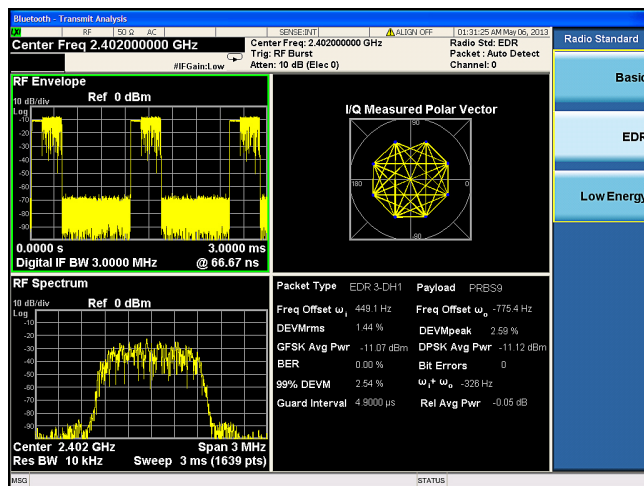
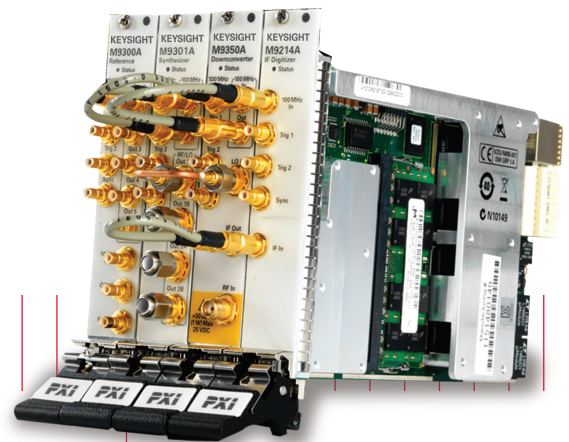


Keysight Technologies

M9081A Bluetooth®

X-Series Measurement Application for PXIe Vector Signal Analyzers

Technical Overview



- Measure **Bluetooth** RF transmitter performance, compliant to **Bluetooth** RF test specifications 2.1+EDR and Low Energy (RF-PHY.TS/4.0.0)
- Perform one-button tests with pass/fail limits per **Bluetooth** RF test specifications
- PC-based SCPI remote interface and manual user interface
- Leverage built-in context sensitive help with SCPI command reference
- Transportable license supports up to four PXI VSA channels in one mainframe

Bluetooth measurement application

Expand the capabilities of your M9391A and M9393A PXIe vector signal analyzers (PXI VSAs) with Keysight's library of measurement applications - the same applications used to increase the capability and functionality of its X-Series signal analyzers. Eleven of the most popular applications are now available for use with Keysight's new M9393A PXIe performance VSA and the M9391A PXI VSA. When you combine the raw hardware speeds of the PXI VSAs and the X-Series measurement applications for modular instruments, you can test more products in less time, while ensuring measurement continuity from design to manufacturing.

The M9081A Bluetooth measurement application transforms the PXI VSAs into standard-based Bluetooth RF transmitter testers by adding fast, one-button RF conformance measurements to help you design, evaluate, and manufacture your Bluetooth devices. The measurement application is standard-compliant to the Bluetooth Core Specification to verify your Bluetooth design with confidence and support manufacturing with a single application covering basic rate, EDR and low energy technologies for production.

Proven algorithms and a common user interface across the X-Series analyzers and modular PXI VSAs create a consistent measurement framework for signal analysis that ensures repeatable results and measurement integrity so you can leverage your test system software through all phases of product development. The Bluetooth measurement application is just one in a common library of several measurement applications. You can further extend your test assets by utilizing up to four PXI VSAs with one software license.

Keysight's X-Series applications for modular instruments also include a unique "Resource Manager" that provides direct access to PXI VSA

hardware drivers for the fastest power and spectrum-based measurements, while simultaneously using the X-Series applications for fast

modulation quality measurements and the 89600 VSA software for fast spectrum measurements.

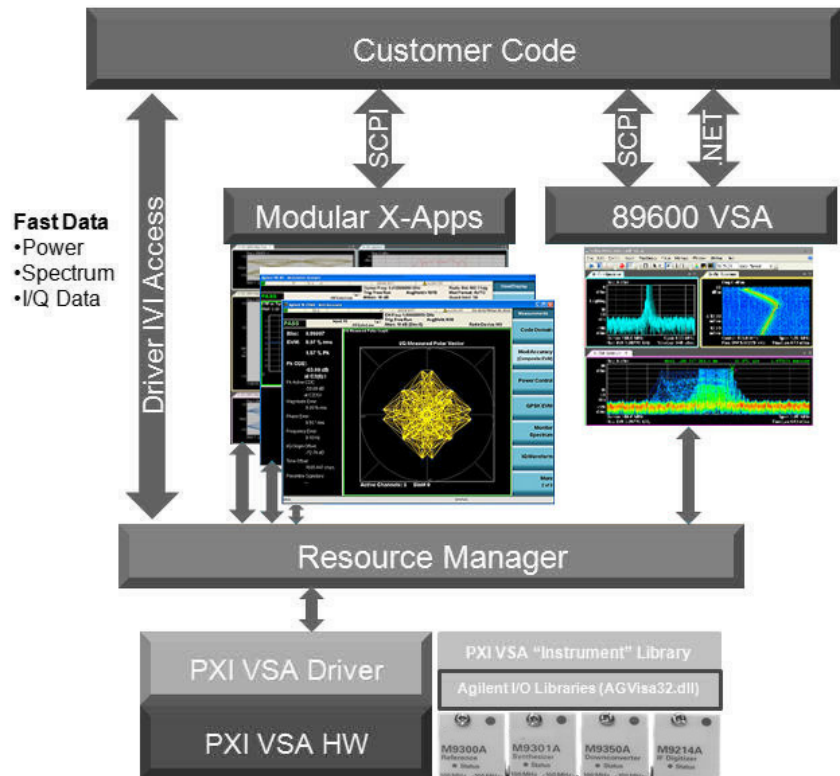
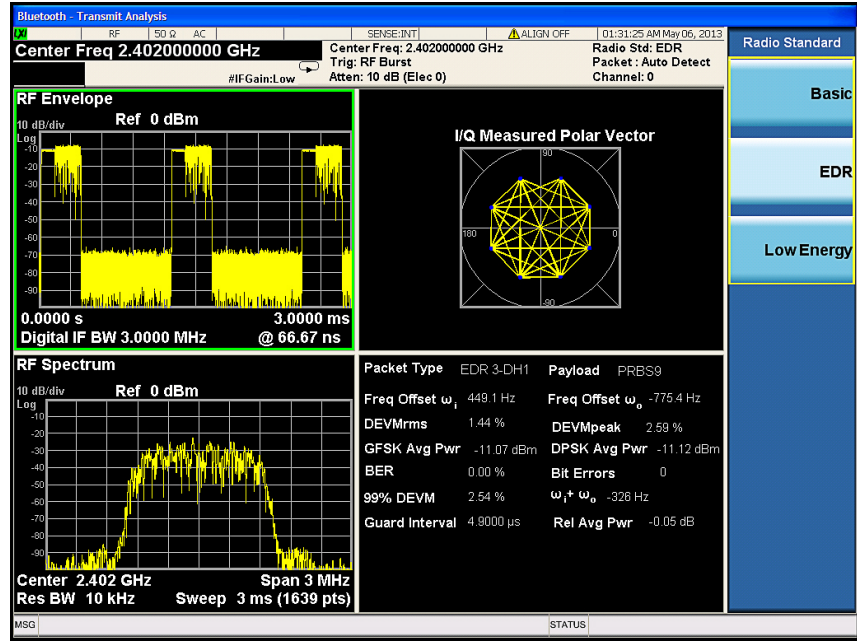


Figure 2. Resource Manager is included with all X-Series measurement applications for modular instruments.

Bluetooth technology overview

Bluetooth is an open wireless technology standard for exchanging voice and data over short distances between fixed and mobile devices, creating personal area networks (PANs) with high levels of security. **Bluetooth** wireless technology eliminates the need for interconnection cables between information appliances.

The **Bluetooth** Special Interest Group (SIG), chartered to advance and promote **Bluetooth** wireless technology, has defined a test specification for conformance testing on the RF layer.

Bluetooth uses a radio technology called frequency-hopping spread spectrum (FHSS), and the design emphasis is on very low power, extremely low cost, and robust operation in the globally unlicensed, interference-dominated RF environment of the Industry, Scientific and Medical (ISM) band at 2.4 GHz.

In Classic **Bluetooth**, which is also referred to as basic rate (BR) mode, the modulation is Gaussian frequency-shift keying (GFSK). It can achieve a gross data rate of 1 Mbit/s.

Enhanced data rate (EDR) is an enhancement to the **Bluetooth** Core Specification version 1.2 (v1.2) and is described in the **Bluetooth** version 2.0 specification. It uses $\pi/4$ -DQPSK and 8DPSK modulation giving 2 and 3 Mbit/s data transfer rates, respectively.

Bluetooth low energy (LE) technology was finalized in December 2009 by the **Bluetooth** SIG. This ultra low power **Bluetooth** technology is intended to discover new use case scenarios for tiny low power devices that were not served by existing local connectivity solutions. Two modes have been designed: single-mode and dual mode. The **Bluetooth** low energy dual-mode chips support both

Bluetooth low energy and Classic **Bluetooth** technology; single-mode chips support only **Bluetooth** low energy. The low energy wireless technology is part of the Core Specification v4.0.

Additionally, the **Bluetooth** new Core Specification version 2.1 + EDR, has been published by the SIG with security improvements, simplified pairing and power consumption. These will offer more advances in short range wireless technology and make it easier for consumers to connect.

Table 1. Key Bluetooth parameters

| | Bluetooth (Basic rate) | Bluetooth (Enhanced data rate) | Bluetooth (Low energy) |
|------------------------------|--|--|--|
| Frequency range ¹ | 2400 to 2483.5 MHz | 2400 to 2483.5 MHz | 2400 to 2483.5 MHz ² |
| Modulation | GFSK | Header: GFSK Data: $\pi/4$ -DQPSK, 8DPSK | GFSK |
| Frequency hopping | FHSS with 1600 hops/s (in normal operation) ³ | FHSS with 1600 hops/s (in normal operation) ³ | FHSS with 1600 hops/s (in normal operation) ³ |
| Duplex method | TDD | TDD | TDD |
| Channel spacing | 1 MHz | 1 MHz | 2 MHz |
| Data rate | 1 Mbps | 2 to 3 Mbps | 1 Mbps |

1. The Bluetooth specification includes a special frequency hopping pattern to provide provisions for compliance with national limitations such as those in France. The frequency range for France is 2445.4 to 2483.5 MHz and the corresponding RF channels are $f = 2454 + k$ MHz, $K = 0, \dots, 22$.
2. The Bluetooth low energy system uses center frequencies $2402 + k \times 2$ MHz ($k = 0 \dots 39$).
3. Hop speed may vary, depending on packet length

RF transmitter tests

With the PXI VSAs and the **Bluetooth** measurement application, you can perform the RF layer test procedure and specification (TSS/TP⁴).

Standard-based RF transmitter tests

The **Bluetooth** specifications are developed and licensed by the **Bluetooth** Special Interest Group (SIG). The **Bluetooth** Test Specification document contains the Test Suite Structure (TSS) and Test Purpose (TP) to test the **Bluetooth** RF layer including Enhanced Data Rate. This specifica-

tion is a basis for conformance tests of **Bluetooth** devices, giving a high probability of air interface interoperability between different manufacturer's **Bluetooth** devices. For the **Bluetooth** low energy, it is integrated into an existing Classic **Bluetooth** controller, so its architecture shares much of Classic **Bluetooth's** existing radio and functionality resulting in a minimal cost increase compared to Classic **Bluetooth**.

The Keysight X-Series **Bluetooth** measurement application refers to the following **Bluetooth** RF test specifications:

- **Bluetooth** Test Specification 1.2/2.0/2.0+EDR/2.1/2.1+DER
- **Bluetooth** Low Energy RF Test Specifications: RF-PHY.TS/4.0.0

Table 2 provides a list of tests with their test purpose identifiers and corresponding measurement applications for transmitter tests only.

Table 2. Bluetooth RF transmitter measurements and the corresponding measurements in M9081A

| Bluetooth transmitter tests | Identifier² | N/W9081A X-Series measurement application |
|---|-------------------------------|--|
| Basic rate | | |
| Output power | TRM/CA/01/C | Transmit analysis |
| Tx output spectrum -20 dB bandwidth | TRM/CA/05/C | Output spectrum bandwidth |
| Tx output spectrum - adjacent channel power | TRM/CA/06/C | Adjacent channel power |
| Modulation characteristics | TRM/CA/07/C | Transmit analysis |
| Initial carrier frequency tolerance | TRM/CA/08/C | Transmit analysis |
| Carrier frequency drift | TRM/CA/09/C | Transmit analysis |
| Enhanced data rate (EDR) | | |
| EDR relative transmit power | TRM/CA/10/C | Transmit analysis |
| EDR carrier frequency stability and modulation accuracy | TRM/CA/11/C | Transmit analysis |
| EDR differential phase encoding | TRM/CA/12/C | Transmit analysis |
| EDR in-band spurious emissions | TRM/CA/13/C | EDR in-band spurious emissions |
| Low Energy (LE) or Ultra Low Power (ULP) | | |
| Output power at NOC | TRM-LE/CA/01/C | Transmit analysis |
| Output power at EOC | TRM-LE/CA/02/C | Transmit analysis |
| In-band emission at NOC | TRM-LE/CA/03/C | LE in-band emission |
| In-band emission at EOC | TRM-LE/CA/04/C | LE in-band emission |
| Modulation characteristics | TRM-LE/CA/05/C | Transmit analysis |
| Carrier frequency offset and drift at NOC | TRM-LE/CA/06/C | Transmit analysis |
| Carrier frequency offset and drift at EOC | TRM-LE/CA/07/C | Transmit analysis |

1. Radio frequency Test Suite Structure (TSS) and Test Purposes (TP) system specifications
2. Identifier format is: (Test)/CA/NN/C, in which
 - TRM = Transmitter test
 - CA = Capability test (defines the type of testing)
 - NN = Test purpose number
 - C = Conformance test performed on dedicated Bluetooth test system

Measurement details

All of the **Bluetooth** RF transmitter measurements as defined for basic, EDR and low energy in the test specifications, as well as a wide range of additional measurements and analysis tools, are available with a press of a button (Table 3). These measurements are fully remote controllable via the IEC/IEEE bus or LAN, using SCPI commands.

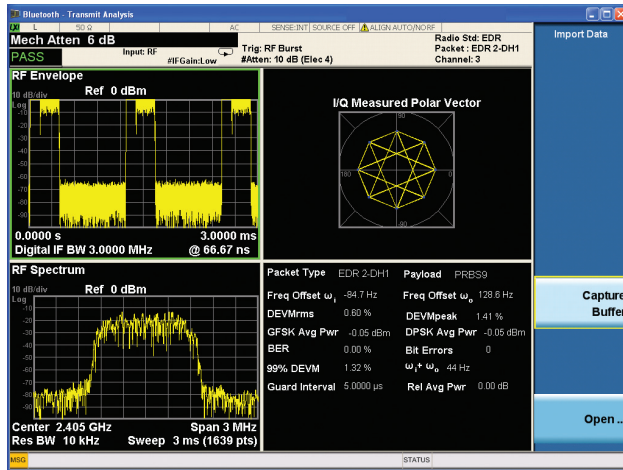


Figure 1. Transmit analysis for EDR signal

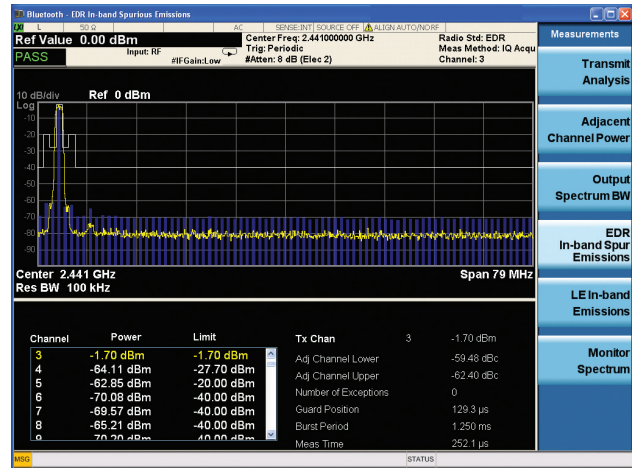


Figure 3. EDR in-band emission

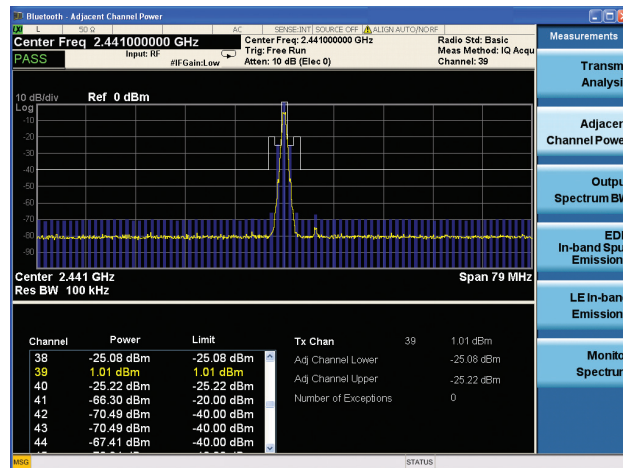


Figure 2. Adjacent channel power for basic rate Bluetooth signal

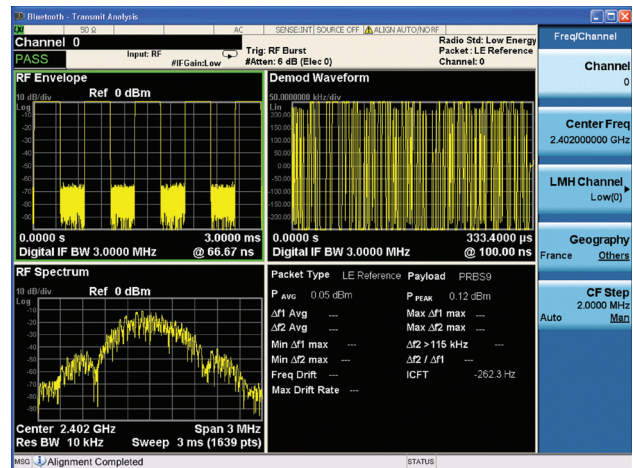


Figure 4. Transmit analysis for low energy (LE) signal

Table 3. One-button measurements provided by the M9081A measurement application

| Bluetooth Technology | Basic data rate | Enhanced data rate | Low energy |
|--|------------------------|---------------------------|-------------------|
| Transmit analysis | | | |
| Output power (in time domain) | | | |
| Peak power | • | | • |
| Average power | • | | • |
| Modulation characteristics | | | |
| $\Delta F1$ avg (11110000) | • | | • |
| $\Delta F2$ avg (10101010) | • | | • |
| Min $\Delta f1$ / $\Delta f2$ max, | • | | • |
| Max $\Delta F1$ / $\Delta F2$ max, | • | | • |
| $\Delta F2 > 115$ kHz | • | | • |
| $\Delta F2/\Delta F1$ ratio | | | |
| Initial carrier frequency tolerance (ICFT) | • | | • |
| Carrier frequency drift | | | |
| Frequency drift | • | | • |
| Max drift rate | • | | • |
| Adjacent channel power | • | | |
| Output power – 20 dB bandwidth | • | | |
| EDR transmit analysis | | | |
| Relative transmit power | | | |
| GFSK average power | | • | |
| DPSK average power | | • | |
| Relative power | | • | |
| Frequency stability and modulation accuracy | | | |
| Freq offset $\omega_i/\omega_0, \omega_i+\omega_0$ | | • | |
| RMS DEVM (differential DVM) | | • | |
| Peak DEVM | | • | |
| Differential phase decoding | | | |
| BER | | • | |
| Bit error | | • | |
| 99% DEVM | | • | |
| EDR in-band spurious emissions | | • | |
| LE in-band emissions | | | • |

Supported devices and standard version

| Device type | Bluetooth devices |
|-------------------------------------|---|
| Standard version | Bluetooth radio frequency system specification 1.2/2.0/2.0+EDR/2.1/2.1+EDR revision 2.1.E.0 - basic rate - enhanced data rate Bluetooth Low Energy RF PHY test specification (LE RF-PHY.TS/4.0.0) |
| Power classes | Class 1, class 2 and class 3 |
| Radio band | Bluetooth basic rate and EDR system: 2.400 to 2.4835 GHz ($f = 2402 + k$ MHz, $k = 0, \dots, 78$) Bluetooth low energy system: 2.400 to 2.4835 GHz ($f = 2402 + k \times 2$ MHz, $k = 0, \dots, 39$) |
| Supported standards | |
| Bluetooth basic rate | Revision 2.1.E.0 |
| Bluetooth Enhanced Data Rate | Revision 2.1.E.0 |
| Bluetooth Low Energy | LE. RF-PHY.TS/4.0.0 |

You can upgrade!

Options can be added after your initial purchase.

All of our X-Series application options are license-key upgradeable.

Measurement consistency you can trust

Did you know that X-Series measurement applications for modular instruments use the same measurement algorithms and programming commands as the bench top applications? This means you will get consistent measurement results if you use Keysight bench top and modular equipment across the product development cycle. Learn how this consistency and programming compatibility will increase the efficiency of your product development cycle.

www.keysight.com/find/measurementconsistency

Ordering information

Software licensing and configuration

- Transportable, perpetual license: This allows you to run the application using an embedded PXI PC controller or external PC, plus it may be transferred from one controller or PC to another. One software license supports up to four modular PXI VSA channels in one PXI mainframe.

Try before you buy!
Free 30-day trials of X-Series measurement applications provide unrestricted use of each application's features and functionality on your modular PXI VSA. See www.keysight.com/find/M90XA for more information.

One button transmit analysis provides multiple results
The measurement sequence performed by the analyzer can accommodate any mix of transmitter power measurements and modulation quality measurements performed on the data collected within the capture period.

The table below contains information on our transportable, perpetual licenses. For more information, please visit the product web pages.

M9081A *Bluetooth* X-Series measurement application

| Description | Model-Option |
|-------------|--------------|
| Bluetooth | M9081A-2TP |

Recommended hardware configuration

M9391A PXIe vector signal analyzer configuration

| Model number | Description | Notes |
|---------------------------|---|---|
| M9391A-F03, -F06 | 3 GHz or 6 GHz frequency range | One required |
| M9391A-B04, -B10, or -B16 | 40 MHz, 100 MHz or 160 MHz analysis bandwidth | One required. -B16 recommended for fastest spectrum measurements with 89600 VSA software Option SSA. |
| M9391A-300 | PXIe frequency reference | Recommended. |
| M9391A-UNZ | Fast tuning | Recommended. Highly recommended for fastest spectrum measurements with 89600 VSA software Option SSA. |
| M9391A-M01, -M05, or -M10 | Memory options (512 MB, 2 GB, or 4 GB) | Recommend 1 Gsa/4 GB memory |

M9393A PXIe performance vector signal analyzer configuration

| Model number | Description | Notes |
|---------------------------------|--|---|
| M9393A-F08, -F14, -F18, or -F27 | 8 GHz, 14 GHz, 18 GHz, or 27 GHz frequency range | One required |
| M9393A-B04, -B10, or -B16 | 40 MHz, 100 MHz or 160 MHz analysis bandwidth | One required. -B16 recommended for fastest spectrum measurements with 89600 VSA software Option SSA. |
| M9393A-300 | PXIe frequency reference | Recommended. |
| M9393A-UNZ | Fast tuning | Recommended. Highly recommended for fastest spectrum measurements with 89600 VSA software Option SSA. |
| M9393A-M01, -M05, or -M10 | Memory options (512 MB, 2 GB, or 4 GB) | Recommend 1 Gsa/4 GB memory |

Related literature

- *N9081A & W9081A Bluetooth, Self-Guide Demonstration*, Literature Number 5990-6161EN
- *Bluetooth Measurement Fundamentals, Application Note*, Literature Number 5988-3760EN
- *Verifying Bluetooth Baseband Signals using Mixed Signal Oscilloscopes, Application Note AN 1333-3*, Literature Number 5988-2181EN
- *Keysight E4438C Signal Studio for Bluetooth, Application Note 1421*, Literature Number 5988-5417EN
- *Keysight Innovative Solution for Testing Bluetooth Enhanced Data Rate Products, Product Overview*, Literature Number 5989-3055EN
- User's and Programmer's Reference Guide is available in the library section of the N9083A and W9083A product pages.
- *M9391A PXIe Vector Signal Analyzer Datasheet*, literature number 5991-2603EN
- *M9391A & M9381A PXIe Vector Signal Analyzer & Generator Configuration Guide*, literature number 5991-0897EN
- *X-Series Measurement Applications for Modular Instruments Brochure*, literature number 5991-2604EN

Web

- Product page:
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- X-Series measurement applications:
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