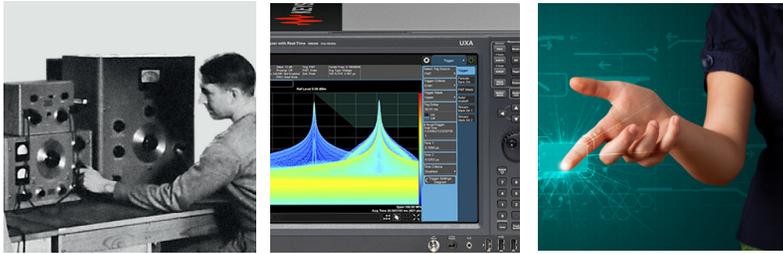


www.pxisa.org

PCI eXtensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.

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.

EMV™ is a trademark owned by EMVCo.

www.keysight.com/find/scopes-nfc

www.keysight.com/find/infiniivision

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)



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, 2017
Published in USA, January 9, 2017
5992-2067EN
www.keysight.com