Keysight Technologies
Solving Design and Test Challenges for Medical Devices

Greater accuracy. Greater performance. Design and test next-generation medical devices with greater confidence.

KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

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Introduction

Across the globe, the demand for medical services is growing. As the need for healthcare grows, technology continues to play a larger role in patient care, leading to unique challenges in the design and testing of the medical devices used.

Patient monitoring is a key example. Although a wired connection is considered the most reliable approach, robust wireless connections are becoming more widely used for emergency, in-patient and out-patient scenarios. In addition to wireless monitoring, technology enables new capabilities in diagnostics, therapeutics, imaging and surgical robots. Present and future radio frequency (RF) wireless, digital, component and material technologies will enable improvements in the quality of care delivered around the world.

Keysight is ready to help you address the challenges involved in the design, development and testing of these new medical devices. Our expertise and product portfolio span the RF, microwave, wireless and digital technologies that are the building blocks of today's medical technology. Keysight provides solutions that address general areas of concerns such as electromagnetic interference and battery power consumption, as well as specific applications such as imaging organic and biological materials to elucidate the structure of a material at the micro- or nano-scale level.

When it comes to medical care, even the smallest detail matters. Whether you are testing pacemakers or designing devices that will help set up the next medical breakthrough, you get the accuracy, reliability and performance you need with Keysight solutions.

RF Wireless Challenges

Interference between devices and environment

Electromagnetic interference (EMI) or radio-frequency interference (RFI) is one of the most critical challenges for medical device developers, and can cause electronically-controlled medical devices, such as pacemakers or hearing aids, to operate incorrectly. Depending on the severity of the interference and the type of affected device, the consequences can range from inconvenient to life-threatening.

EMI occurs when the electromagnetic radiation emitted by electrical circuits causes unwanted signals or interference in other circuits. Most electronically-controlled medical devices do not have adequate protection against EMI, and the challenge is exacerbated by the increase of RF sources used both in and outside the hospital. Portable wireless communications devices, such as cellular phones and tablets, are one of the largest sources of EMI.

Recommended Keysight solutions

Pre-compliance measurements

X-Series signal analyzer with N6141A embedded EMI measurement application

To avoid costly delays that can result from failed compliance testing, Keysight's EMI measurement application on X-Series signal analyzers allows you to perform pre-compliance measurements and diagnostic evaluation of your designs. Find and fix problems before they enter the test chamber with the N6141A measurement application on the N9030A PXA, N9020A MXA or N9010A EXA, or W6141A measurement application on the N9000A CXA for a low-cost pre-compliance test solution.

EMC compliance testing

N9038A MXE EMI receiver

In EMC compliance testing, your success depends on moving products through the test queue quickly and efficiently. Conduct full standards-compliant testing in accordance with CISPR and MIL-STD with the upgradeable N9038A MXE EMI receiver. For a complete EMI test solution, Keysight Solutions Partners provide a single point of contact for you to combine the MXE with chambers, antennas, software, value-added integration, probes, and more.

Keysight offers design, simulation and test capability for all of your EMC/EMI design and test needs. After designing your device, you can utilize Keysight test equipment to verify your designs. Keysight products include X-Series signal analyzers, MXE EMI receiver, network analyzers, signal sources and oscilloscopes.

Important considerations

- Ensure wireless coexistence between medical devices and other devices that operate on the same or adjacent RF band, to avoid interference that might affect performance or interrupt the transmission or reception of signals.
- Device must meet the stringent IEC 60601-1-2 standard or other appropriate standards
- Recommended separation distances from other devices or sources of electromagnetic discharge or other plans must be put in place if EMI susceptibility is discovered during testing

Related medical devices

- Hearing aids
- Computed tomography devices (CT scan)
- Pacemakers
- X-ray devices
- Electro-diagnostic devices
- Fitness wearables
- MRIs
- Ultrasound

Magnetic fields immunity test

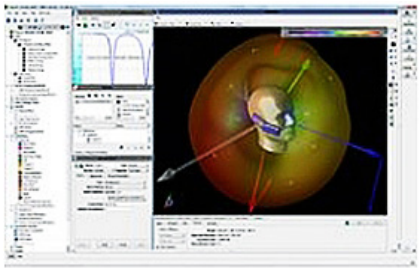
6813B AC power source/power analyzer

Electronic devices can encounter magnetic fields at power line frequencies in many settings, so it is important to test these devices to ensure that they can operate reliably even when exposed to magnetic fields. The 6813B AC power source/power analyzer has the capability of producing output voltages up to 300 Vrms and output currents up to 13 Arms, with a maximum output rating of 1750 VA in either continuous or pulsed output waveform sine wave. The low distortion output voltage from 6813B can be used to drive an induction coil cage directly to generate the magnetic field to test the device.

EMI/EMC Simulation

Electromagnetic Professional (EMPro)

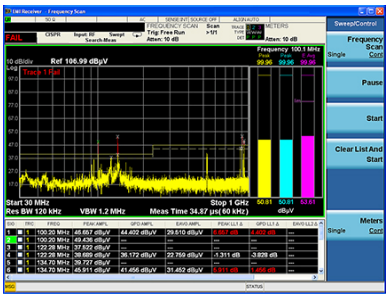
EMPro is a 3D modeling and simulation environment for analyzing various 3-dimensional EM problems. Simulation and analysis environment, high capacity time- and frequency – domain simulation technologies (FDTD and FEM) and integration with ADS (Advanced Design System), the industry's leading RF/microwave and high-speed design environment. EMI, medical, and bio applications, for example, MRI and pacemaker designs. By using EMPro, designers can also ensure the design passes regulatory and operator compliances, such as Over-The-Air performance, Specific Absorption Ratio (SAR), and Hearing Aid Compatibility (HAC), before going into expensive physical design testing.



EMPro software

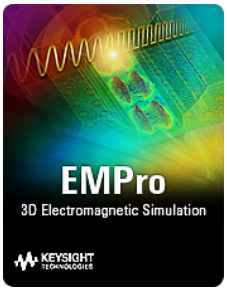
Keysight Solutions at a Glance

Pre-compliance measurements



X-Series signal analyzer (PXA, MXA, EXA, CSA) + N6141A embedded EMI measurement application software

EMPro simulation software



EMC compliance testing

N9038A MXE EMI teceiver

Magnetic field immunity test

6813B AC power source/power analyzer

Wireless Technology Design Challenges

Using wireless technologies in medical devices provides many benefits, including always-on patient monitoring, seamless communications (person to person and machine to machine) and wireless sensing. In addition to dedicated medical wireless technologies, the medical industry is widely adapting off-the-shelf wireless connectivity technologies such as WLAN, *Bluetooth*® Low Energy, Zigbee, Near Field Communication (NFC) and cellular technologies including HSPA and LTE for better wireless connections among medical devices and systems.

Wireless technologies in medical devices

The Federal Communications Commission recommends the following frequency bands for medical devices.

Important considerations

Designs must meet the specifications of the wireless technology used.

Related medical devices

- Hearing aids
- Fitness wearables
- Monitoring devices (wireless)

	Technologies	Major application	Frequency	Coverage (m)
Dedicated medical devices	Inductive coupling implants	Low data rate monitoring/control with implanted devices	Less than 1 MHz	Less than 1
	Medical device radiocommunication service	Medium data rate communication with implanted/on/near body devices	401-406 MHz	2-10
	Medical micropower networks	Implanted micro stimulators for artificial nervous system	413-419, 426-432, 438-444, 451-457 MHz	Less than 1
	Medical body area networks	Personal Area Network (“PAN”) for multiple on/near body sensors for patient monitoring; not for implanted sensor	2360-2400 MHz	Less than 1
	Wireless medical telemetry	The measurement and recording of physiological parameters and patient information	608-614, 1395-1400, 1427-1429.5 MHz	Up to 60
Off-the-shelf medical devices	WLAN 802.11a/b/g/n/ac/ad	Communication within medical sensors/ devices/ hubs for healthcare data systems	2.4/5 GHz	250
	Bluetooth Low Energy	Low power medical sensors/devices connection	2.4 GHz	~ 50
	Zigbee	Low power medical sensors/devices mesh connection	868 MHz (EU), 915 MHz (US), 2.4 GHz	10 to 20
	NFC	Low power medical sensors/devices connection	13.56 MHz	< 20 cm

Recommended Keysight Solutions

Signal generation

X-Series vector signal generators with signal studio signal creation software

This solution enables you to create high performance signals covering a frequency range of 9 kHz up to 6 GHz with up to 160 MHz modulation bandwidth, quickly and easily verify the performance of devices and receivers that use broad wireless standards, verify interference testing, and troubleshoot a device's operation in the presence of common wireless signals.

Signal analysis

X-Series signal analyzers and 89600 VSA software

This solution accurately measures frequency, amplitude and modulation including distortion, spurious, phase noise, and 2G to 4G cellular communication signals as well as various wireless connectivity signals such as WLAN, *Bluetooth*, Mobile WiMAX®, and more. It also offers flexible modulation analysis software or measurement applications so you can demodulate a broad range of standard-based and general-purpose digital signals and formats.

Wireless connectivity

EXM wireless tester set

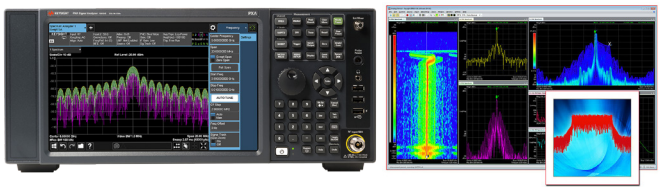
The EXM wireless test set provides turnkey solutions to test multi-format of wireless connectivity signals such as 802.11a/b/g/n/j/p/ac/af/ah, WLAN MIMO 2x2/3x3/4x4, *Bluetooth* Low Energy, WiMAX, multi-satellite GNSS, FM, Zigbee and digital video.

Keysight Solutions at a Glance

Signal generation

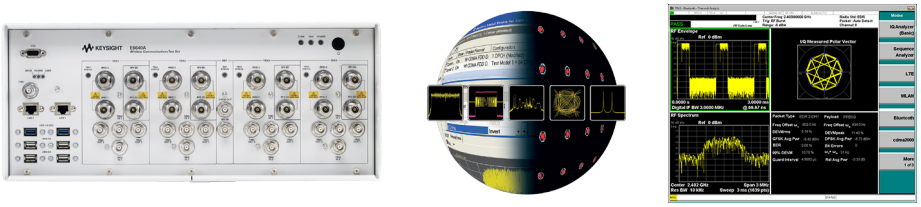
RF signal source + signal studio and signal creation software

Signal analysis



X-Series signal analyzer + 89600 VSA software

Wireless connectivity



EXM wireless test set + signal studio and signal creation software or X-Series measurement application

RF/Wireless Components Design and Characterization

RF device and component testing requires an innovative mix of time, coverage and cost per device-under-test (DUT). Finding your balance starts with the right combination of speed and performance in your test system.

Important considerations

Each RF component should guarantee its performance to secure device level quality

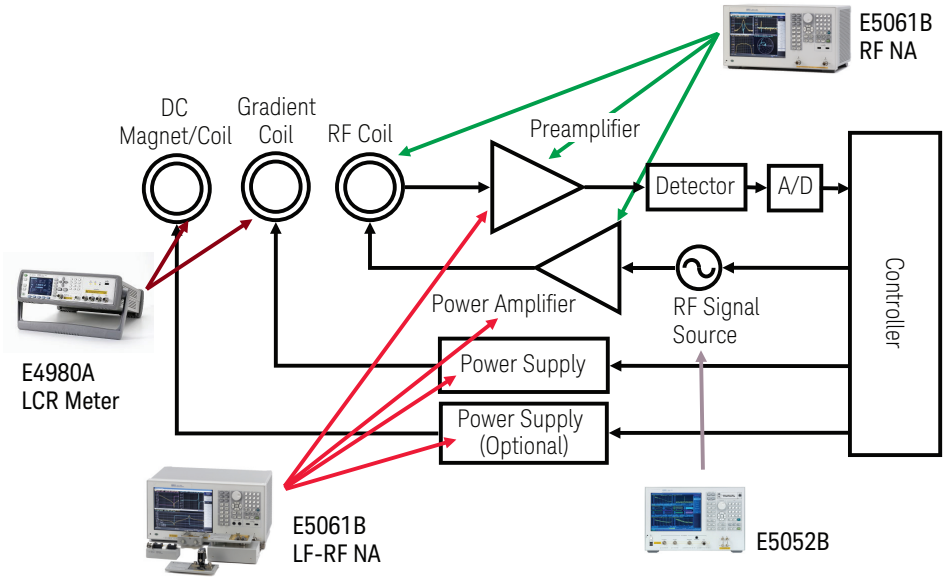
Related medical devices

- Hearing aids
- Pacemakers
- Fitness wearables
- Electro-diagnostic devices
- MRIs

Recommended Keysight Solutions

Component test solution for MRI systems

Keysight provides various component test solutions including E5061B RF/LF-RF network analyzers, LCR meters and E5052B signal source analyzer. For MRI components test, the E5061B LF-RF network analyzer is the best choice for R&D engineers and circuit designers to verify the amplifiers and power supply. The E5061B RF network analyzer, a direct successor of the HP/Keysight 8712, helps MRI production engineers test RF coils, amplifiers and filters with its fast, accurate and cost-performance balanced test capabilities. The E5052B signal source analyzer measures MRI oscillators phase noise with exceptionally fast and accurate test capabilities along with its easy operation and one-box simple configuration.



MRI component test diagram

SystemVue Electronic System-Level (ESL) design software

Parallel MRI imaging using multichannel digital front-end design is a common approach for modern advanced MRI scanners. Many MRI receivers are designed with high performance ADCs, wideband RF amplifiers and reconfigurable digital front ends. The challenge in MRI signal acquisition is to obtain high quality images. This revolves mostly around the accuracy of overall signal processing. The MRI receivers require ultra-low-noise, high SNR and high dynamic range.

SystemVue is a focused electronic design automation (EDA) environment for ESL design, and provides design simulations for medical/bio applications. SystemVue enables multi-channel digital MRI receiver designers to troubleshoot hardware implementations, while still maintaining a higher-level view of system performance.

Advance Design System (ADS)

Advanced Design System is the world's leading electronic design automation software for RF, microwave and high-speed digital applications. ADS comes with a powerful and easy-to-use interface and pioneers the most innovative and commercially successful technologies, such as X-parameters and 3D EM simulators, used by leading companies in the wireless communication & networking and aerospace & defense industries. ADS provides full, standards-based design and verification with Wireless Libraries and circuit-system-EM co-simulation in an integrated platform.

Creating the solution you need with PXI solutions

Combine Keysight quality and performance in a PXI form factor. PXI solutions accelerate throughput by delivering new levels of speed in signal generation-fastest analog tuning, fastune digital baseband tuning, versatile list mode, and more—to accelerate the characterization, validation and production of RF components and devices.
Keysight PXI products include:

- PXI vector signal analyzer
- PXI signal generator
- PXI signal analyzer
- PXI network analyzer

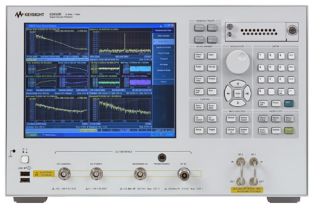
Keysight Solutions at a Glance

MRI testing solutions

DC coil testing

LCR meter

RF signal source



SSA signal source analyzer

MRI RF coil, preamplifier, power amplifier, power supply

Network analyzer

PXI solutions

PXI card

PXI chassis

Design software

SystemVue Electronic System Level (ESL) design software

Advanced Design System

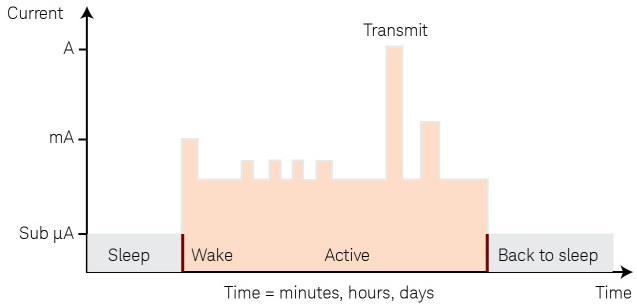
Non-RF Challenges

Power consumption for battery-operated medical devices

The importance of battery life is critical for portable battery powered medical device developers. The convergence of wireless connectivity, high-speed digital processing, and real-time monitoring abilities requires understanding and accurately measuring battery current drain. Long periods of sleep/idle, wakeup/active, and short RF bursts create a tough demand on the battery.

The typical peak current consumption for wireless technologies is shown below:

Wireless technologies	Peak current draw
Bluetooth Low Energy	< 15 mA (read and transmit)
NFC	< 15 mA (read)
ZigBee	~ 5.9 mA to 34 mA



Example of current drain profile.

Important considerations

- Dynamic current makes measurement and testing difficult due to
  - Extremely wide dynamic ranges
  - Different devices having different current needs: low current, pulsing current, current with fast rise/fall times
  - Rapidly changing current signals occur depending on what tasks the device or sub-circuit is performing (waking up, transmitting, going back to sleep mode)
- Test instruments such as DC source may impact the accuracy of the current measurement

Related medical devices

- Hearing aids
- Pacemakers
- Fitness wearables
- Monitoring devices

Recommended Keysight Solutions

Keysight current drain analysis solution

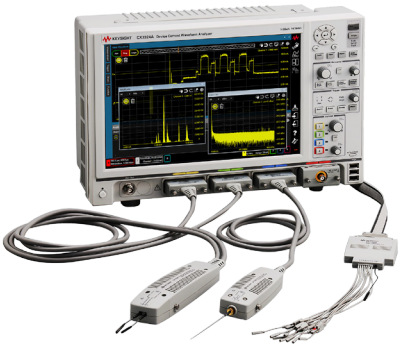
This solution consists of the N6705 DC power analyzer, N6781A 2-quadrant source/measure unit (SMU) and 14585A Control and Analysis software. This integrated solution includes a patented innovative measurement called “Seamless Measurement Ranging.” This capability provides you with the ability to measure dynamic current drain from sub-microamperes to amperes in a single measurement acquisition.

The N6781A SMU module in the N6705 DC power analyzer is optimized for determining run-time of the whole portable medical device, making this the best choice for DC measurement with the highest sensitivity and widest dynamic range for battery drain analysis.

Perform battery run down tests using the actual medical device battery. The N6781A SMU module is configured as a virtual logging ammeter to digitize the current drain. The N6781A Aux DVM input is connected across the battery to record the battery voltage. Average current, charge (mAh), energy, (Wh), and run time, are calculated based on 14585A software markers at the start and shutdown points.

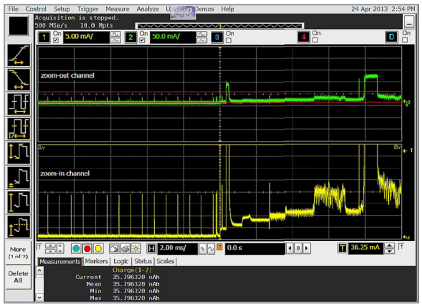
Low current power measurement solution

The CX3300 series device current waveform analyzers is the world's first instrument that clearly and precisely visualizes previously undetectable low-level current waveforms. Dedicated current sensors measure from 100 pA level dynamic current up to 10 A with a maximum of 200 MHz bandwidth. The CX3300 series enables engineers to easily and accurately visualize wide-band and low-level current waveforms and make quantitative evaluations of current waveforms, while reducing the power consumption of low power devices.



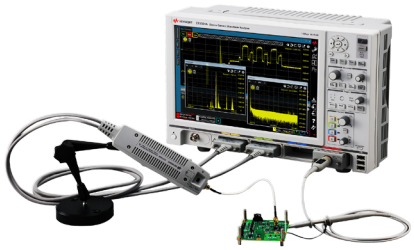
Low current measurement troubleshooting

Oscilloscope is a major tool of choice when it comes to measuring low level AC/DC current signals as well as voltage signals. The N2820A Series High Sensitivity Current Probes address the need for high-sensitivity current measurements with a wide dynamic range (50uA to 5A). The probes also offer physically small connections to the device under test since most application environment requires small form factor.

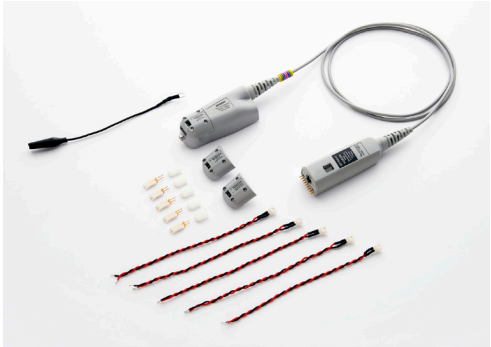


Keysight Solutions at a Glance

DC power analyzer and 2-Quadrant source unit



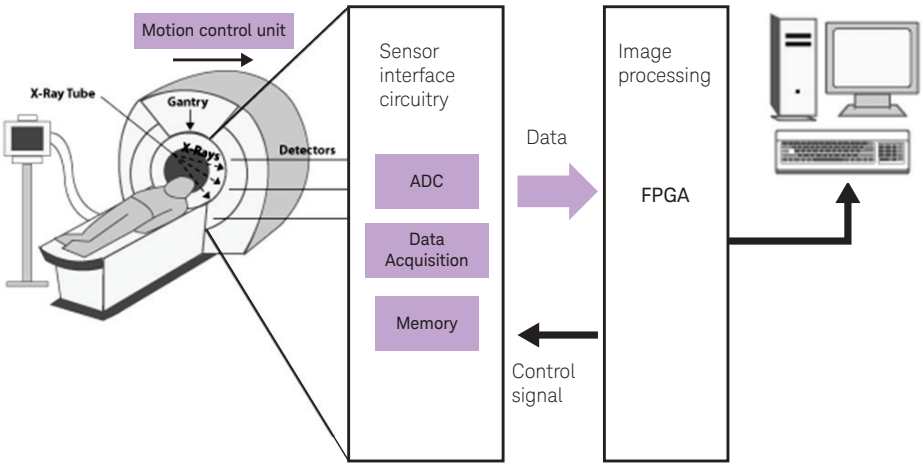
Device current waveform analyzer



N2820A/N2821A AC/DC current probes

High-Speed Medical Imaging

Field-programmable gate arrays (FPGAs) are integrated circuits that are intended to be configured by a designer after manufacturing. They are used in medical imaging equipment (such as x-rays, ultrasounds and MRIs) and other measuring and analysis equipment for detection and image construction.



Typical block diagram for medical imaging system

Important considerations

- Fast data acquisition is needed for sound images and high image quality
- Multiple receivers' signals must be processed in parallel
- Flexible acquisition memory is needed at various resolutions
- Fast data throughput and signal processing is required for image reconstruction

Related medical devices

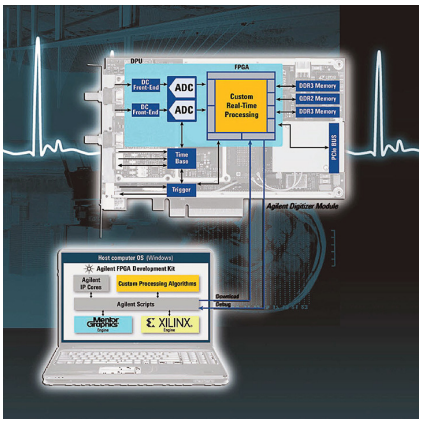
- Computed tomography devices
- Ultrasound
- MRI

Recommended Keysight Solutions

High-speed digitizer and FPGA development kit

This solution consists of an accurate and precise 12-bit PCIe digitizer with programmable on-board processing. Benefitting from the very high data transfer rates of the PCIe 2.0 interface, and occupying a single x8 slot in a host PC, this solution offers high performance in a small footprint, making it an ideal data acquisition platform for many commercial, industrial and aerospace & defense embedded systems and high-speed medical imaging such as OCT and ultrasound.

To help end-users focus on solution creation, Keysight's FPGA development kit includes the following elements: a library of building blocks, from basic gates to dual-port RAM memories, a set of IP cores, and ready-to-use scripts that handle all aspects of the build flow. Smooth and efficient system integration is ensured with a full-speed design example and companion software application.



Mixed signal oscilloscopes (MSO)

Debug FPGAs faster and more effectively with a MSO. Design engineers typically take advantage of the programmability of the FPGA to route internal nodes to a small number of physical pins for debugging. MSOs can help users understand the behavior of their FPGA in the context of the surrounding system by allowing them to view internal activity of the FPGA, make multiple measurements in seconds, and leverage the work they have done in the design environment.

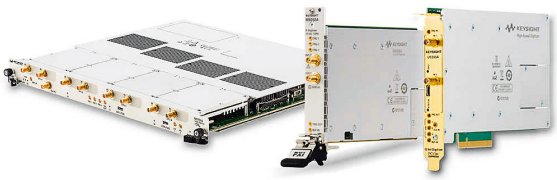
The digital channels on an MSO normally limit engineers to measuring signals at the periphery of the FPGA. With the FPGA dynamic probe, users can now access signals internal to the FPGA and measure up to 64 internal signals for each external pin dedicated to debug.

Moving probe points internal to an FPGA used to be time consuming; a Keysight MSO can easily measure different sets of internal signals without design changes in less than a second. FPGA timing stays constant when new sets of internal signals are selected for probing.

The FPGA dynamic probe maps internal signal names from the FPGA design tool to the Keysight MSO. This automatic setup of signal and bus names eliminates unintentional mistakes and saves hours.

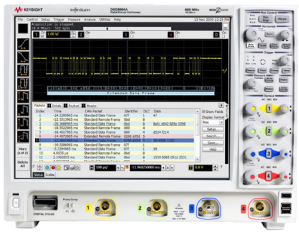
Keysight Solutions at a Glance

FPGA design



High-speed digitizer + FPGA development kit

FPGA debugging



Mixed signal oscilloscope

Electronic Components Design and Characterization

Electrical testing or non-RF wireless testing of medical devices is equally important to characterize medical devices. Many medical devices operate at low voltage, low current, low frequency and high accuracy environments, and high precision test equipment is needed to ensure that the medical device-under-test meets the required regulatory compliance.

Recommended Keysight solutions

Digital multimeter (DMM)

Accurately measuring the load current of an implantable medical device can be quite a challenge. Devices such as pacemakers draw very low currents (as low as microamps) when in sleep or standby mode, but draws much higher currents during active mode. The 34465A and 34470A Truevolt DMMs capture the current profile by running the device-under-test multiple times to capture the sleep and standby modes separately and then the operating mode currents.

Arbitrary waveform generator

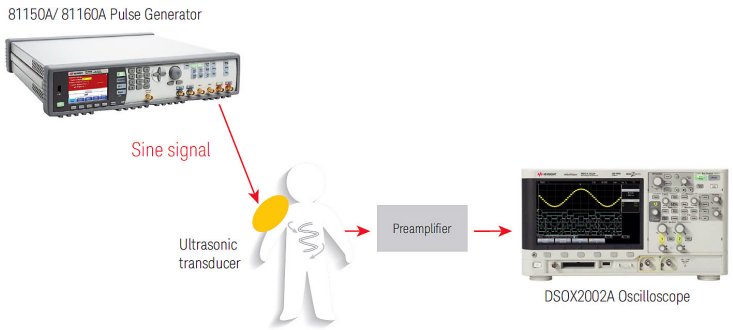
Arbitrary waveform generators (33500B and 33600A Series) allow users to generate complex ECG patterns. These instruments also come with a sequencing feature, allowing them to switch seamlessly across various ECG signals stored in the arbitrary waveform memory, and to simulate the gradual onset of various ECG signal abnormalities without any discontinuities in the test.

Pulse generator with oscilloscope

Pulse function arbitrary noise generators can simulate distorted sensor signals in fitness wearable devices. These instruments can generate high-precision and repeatable simulations of any kind of clean signals overlaid with a distortion, as well as motion artifacts in the Hz-range and acoustic signals corrupted by ambience acoustic noise. Overshoot and other voltage level effects that occur during wake-up from sleep mode can also be created.

With real-time bandwidth and high measurement accuracy, oscilloscopes can help you to quickly debug any design issues in the device-under-test.

For medical doppler sonography applications, the pulse generator can emit a continuous sinusoidal signal in the kHz range (depending on the investigated process), which is transmitted into an ultrasonic transducer.



Important considerations

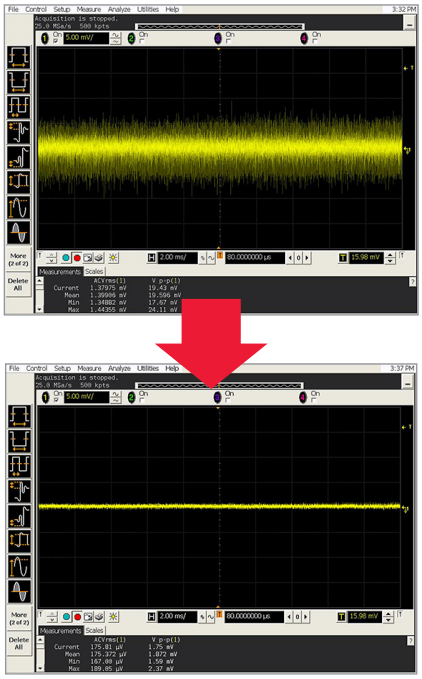
Test equipment must be able to make low voltage measurements for low-leakage current draw, generate precise and accurate signals, and generate versatile waveforms for device simulation

Related medical devices

- Hearing aids
- Pacemakers
- Fitness wearables
- Electro-diagnostic devices

Precision low noise voltage and current sourcing

Keysight B2961A/62A are a new generation of low noise power sources with 6.5 digit best-in-class precision, wide bipolar voltage and current output ranges of 100 nV to 210 V and 10 fA to 10.5 A. These power sources come with extremely low noise floor of 10 µVrms and 1nVrms/√Hz (at 10 kHz), and offer innovative features such as graphing capability and arbitrary waveform generation capability from 10 mHz to 10 kHz, enabling tests and evaluation beyond conventional power sources. B2961A/62A power sources are ideal to pair with other instruments, such as oscilloscopes, network analyzers, spectrum analyzers, frequency counters and digital multimeters.



Captured by oscilloscope

Keysight Solutions at a Glance

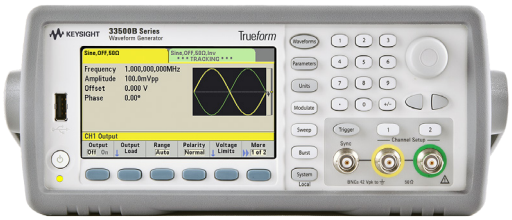
Low current measurement

Performance DMM

Simulate distorted sensor signal

Pulse function arbitrary noise generator

Generates ECG/ EEG patterns



Function/arbitrary waveform generator

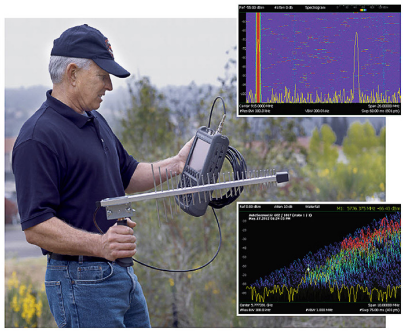
Precision low noise voltage & current sourcing

B2961A/B2962A low noise power source

Service and Maintenance

Whether inside a hospital or an outside clinic, it is critical for medical device developers and medical service providers to have the most accurate test and measurement capabilities at their fingertips, allowing them to quickly and accurately install and maintain wireless medical devices and systems to continuously address the safety of patients.

Recommended Keysight solutions

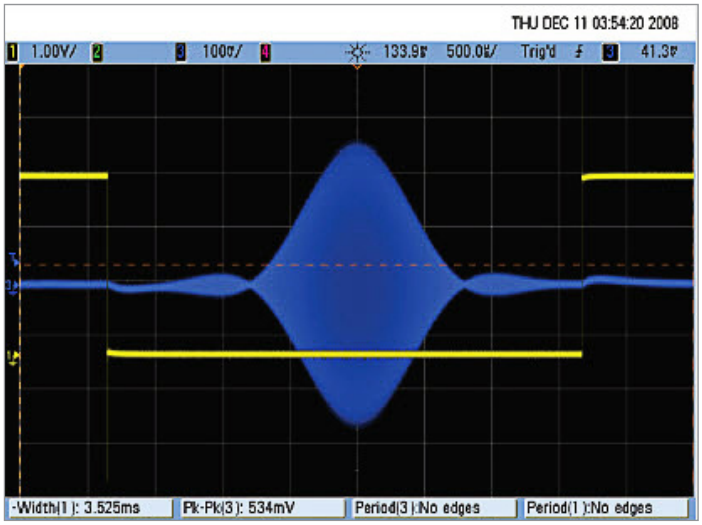


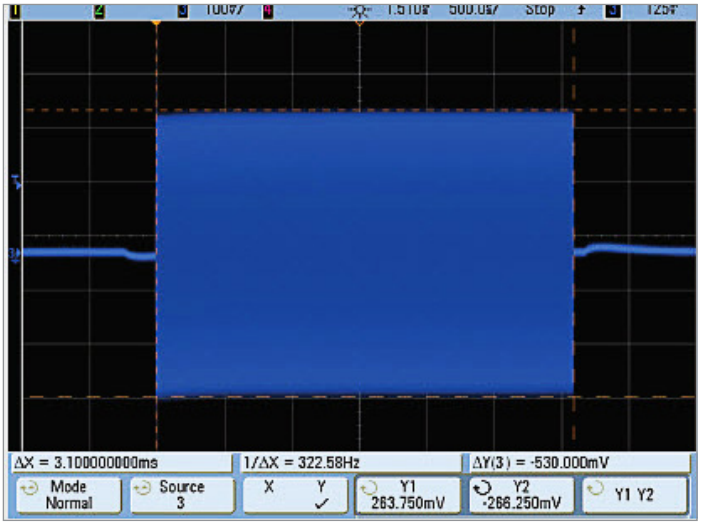
FieldFox handheld RF and microwave analyzers

These handheld solutions enable users to carry the precision of a benchtop analyzer in the palm of their hands, making it easier to install and maintain wireless medical devices and systems in hospitals and clinics. FieldFox's measurement precision enables installers to be assured that telemetry characterization will correlate with performance data from the manufacturer. The interference analysis tools enable the biomedical and clinical engineering teams to quickly pinpoint and mitigate electromagnetic interference.

RF power measurement kit

Accurate power measurements are critical for medical device designs to provide precise, safe medical analysis, as well as, fast rise time, bandwidth and reading speeds. The RF power measurement kit consists of the E4416A power meter, E9321A power sensor and a directional coupler, and is designed calibrate MRI RF amplifiers. This solution provides accuracy and intuitive measurements, displaying measured power in the preferred kW or dBm units. With one single sensor, this solution can cover a wide dynamic range from 316 W to 35,500 W (55 dB to 75.5 dB), offering more than 20 dB of usable dynamic range to support multiple types of RF platform. The E4416A (Option E22) power meter comes with measurement speeds of more than 40 readings per second and accuracies better than 5% over the operating frequency range of 10 MHz to 300 MHz, and can quickly and accurately measure the average and peak power of an excitation signal in the form of a pulse (i.e., rectangular, trapezoidal, complex sine).





Handheld oscilloscopes

The U1620A is a battery-powered handheld digital storage oscilloscope (DSO). This portable solution allows for safe and easy transportation from room to room or facility to facility. Obtain clear and detailed information with the U1620A's VGA display, or use the Scope Link software to access the handheld oscilloscope from a PC via USB connection to monitor or log data in real-time basis. The U1620A also provides 1,000,000 points per channel, a 100 times improvement in memory capacity as compared to normal DSOs.

Keysight Solutions at a Glance

FieldFox handheld RF and microwave analyzer

MRI RF power measurement kit

Handheld oscilloscope

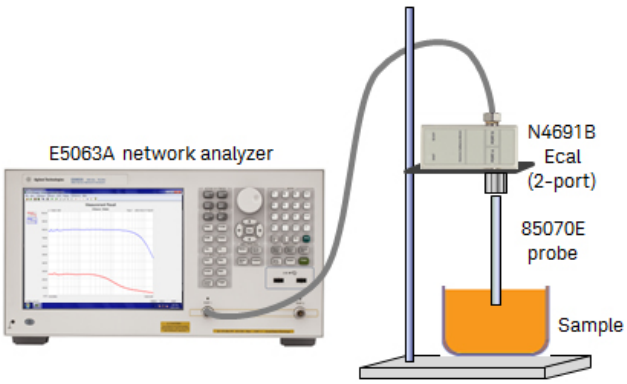
Other Solutions

Phantoms material measurement

Phantoms (designed objects that simulate various constants of biological tissues) have been widely used for antenna characteristic evaluation and specific absorption rate (SAR) measurements for mobile handsets and other wireless communication devices. The test standards require measuring dielectric properties of the phantom material, such as relative permittivity and conductivity, prior to testing SAR. Phantoms are also increasingly required for a variety of medical research purposes such as microwave imaging to detect breast cancers. It uses the difference of microwave reflectivity between normal tissue and cancer tissue due to different dielectric properties.

The coaxial probe method is best for liquid phantom materials and a typical measurement system consists of a network analyzer or impedance analyzer, a coaxial probe and software. Keysight offers a complete product solution consisting of the 85070E software with the dielectric probe kit (included), and a Keysight network analyzer or the E4991A impedance analyzer. The system provides simple, convenient and non-destructive measurements.

For more information, refer to the application brief, Materials Measurement: Phantoms (5991-4716EN).

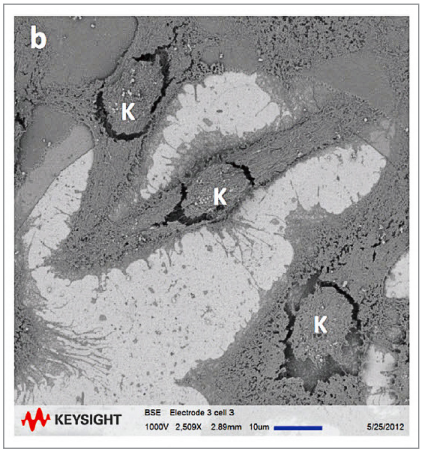


Typical system configuration

Imaging organic and biological materials with low voltage scanning electron microscopy

Scanning electron microscopy has become a popular imaging tool in different areas of science and engineering. Being able to elucidate the structure of a material at the micro-and/or the nano-scale level is indeed crucial to characterizing the material, understanding its mechanism and mode of formation and explaining/predicting its properties and performance under a given set of environmental or load conditions. Secondary electron imaging is commonly used to reveal surface topography, grain morphology and size, phase composition, and fracture profile. Keysight 8500 low voltage scanning electron microscope (FE-SEM), imaging of organic and biological materials is strongly facilitated.

For more information, refer to the application note, Imaging Organic and Biological Materials with Low Voltage Scanning Electron Microscopy (5991-0791EN).



HeLa cervical cancer cells used to study the effect of irreversible electroporation on adherent cells

Medical pendants functional test

Wireless medical alert systems typically have two simple components: a console and a pendant with a button, worn around the user's neck. In the case of a fall or other emergency, the user can summon help with the touch of a button. This sends a call over phone lines or the internet to a service representative who can call the user's emergency contacts and/or emergency medical responders, depending on the situation. Because the pendants are worn, they offer a more reliable resource than a cellular phone which may not be readily available when needed.

Circuit Check, a Keysight Solution partner, worked with medical alert system suppliers to design and deploy manufacturing test systems that ensure the accuracy and reliability of the medical alert system before leaving the production factory.
The test systems were configured into two core platforms:

- Final PCA Tester: For board test early in the production process.
- Final Functional Tester: For final, finished product test.

These platforms use the following Keysight instruments

- 34980A Multifunctional Switch/Measure Unit
- 34921A 40-Channel Armature Multiplexer for 34980A
- Y1130A Rackmount for mainframe
- N5181A RF Analog Signal Generator (with options)
- N5181A-1CM Rackmount Kit for N5181A

For more information, refer to the application brief, *Ensuring Medical Alert Pendants Are Accurate and Reliable with Modular Function Test* (5992-0294EN).

Product Solutions Summary

Interference Between Devices and Environment	Publication Number
X-Series Signal Analyzer	5992-1316EN
N6141A Embedded EMI Measurement Application	5990-6035EN
N9038A MXE EMI Receiver	5990-7422EN
6831B AC Power Source/Power Analyzer	5989-8853EN
Electromagnetic Professional (EMPro) Simulation Software	5990-4819EN
Wireless Technology Design Challenges	
X-Series Signal Source	5990-9956EN
Signal Studio and Signal Creation Software	5989-6448EN
89600 VSA Software	5990-6553EN
E4460A EXM Wireless Test Set	5991-4287EN
RF/ Wireless Components Design and Characterization	
MRI Testing Solutions	
– LCR Meters	5952-1430E
– Network Analyzer	5989-7603EN
– E5052B SSA Signal Source Analyzer	5989-6388EN
SystemVue Electronic System-Level (ESL) Design Software	5992-0106EN
PXI Solutions	5992-0600EN
Power Consumption for Battery-Operated Medical Devices	
DC Power Analyzer	5989-6319EN
Device Current Waveform Analyzer	5992-1430EN
N2820A/ N2821A High Sensitivity, High Dynamic Range Current Probes	5991-1711EN
High-Speed Medical Imagining	
High Speed Digitizer	5989-8038EN
FPGA Development Kit	5991-2424EN
Oscilloscope	5989-7650EN
Electronic Components Design and Characterization	
Digital Multimeter	5990-5315EN
Functional/Arbitrary Waveform Generators	5991-0692EN
Pulse Function Arbitrary Noise Generators	5989-6433EN
B2961A/B2962A 6.5 Digit Low Noise Power Source	5991-1388EN
Service and Maintenance	
FieldFox Handheld RF and Microwave Analyzer	5990-9783EN
RF Power Measurement Kit	5989-6240EN
Handheld Test Tools	5990-5316EN

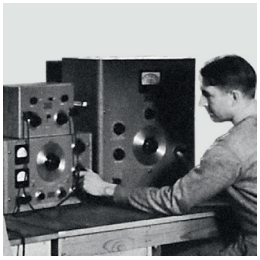
Did You Know?

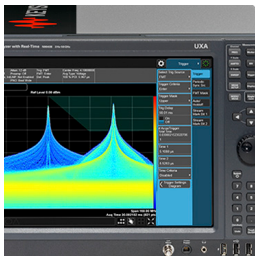
The Hawaii Center for Advanced Communications at the University of Hawaii is working with Keysight microwave instrumentation to develop new applications in healthcare and remote patient monitoring, such as accurately measuring key vital signs from a single microwave measurement.	Find out more
Dr. Elise Fear from the University of Calgary is using the Keysight PNA-X microwave network analyzer and ADS software to develop a new low-power, non-invasive solution for the detection of breast tumors.	Find out more
The University of Utah is researching new methods to restore or provide partial vision to those affected by eye diseases, using Keysight test equipment such as the wireless vector network analyzer. The heart of a solution is a device that would emulate the function of lost photoreceptors, which would be implanted in a patient's eye.	Find out more

Visit the Keysight medical solution website at **www.keysight.com/find/medical** for more information.

Evolving

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





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