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# SOLUTIONS FOR SCIENTIFIC AND ENGINEERING RESEARCH







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You'll find Tektronix at the frontier of science and technology, partnering with engineers and scientists to find solutions to the most cutting-edge challenges.

Our products and solution offerings enable you to capture, measure, analyze and simulate the physical world with ever-increasing ease and insight and in compliance with the most up-to-date standards.

- Quantum
- High Energy Physics
- Optical Communications
- Nanotechnologies
- Energy and Efficiency Research
- Next Generation Wireless

# QUANTUM RESEARCH – FLEXIBLE, LOW NOISE SIGNALS FOR TRIGGERING QUBITS

There's a race going on to develop technology based on uniquely quantum or subatomic phenomena. Institutions are working to take data processing to the next level through quantum computing. Laboratories are studying and developing applications of quantum entanglement to create instantaneous communication anywhere in the universe. We are standing at the edge of a new age of science and potentially the birth of new, culture shifting technologies.

It may not sound like a quantum computer, a miles long laser-interferometer and a quantum entanglement have much in common, but when you zoom out, these technological developments all face similar challenges. How do you set up the signals that trigger what you want to observe? How do you ensure timing? How do you scale up a solution?

8 Channels, 16 Bit Resolution.  
Less Noise. Cleaner Signals.

**The New Tektronix 5200A Arbitrary Waveform Generator combines high signal fidelity at a low cost with scalability.** With code compatibility you can fast forward integration and scaling while simplifying waveform design. Test and validate complex, sensitive devices with the accuracy and quality you expect from Tektronix AWG's.

## Oscilloscopes for Troubleshooting and High-Speed Acquisition

**Tektronix builds oscilloscopes for applications ranging from basic undergraduate lab work, to microwave signal analysis.** Mixed Domain Oscilloscopes like the MDO3000 Series and MDO4000C Series combine an oscilloscope and spectrum analyzer in one instrument, providing visibility in both the time and frequency domains. They include digital inputs so you can see as many as 20 analog and digital signals at once.

The MDO4000C lets you see both time and frequency information at the same time, so you can see how a spectrum changes with respect to other signals in the system. The MSO/DPO70000C/DX/SX Series provides high-speed signal acquisition performance up to 70GHz and 200 GS/s with over 30 customizable application-specific software analysis packages.

## Resources

### [Measurement System Signal Integrity: Important Factors to Consider –](#)

Sufficient bandwidth is a key oscilloscope requirement for making accurate measurements. However, there are a number of other factors and specifications that can help you properly perform signal integrity characterization.

### [Fundamentals of the MDO4000 Series Mixed Domain Oscilloscope –](#)

Learn how a Mixed Domain Oscilloscope (MDO) offers time-correlated analog, digital, and RF signal acquisition for a complete system view. Discover the benefits of seeing both the time and frequency domains in one glance, and the advantages of viewing RF spectrum changes over time.

### [XYZ's of Signal Generators Primer –](#)

Explains the basics of Signal Generators, including the many types of generators, their applications and their contribution to a complete test and measurement solution.

### [Overcoming RF Signal Generation Challenges in Quantum Computing with New DAC Technologies White Paper –](#)

In this document, some important features for direct RF complex signal generation are presented followed by a discussion on two architectural techniques that can expand frequency coverage with a focus on reducing cost and complexity for multi-channel applications.





## HIGH ENERGY PHYSICS – MEASURING AT HIGH-SPEED

With new and compelling questions about the origin of particle masses, the nature of dark matter and the role of neutrinos, scientists need instruments that can capture or simulate fleeting events that represent the world of fundamental particles. Our oscilloscopes are used in the quest to achieve longer-duration reactions, such as high gain nuclear fusion, to capture high-speed pulses and to test the latest generation of accelerators and synchrotrons.



## The World's Standard in Oscilloscopes

Scientists around the world trust Tektronix to capture high-speed pulses and test the latest generation of accelerators and synchrotrons. With the broadest portfolio of digital oscilloscopes available, the most extensive analysis capability, and our award-winning service and support, Tektronix has the right oscilloscope to meet your needs.

## The World's Fastest and Most Versatile Signal Generators for Today's Complex Signals

With sample rates up to 50 GS/s, our 10-bit digital-to-analog technology enables AWG70000 Series Arbitrary Waveform Generators to cover a wide range of HEP applications, from replicating pulse detector signals to generating RF events. These signal generators can create virtually any signal - analog or digital, ideal or distorted, standard or custom. RFXpress software lets you experiment with complex RF/IF/IQ waveforms. SerialXpress helps you build serial data streams on your PC. And ArbExpress is free, general purpose waveform editing software that lets you develop signals to simulate real world events.

## World's Leading Step, Pulse, and Impulse Generators

Our pulse generators provide ultra-performance in a broad range of dimensions for step, pulse and impulse sources. These include shortest transition time, most versatile risetime/falltime control, maximum frequency and duration control and high signal amplitudes, providing the highest performance for this class of source products.

## Real-Time Spectrum Analyzers

Real time spectrum analyzers are invaluable for tracking high-frequency electromagnetic interference and characterizing transient RF events.

## Resources

### [Fundamentals of Signal Integrity](#)

**Primer** – Review the challenges associated with sending and receiving high-speed signals. Learn measurement techniques that may be used to uncover problems and characterize performance.

### [Fundamentals of Real-Time Spectrum](#)

**Analysis Primer** – Find out how real-time spectrum analyzers reliably detect and characterize rapidly changing RF signals.

### [Asynchronous Time Interleaving](#)

**White Paper** – Introduces new technology that extends the bandwidth performance of real-time oscilloscopes to 70 GHz.

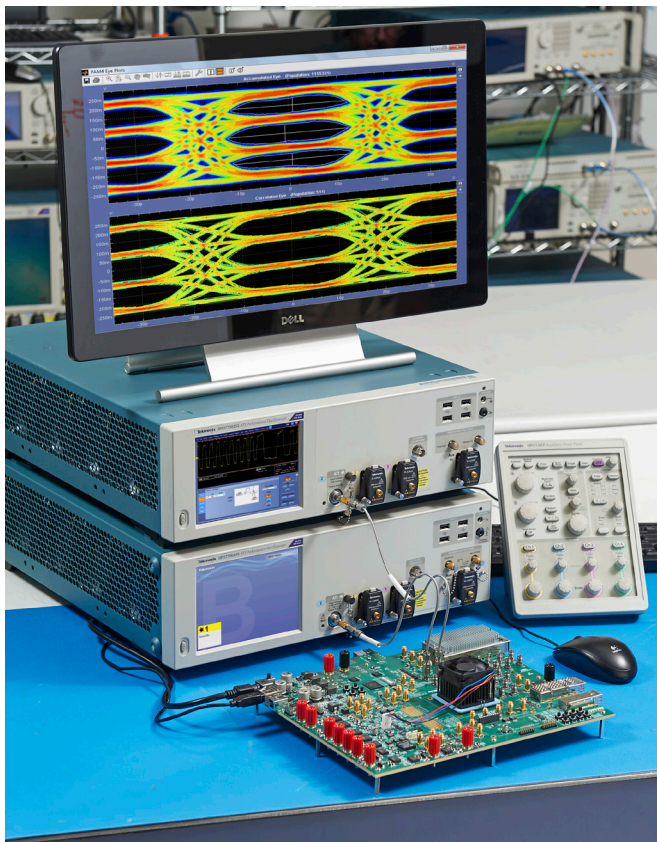
### [XYZs of Signal Generators Primer](#) –

Explains the basics of Signal Generators, including the many types of generators, their applications and their contribution to a complete test and measurement solution.

# OPTICAL RESEARCH – A COMPLETE RX/TX MEASUREMENT SOLUTION

**Whether you work on optical components, transceiver sub-assemblies or transmission systems, there are critical PHY layer tests that need to be done:** eye diagrams and jitter performance, stressed receiver testing, crosstalk & BER tests, and optical modulation analysis. Tektronix provides you with the expertise and equipment to perform standards compliant TX, RX and Coherent Optical testing to 400 Gb/sec and beyond.

As network demands increase, long-haul communications are becoming more complex. Advanced test tools are required to test the latest communication systems for 100G, 400G, 1Tb/s and beyond. Tektronix is the only test and measurement vendor that can offer a complete coherent optical test system from signal generation to modulation, coherent detection, acquisition, and analysis.



## Signal Acquisition and Analysis: The World's Lowest-Noise, Real-Time Oscilloscope and More

The MSO/DPO70000C/DX/SX Series oscilloscope delivers exceptional signal acquisition performance and analysis capability. The DPO70000SX 70 GHz oscilloscope provides the industry's lowest-noise real time acquisition using Tektronix' patented Asynchronous Time Interleaving (ATI) technology. Discover your real signals with uncompromised acquisition on all 4 channels and capture more signal details with the industry's highest waveform capture capability. Automate setup, acquisition and analysis of high-speed serial data signals with a toolset engineered to deliver faster design and compliance testing.

All Tektronix high performance oscilloscopes, can be equipped with SignalVu Vector Signal Analysis (VSA) Software for wideband modulation analysis. In coherent optical research, SignalVu Software helps with phase correction using multi-tone calibration. It is ideal for demodulating orthogonal frequency division multiplexing (OFDM) modulation.



DSA8300 Series Sampling Oscilloscopes are suitable for accurate characterization of optical transmitter performance using built-in optical reference receivers and very low jitter noise floor. With an industry-leading intrinsic jitter of less than 100 fs, the DSA8300 Series provides support for today's optical communications standards, time domain reflectometry and S-parameter analysis. The DSA8300 Digital Sampling Oscilloscope is a complete high-speed PHY Layer testing platform for data communications from 155Mb/sec to 100G.

The OM4245 Coherent Optical Modulation Analyzer, together with the MSO/DPO70000SX 70 GHz Series oscilloscopes, makes an ideal coherent optical signal acquisition system for 400G, 1Tb/s and beyond. The OM4245 optical modulation analyzer provides laboratory instrument-grade optics and optical-to-electrical conversion capable of handling the latest coherent optical signals up to 80 GBaud. The OM2210 Coherent Receiver Calibration Source provides a simple solution for calibrating the OM4245 or other coherent receivers.

Developed specifically for coherent optical analysis, OM1106 Coherent Lightwave Signal Analyzer software provides state-of-the-art demodulation, measurements and visualization tools for all of today's coherent optical standards. It also includes support for spatial (or modal) division multiplexing that requires an OMA to down convert and digitize data for each channel. Multi-carrier communication applications also require one OMA per wavelength channel when the

wavelength separation is more than the OMA bandwidth. Unique MATLAB integration provides unparalleled levels of algorithm, signal processing, and workflow customization. The OM1106 analysis software is available separately or included with the OM4245 Coherent Optical Modulation Analyzer.

## Setting the Standard for Signal Generation

The AWG70000 Series of arbitrary waveform generators represents the cutting edge in sample rate, signal fidelity and waveform memory. The AWG70000 Series can reach sampling rates as high as 50 GS/s with 10 bits vertical resolution, enabling creation of multi-level signals such as 16QAM or 64QAM at up to 32 GBaud data rates. Up to 4 instruments can be synchronized to provide 4 channels at 50 GS/s each.

The AWG5200 Series of arbitrary waveform generators deliver the industry's best combination of sample rate and vertical resolution at a surprisingly low price. Create real-life environments based on accurate, noise-free signals, and 10 GS/s 16-bit performance that allows for direct generation of signals up to 6 GHz.

The PPG3000 Series is capable of generating patterns up to 40 Gb/s and offers up to 1, 2, or 4 channels in a single instrument for creation of dual-polarization I-Q waveforms.

The OM5110 Multi-format Optical Transmitter provides the flexibility to modulate all of the most common coherent optical formats at rates up to

46 GBaud. The OM5110 Multi-Format Optical Transmitter is a C- and L-Band transmitter capable of modulating the most common coherent optical modulation formats such as PM-QPSK and PM-16QAM. For those who are testing multi-carrier systems, the OM2012 Tunable Laser provides extra lasers in both C- and L-band.

## Bit Error Rate Testing

PatternPro® PPG and PED Series Single and Multi-Channel Pattern Generators and Error Detectors are ideal for simultaneous BER testing of up to four lanes at 32Gb/s, and now include pattern generation and error detection capability at rates up to 40 Gb/s.

BERTScope BSA Series Bit Error Rate Testers use long pseudo-random patterns and accurate BER measurements for comprehensive signal integrity measurements on communications systems up to 28 Gb/s.

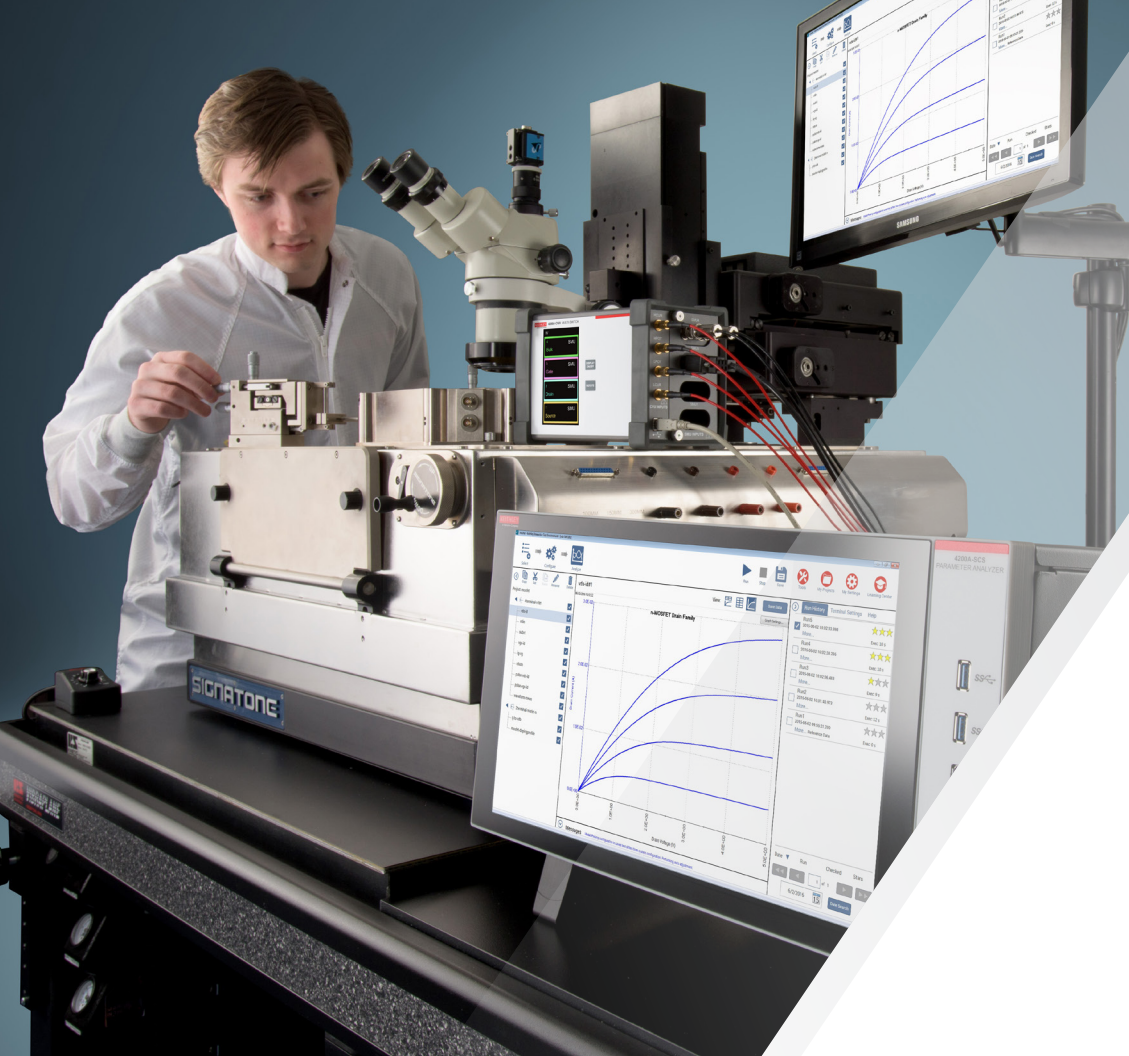
## Resources

### [Physical Layer Tests of 100 Gb/s Communications Systems App Note –](#)

Learn how to prepare for compliance measurements on 100G standards.

### [Coherent Optical Signal Generation with High Performance Arbitrary Waveform Generator App Note –](#)

Learn how instrument characteristics influence the ability to generate different modulation schemes, how to compensate for internal and external device imperfections, and to emulate component and link distortions.



## NANOTECHNOLOGY – ADVANCED MEASUREMENT FOR ADVANCED MATERIALS

If you're researching or developing the materials or devices of the future like silicon-based compound semiconductors, thin film for solar cells, graphene and other nanoscale materials, you're at the fore-front of breakthroughs in new applications in semiconductor technology, electronics, medical devices, health care and more.

Our comprehensive solutions for electrical characterizations of new materials and devices can help you innovate further and reimagine our world.



## Source-Measure Units– (SMU) Instruments

Source-measure units or SMUs are ideal instruments for making nanoscopic material and device measurements. They are a smart alternative to separate power supplies and digital multimeters (DMMs). Keithley SourceMeter®SMU instruments combine a power supply, true current source, 6.5-digit DMM, arbitrary waveform generator, V or I pulse generator with measurement, electronic load and trigger controller in one instrument with a convenient DMM-like user interface.

A source and measure unit can rapidly switch from outputting a specified voltage and accurately measuring the resulting current, to the other way around. When materials such as carbon nanotubes (CNTs) or graphene are in a high impedance state, the SMU can source voltage and measure current quickly and accurately. When the material is in a low impedance state, the SMU can quickly reconfigure to source current and measure voltage. Furthermore, the SMU has a current compliance function that can automatically limit the DC current level to prevent damage to the material or device under test (DUT).

From 3000V to 10nV and 50A pulse to 1fA, Keithley's family of SourceMeter SMU instruments offers the broadest measurement range available. Each is fully programmable and provides higher precision, resolution and flexibility for materials research, semiconductor devices (transistor, BJT, diode, power MOSFET, power semi, LED), electronic circuits, and more.



## Highest Performance Parameter Analyzer

Keithley's 4200A-SCS is a modular, customizable, and fully-integrated parameter analyzer that provides synchronized insight into current-voltage (I-V), capacitance-voltage (C-V), and ultra-fast pulsed I-V electrical characterization. Its optional 4200A-CVIV Multi-switch module enables effortless switching between I-V and C-V measurements without re-cabling or lifting probe needles. Offering up to 2X faster characterization insight, the 4200A-SCS accelerates testing of complex devices for materials research, semiconductor device design, process development or production.

Keithley also offers the industry's most complete line of picoammeters, electrometers and nanovoltmeters for highly sensitive voltage, current and resistance measurements for nanoscience applications.

## Resources

[Advances in Electrical Measurements for Nanotechnology eBook](#) – Learn why sensitive electrical measurement tools are essential for nanoscience research. Understand how these tools provide the data needed to understand the electrical properties of new materials fully and the electrical performance of new nanoelectronic devices and components.

[Electrical Characterization of Carbon Nanotube Transistors \(CNT FETs\) with the Model 4200-SCS Parameter Analyzer App Note](#) – Learn how to perform IV characterization on carbon nanotube FETs.



## ENERGY AND EFFICIENCY RESEARCH – MEASURING FOR TODAY AND TOMORROW

Sustainable energy research aims to meet the energy needs of the present without sacrificing the ability of future generations to meet their needs. The technologies are wide-ranging, including renewable energy sources, such as hydroelectricity, solar energy, wind energy, wave power, geothermal energy, artificial photosynthesis, and tidal power. Sustainable energy research also aims to improve energy efficiency and power consumption on widely used power converters, electronics, common appliances and battery operated portable devices. Tektronix offers several categories of instruments in the areas of precision power measurement, waveform analysis, transducers (probing), and semiconductor characterization.



## Power Analyzers for Accurate Power Measurements

Power analyzers are designed especially for making accurate power measurements on a wide range of power conversion systems: from cell-phone chargers to 1000 kW grid-connected inverters. PA3000 Series Power Analyzers can be configured with one to four input channels for testing three-phase devices, or for testing input and output power simultaneously. The PA3000 also includes special modes for testing efficiency and standby power on power supplies, PWM motor drives, LED drivers and lighting ballasts. The PA1000 is designed for precision power analysis and testing power consumption on single phase applications such as appliances, power supplies and hand tools. Both analyzers enable you to measure conversion efficiency and perform pre-compliance testing.

## Power Supply Switching Analysis

A significant amount of power is lost during FET switching, and many Tektronix oscilloscopes can be outfitted with special power analysis software to quantify this important switching loss. For example, an MSO/DPO5000B equipped with DPOPWR power analysis software can measure switching loss, magnetic loss, safe operating area and harmonics.

IsoVu isolated measurement systems combine bandwidth up to 1GHz, common mode rejection of 10000:1 and complete optical isolation to enable accurate measurements on next generation GaN and SiC switching devices.

## Making High-speed Current Measurements

Making accurate current amplitude measurements even at high slew rates is critical to achieving maximum power efficiency. Tektronix current probes provide industry-leading measurement sensitivity down to 1mA and bandwidths up to 100 MHz. When paired with today's Tektronix oscilloscopes the latest current probes automatically scale the readings to amperes and provide status information right on the oscilloscope display. The IsoVu isolated measurement system can also be used to measure current across shunt resistors up to 1 GHz.



## Resources

### [Power Supply Measurement and Analysis Primer](#)

– Discover how to make many common power measurements including switching loss, safe operating area, magnetic power loss, and harmonic analysis.

### [Testing Power Semiconductor Devices with Keithley High Power System SourceMeter SMU Instruments](#)

– Learn about the most commonly performed power semiconductor device tests, the challenges associated with them, and how SMU instruments can simplify the testing process.

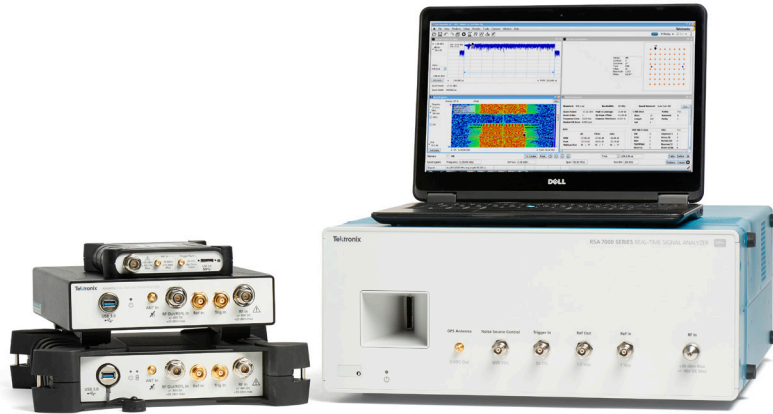


## NEXT GENERATION WIRELESS – SPEEDING INTO THE FUTURE

If you're working in 5G you're developing new protocols, like WiGig, while simultaneously designing and creating devices to meet these, as yet, undefined standards. You're chasing the dream of ever lower latency and higher data rates, operating with the lowest possible power. And you're also chasing impossible deadlines.

At Tektronix, we're continuously developing new measurement tools and solutions to advance world-changing research and innovations. From higher speeds for cutting edge performance, to built-in tests for ease-of-use, our solutions are designed to get you the insights you need quickly and efficiently.





## Real-Time Spectrum Analyzers

Our RSA spectrum analyzer series provides the speed and real-time capability to help you find elusive transient signals quickly and efficiently. The disaggregated form factor enables a lower cost and more flexibility as you use the same software package across the range. They range from 40 MHz bandwidth RSA306B handheld spectrum analyzers to RSA7100 RF recording and analysis solution with up to 800MHz of real-time bandwidth.

## Ultra-Low Power Analysis Solution

Our Keithley digital multi-meters and high performance power supply solutions enable you to characterize total power consumption of your device. Measure performance when the device is in sleep or active mode, capture transients that last microseconds and measure current change as the battery discharges.



## The World's Highest Bandwidth, Real-Time Oscilloscope

The DPO70000SX 70 GHz oscilloscope provides the most accurate real-time

performance for ultra-bandwidth applications. Coupled with SignalVu Option SV30 software, the DPO70000SX offers 2.5 percent (-32.0 dB) error vector magnitude (EVM) precision for the industry's most accurate solution for wide bandwidth, with a single instrument that uses zero down-conversion.

## 6-in-1 Versatility in One Powerful Oscilloscope

Our Mixed Domain Oscilloscope series includes up to six built-in instruments, each with exceptional performance to address tough challenges. Every MDO4000C features powerful triggering, search and analysis. The only scopes to offer synchronized analog, digital and RF signal analysis at the same time, so you can view events across domains simultaneously.

## Resources

[WiGig Case Study](#) – Learn more about how Tektronix DPO70000SX was used to overcome WiGig test and measurement challenges.

[WiGig Webinar](#) – Focusing on how this technology is being commercially adopted and the challenges related to that adoption, this webinar features insights on the key factors to consider when performing transmitter testing to IEEE 802.11ad.

[Determining Power Consumption and Battery Life in Low Power , Portable IoT Devices Webinar](#) –

presents options for measuring power consumption, simulating a battery and creating a model of a battery to provide an optimum solution for assessing battery life.







## **Contact Information:**

**Australia\*** 1 800 709 465  
**Austria** 00800 2255 4835  
**Balkans, Israel, South Africa and other ISE Countries** +41 52 675 3777  
**Belgium\*** 00800 2255 4835  
**Brazil** +55 (11) 3759 7627  
**Canada** 1 800 833 9200  
**Central East Europe / Baltics** +41 52 675 3777  
**Central Europe / Greece** +41 52 675 3777  
**Denmark** +45 80 88 1401  
**Finland** +41 52 675 3777  
**France\*** 00800 2255 4835  
**Germany\*** 00800 2255 4835  
**Hong Kong** 400 820 5835  
**India** 000 800 650 1835  
**Indonesia** 007 803 601 5249  
**Italy** 00800 2255 4835  
**Japan** 81 (3) 6714 3010  
**Luxembourg** +41 52 675 3777  
**Malaysia** 1 800 22 55835  
**Mexico, Central/South America and Caribbean** 52 (55) 56 04 50 90  
**Middle East, Asia, and North Africa** +41 52 675 3777  
**The Netherlands\*** 00800 2255 4835  
**New Zealand** 0800 800 238  
**Norway** 800 16098  
**People's Republic of China** 400 820 5835  
**Philippines** 1 800 1601 0077  
**Poland** +41 52 675 3777  
**Portugal** 80 08 12370  
**Republic of Korea** +82 2 6917 5000  
**Russia / CIS** +7 (495) 6647564  
**Singapore** 800 6011 473  
**South Africa** +41 52 675 3777  
**Spain\*** 00800 2255 4835  
**Sweden\*** 00800 2255 4835  
**Switzerland\*** 00800 2255 4835  
**Taiwan** 886 (2) 2656 6688  
**Thailand** 1 800 011 931  
**United Kingdom / Ireland\*** 00800 2255 4835  
**USA** 1 800 833 9200  
**Vietnam** 12060128

**\* European toll-free number. If not accessible, call: +41 52 675 3777**

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