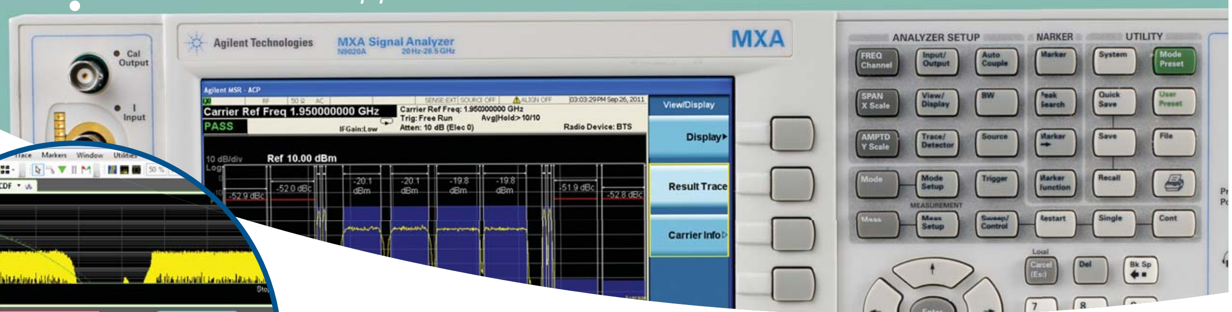
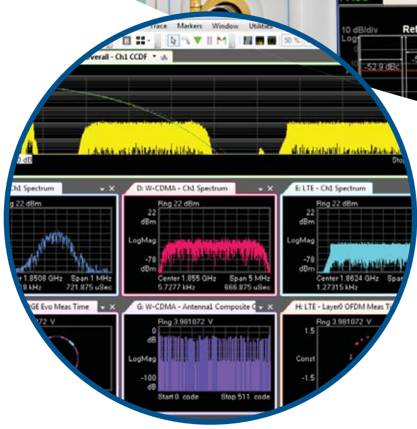
Solutions for

Testing Multi-Standard Radio Base Stations

Achieving Fast, Accurate and Efficient Testing of MSR Base-Station Transmitter Devices

Application Note





Overview

As cellular telecommunications networks have migrated from 2G to 3G, base stations have adapted accordingly. As cellular networks continue their migration to 3.9G and even 4G, base transceiver station (BTS) transmitters are being forced to transition into something new altogether. What once was a single-carrier, narrowband design for GSM/TDMA (2G) networks has now become a multi-carrier wideband design (3/3.5G), and will soon give way to a design characterized by a software-defined radio. These next-generation base-station transmitters and receivers, will support wider bandwidths and include not only multiple carriers (MCs) of a single radio format, but also multiple formats in one transmitter path.

A prime example of this is the Multi-Standard Radio (MSR) base station, which can simultaneously transmit different radio access technologies (RATs) from a single unit. As an example, GSM, W-CDMA and LTE MCs can now be simultaneously transmitted from a single MSR base-station unit. The ability of the MSR base-station to support multiple formats in a cellular network is critical to driving down both base-station size and cost. Because of this, it is expected to enable a smooth and seamless migration from the widely deployed 2/3G radio formats toward 3.9G (e.g., LTE) and even 4G (e.g., LTE-Advanced) technologies.

Problem

Adoption of MSR MC configurations come at a price; namely, having to deal with testing MSR base-station transmitters and receivers. The challenge is conformance testing of MSR base stations in accordance with the 3GPP Release 9 (TS37 series) standard.

The TS37 document covers the MSR MC combinations of 3GPP frequency-division duplex (FDD) and time-division duplex (TDD) formats. In contrast to receiver conformance testing requirements, which are similar to those of each single format, transmitter conformance tests must be performed under MSR MC allocating scenarios. The TS37 document defines MSR RF test requirements, specifying measurement of channel power, modulation quality (EVM), frequency error, spurious emissions, and spectrum emissions mask (SEM) when testing MSR MC-active configurations. Measurement of adjacent channel leakage ratio (ACLR), occupied bandwidth and time alignment between transmitter branches is required when testing each single-format single carrier. These measurements are not required to test under the MSR MC-active configuration, but base-station manufacturers may want to test some of them under this configuration anyway as it more closely resembles a realistic use scenario and provides test efficiency for covering all available formats that the base station-under-test supports.

Solution

Testing of MSR base-station transmitter devices comprises both spectrum and power measurements, as well as, analysis of carrier modulation quality under MSR MC configurations. When making spectrum and power measurements, utilization of a swept spectrum or signal analyzer (SA) measurement approach is generally preferable. It can be used in much the same way as when measuring single-carrier transmitter devices. Fast Fourier transform (FFT) analysis using a vector signal analyzer can also be used. However, for out-of-band or out-of-channel measurements such as spurious emissions, ACLR and SEM, swept analysis is more appropriate since the frequency spans are typically much wider than those for measurement of a single carrier.

When analyzing the modulation quality of each carrier (e.g., the EVM) under MSR MC configurations, two different approaches can be employed. With the first approach, each carrier is acquired sequentially with a narrow bandwidth SA front-end. This approach is both straightforward and cost effective, assuming that the MSR signal-under-test is an arbitrary, repetitive test-mode signal. With the second approach, all carriers are simultaneously acquired with a wide bandwidth SA front-end. While the SA hardware with the wide bandwidth input can be expensive, this approach enables simultaneous capture of all carriers for troubleshooting instantaneous events. The total throughput between each approach depends on how the test sequence algorithm is designed or programmed.

When performing spectrum and power measurements or analyzing carrier modulation quality, use of appropriate signal analysis instrumentation is essential. MSR product developers face all the usual design problems of single-carrier systems, along with tremendous new potential for adverse interactions between dissimilar signals. This demands new tools that can provide new kinds of insights into signal characteristics. The instrumentation must, therefore, be flexible enough to handle the complexity of today's range of standards, able to quickly adapt to changing standards' requirements and support the wide carrier bandwidths of new and emerging standards (e.g., 4G). It must also offer the level of performance necessary to ensure accurate measurements.

Prime examples of instrumentation featuring this mix of capabilities are Agilent Technologies' 89600 Vector Signal Analysis (VSA) software and the X-Series signal analyzers. The 89600 VSA software provides superior general-purpose and standards-based signal evaluation, and troubleshooting tools that engineers can use to dig into signals and gather the data they need to successfully troubleshoot physical layer signal problems. Its multi-measurement capability supports acquisition of simultaneous and sequential carriers from wide-band single or multiple hardware instruments like the X-Series signal analyzer. With this capability, the 89600 VSA can perform testing on over 70 different modulation formats and allow any combination of currently offered measurements (e.g., time, frequency and modulation). The software is compatible with over 30 Agilent signal analyzers, scopes and logic analyzers.

The X-Series signal analyzers represent an evolutionary approach to signal analysis that is future-ready—with a scalable hardware architecture and open Windows® XP Professional software platform—and spans instrumentation, measurements and software (Figure 1). The N9083A MSR measurement application is an embedded application running on the X-Series signal analyzers that allows engineers to make RF conformance measurements in accordance to 3GPP Release 9 standard (Figure 2). The analyzers' swept SA-based measurement enables fast, one-button measurements (e.g., ACP, SEM, and spur) as defined in 3GPP TS37. Using the X-Series MSR measurement application, transmitter tests can be performed on any combination of LTE FDD, W-CDMA/HSPA/HSPA+ and GSM/EDGE/EDGE Evolution multi-RAT signals.

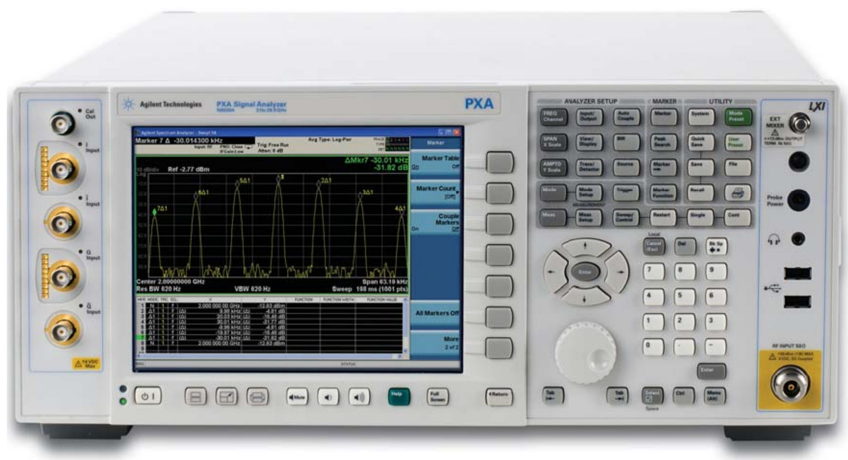


FIGURE 1. Agilent's X-Series signal analyzers comprise the CXA, EXA, MXA, and PXA. As the highest-performance X-Series analyzer, the PXA delivers exceptional performance that reduces measurement uncertainty and reveals new levels of signal detail, starting with up to 75 dB spurious-free dynamic range at the 160-MHz analysis bandwidth. Use of Noise Floor Extension technology, shown here, expands the PXA's dynamic range, allowing engineers to measure low-level signals approaching the theoretical kTB noise floor.

Both the 89600 VSA with its multi-measurement capability and the X-Series signal analyzers with their embedded MSR measurement application provide critical test capabilities for implementing MSR base stations. The 89600 VSA software is ideal for R&D users performing verification and R&D troubleshooting, while the X-Series analyzers running the MSR measurement application, are well suited for manufacturing users performing conformance tests to the 3GPP specification.

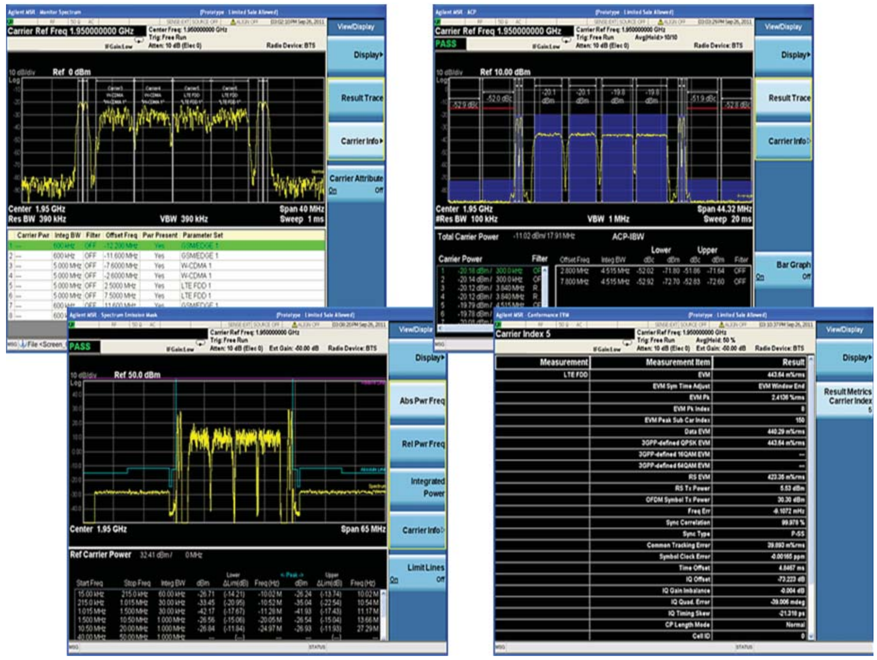
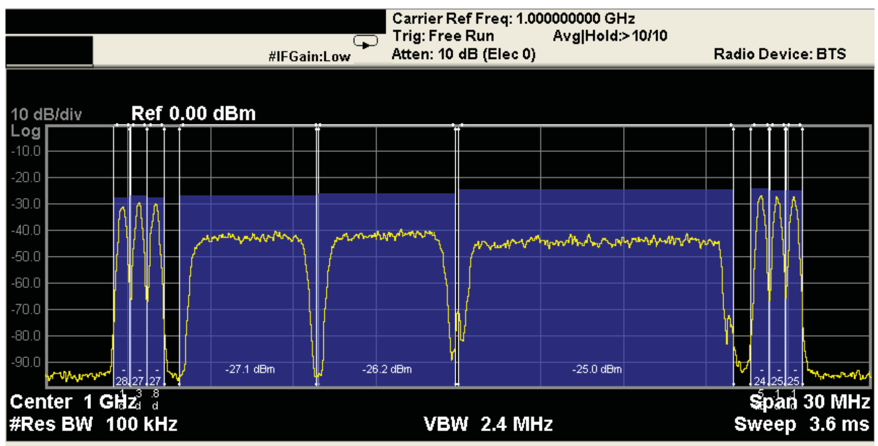


FIGURE 2. As a 3GPP-dedicated MSR signal analysis application, the N9083A MSR measurement application enables fast one-button measurements per 3GPP TS37.

Example: Spectrum Measurements

As an example of a spectrum measurement for MSR, consider a multi-carrier channel power measurement with a signal-under-test of the 3GPP Test Configuration 4c (TC4c) with an assumed base-station transmitter RF bandwidth of 25 MHz. The configuration includes a total of 6 GSM/EDGE MCs with 3 each at the lowermost and uppermost frequency offsets in the RF bandwidth, 2 W-CDMA carriers and 1 LTE FDD 10 MHz carrier. Figure 3 shows this example using the swept-SA based MSR channel power measurement employing the embedded MSR measurement application running on an X-Series signal analyzer. Alternatively, the measurement can be made by manually configuring a swept-SA with an appropriate resolution bandwidth (e.g., 100 kHz) that is narrow enough to distinguish GSM carriers and add integrated band-power markers for each carrier-of-interest.



Total Power -16.51 dBm / 23.6MHz | Total PSD -75.87 dBm / Hz | RF-BW 24.80 MHz

	Carrier Pwr	Integ BW	Filter	Offset Freq	Measure	Parameter Set
1	-28.06 dBm	600 kHz	OFF	-12.200 MHz	On	GSM/EDGE 1
2	-27.26 dBm	600 kHz	OFF	-11.600 MHz	On	GSM/EDGE 1
3	-27.80 dBm	600 kHz	OFF	-11.000 MHz	On	GSM/EDGE 1
4	-27.09 dBm	5.000 MHz	OFF	-7.6000 MHz	On	W-CDMA
5	-26.25 dBm	5.000 MHz	OFF	-2.6000 MHz	On	W-CDMA
6	-24.96 dBm	10.000 MHz	OFF	5.0000 MHz	On	LTE FDD 1
7	-24.49 dBm	600 kHz	OFF	11.000 MHz	On	GSM/EDGE 1
8	-25.12 dBm	600 kHz	OFF	11.600 MHz	On	GSM/EDGE 1
9	-25.09 dBm	600 kHz	OFF	12.200 MHz	On	GSM/EDGE 1

FIGURE 3. Shown here is a swept-spectrum view of a carrier-channel power measurement for one of the MSR conformance testing defined in 3GPP TS37.141.

Example: Measuring Digital Modulation Quality

When analyzing the modulation quality of each carrier under MSR MC configurations, two approaches can be employed: sequential carrier acquisition via a narrow bandwidth SA front-end, or simultaneous carrier acquisition using a wide bandwidth SA front-end. The X-Series signal analyzer, with its N9083A X-Series MSR measurement application, can be used for the first approach, while the 89600 VSA multi-measurement capabilities can be used for the second approach.

For transmitter conformance testing, measurements are made with an arbitrary repetitive-patterned waveform from the device-under-test, such as Test Models (TMs). The 3GPP TS37.141 MSR base station conformance test specification defines several MSR MC allocating patterns for testing called Test Configurations (TCs). To perform transmitter conformance testing using the narrow bandwidth hardware front-end approach, the test engineer simply captures each single carrier on the X-Series analyzer. Modulation quality measurements are then made using the N9083A MSR measurement application.

In an R&D environment, using a wide bandwidth hardware front-end to simultaneously acquire all active MCs of interest is preferable. While this approach may be more costly than using a narrow bandwidth hardware front-end, it is a worthwhile expenditure when verifying and troubleshooting instantaneous events happening in MSR radio devices, such as for functional design validation and real system operating tests (Figure 4). Here, EVM measurement of each carrier is made separately by taking out each carrier from the acquired wideband waveform. The captured sample includes all active carriers that are truly simultaneous events with one other.

Using the 89600 VSA software with its multi-measurement capability, two use cases for carrier acquisition are supported. In the first case, carriers are acquired simultaneously and multiple, simultaneous measurements performed using an X-Series signal analyzer. In the other case, multiple independent analyzer front-ends are used to acquire carriers and then perform loosely synchronized measurements at the same/different frequencies, spans, formats and so on, providing the engineer access to unlimited bandwidth.

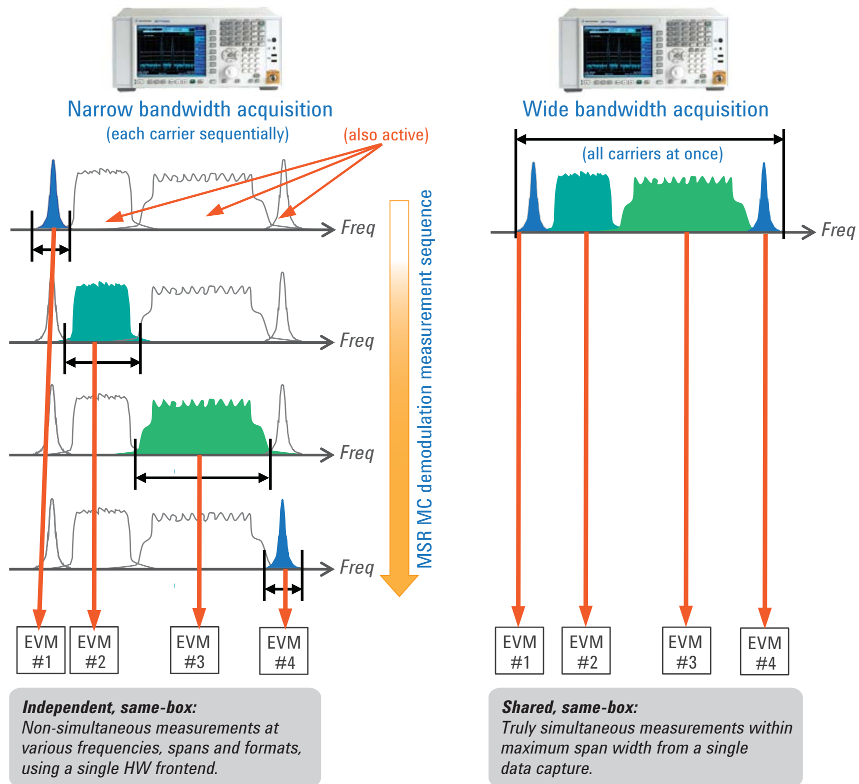


FIGURE 4. This image compares the use of sequential acquisition of each carrier using narrow bandwidth hardware on the left with the use of simultaneous acquisition of all carriers using wide bandwidth hardware on the right, for modulation analysis.

Summary of Results

The MSR base station, with its ability to support multiple RATs, will provide a cost-effective deployment for next-generation high-speed mobile broadband, video and web application services. Ensuring successful deployment, however, requires an accurate and efficient way of testing MSR base-station transmitter devices. With their outstanding performance and flexibility, the 89600 VSA software with its multi-measurement capability and the X-Series signal analyzers with their embedded MSR measurement application, are now providing MSR developers with the comprehensive test capabilities they need to meet this challenge head on.

The Power of X

The Agilent X-Series signal analyzers are key products in Agilent's comprehensive Power of X suite of test products.

The Power to Accelerate Next-Generation Wireless

You face increasing technical and operational complexity. Agilent's X Platforms help you anticipate these growing complexities so you can accelerate your ability to achieve both engineering and business goals faster.

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Related Applications

- LTE-FDD
- W-CDMA/HSPA+
- GSM/EDGE/EDGE Evolution

Related Agilent Products

- N7109A Multi-Channel Signal Analyzer
- N7624B Signal Studio for LTE/LTE-Advanced
- SystemVue System Design Software
- MXG Vector Signal Generator

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