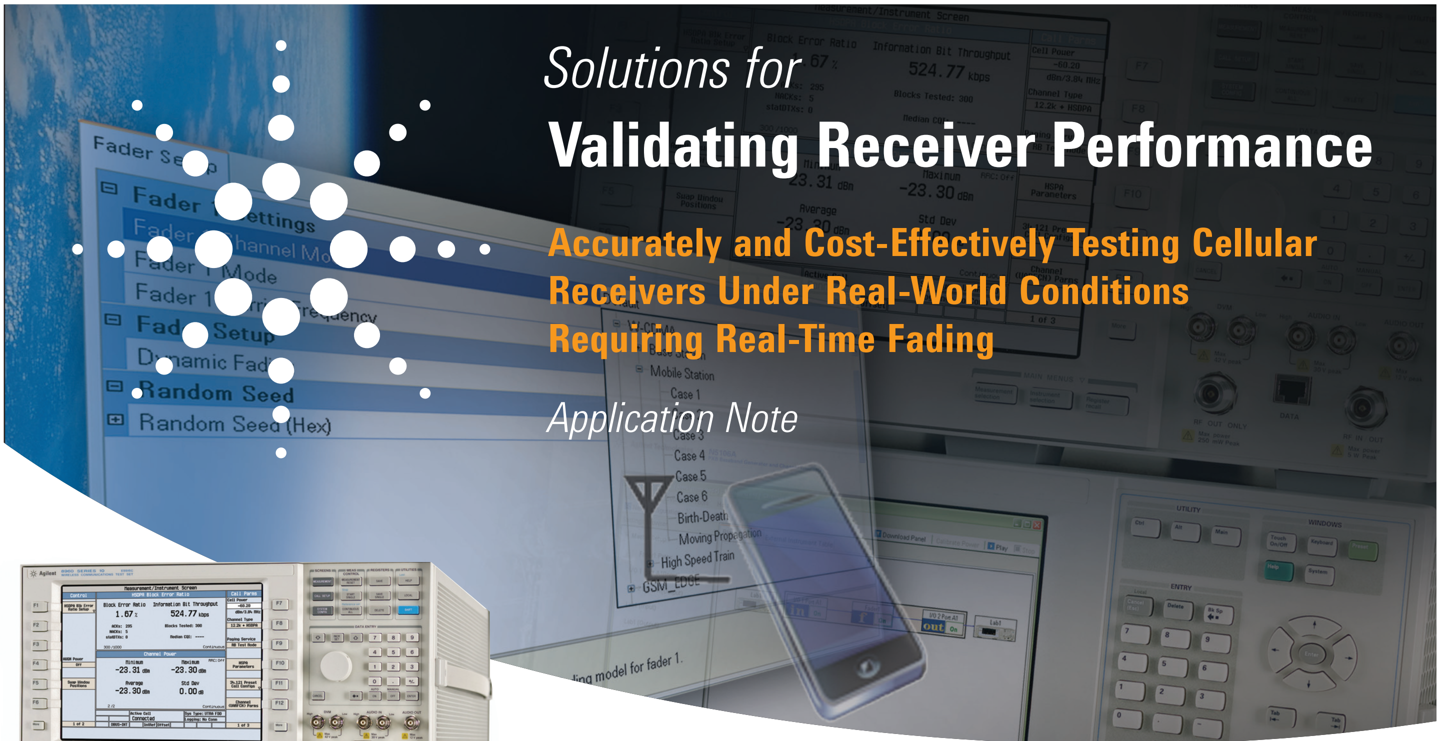
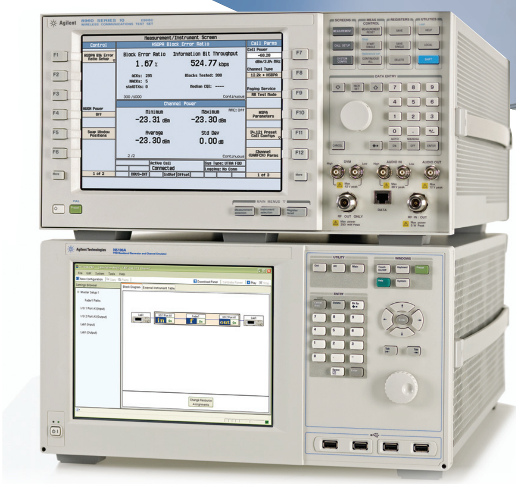


Solutions for

Validating Receiver Performance

Accurately and Cost-Effectively Testing Cellular Receivers Under Real-World Conditions Requiring Real-Time Fading

Application Note



Overview

Validating the performance (e.g., FER/BER/BLER) of a cellular radio receiver under realistic conditions is a critical task for any mobile phone designer or R&D engineer today. Such testing is used for pre-conformance test, as well as to verify how a receiver will perform in the real world, early in the design cycle when any problems are easier to find and fix.

A key factor complicating this task is that signal quality at the receiver's antenna is far from ideal. The degradation of signal quality is the result of the transmitted wave propagating through the atmosphere to the receiver. In the ideal world, the signal would follow one path and arrive at the receiver with little attenuation; however, this is rarely the case. Instead, the signal is reflected, diffracted and scattered from objects in the environment. These multiple paths add constructively or destructively, causing random and rapid fluctuations in the received signal amplitude. If the transmitter or receiver is moving, the signal will also be spread in the frequency domain due to the Doppler effect. In addition to these multipath effects, there is a wide array of competing signals (e.g., atmospheric noise) hitting the antenna.

Problem

Modern communications receivers employ a broad range of techniques to combat fading conditions including antenna diversity, Rake receivers, channel equalization, and data encoding and interleaving. To ensure the receiver is robust enough to provide reliable communications under fading conditions, engineers rely on channel simulation often performed using expensive, dedicated RF faders like Spirent's SR5500 wireless channel emulator or Elektrobit's C8 Propsim multi-channel emulator.

While such tools can comprehensively predict the performance of receivers in response to real-world conditions, they do present some challenges. Dedicated RF faders perform RF to RF fading with fairly simple up and down conversion using a single local oscillator (LO). Consequently, the input signal power has to be fairly high, and the insertion loss associated with having the fader in the path must be compensated with external amplification. This translates into a requirement for extra power at the transmitter. Additionally, since broadband amplifiers are difficult to obtain, RF faders tend to offer a limited range of power and banded frequency ranges. For R&D engineers developing and integrating robust receivers, the challenge is clear: to find a solution that offers performance comparable to that of dedicated RF faders, but that is much more repeatable, versatile and easier to use.

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Solution

Accurately and cost-effectively testing receiver performance under realistic channel conditions including real-time fading, requires a versatile solution. This solution must be able to meet the needs for demanding channel emulation and simulate both large- and small-scale fading scenarios with wide bandwidths. The solution must be able to:

- Keep up with evolving test needs and cost-effectively validate receiver performance. By utilizing general-purpose test equipment, the solution can address more test configurations and radio formats. Doing so also reduces equipment cost and improves asset utilization across multiple R&D stages.
- Provide accurate, repeatable results. An all-digital channel emulator can eliminate unnecessary signal conversions and external equipment. It also maintains RF signal quality, while realizing performance comparable to that of more expensive RF faders.
- Reduce setup complexity and test time. A solution with features like easy one-button channel (fading) model setup and fast, automated power calibration to RF can significantly decrease setup complexity and enable faster testing. One that's built with a modular hardware design also helps by allowing for on-site upgrades as standards and test needs evolve.

One solution that meets this criterion is Agilent Technologies' N5106A PXB baseband generator and channel emulator with its direct digital connection to the 8960 wireless communications test set (Figure 1). The PXB, an all-digital channel emulator, combines multi-format baseband generation real-time fading and signal capture in a single box, enabling comprehensive diagnostics of receiver signal processing components and devices. The 8960 can be used for wireless device development, manufacturing and repair of all major 2G/3G wireless technologies. Working together, these general-purpose instruments offer a cost-effective, digitally accurate, 2G/3G cellular fading solution for R&D engineers validating receiver sensitivity of wireless devices under real-world signal conditions.

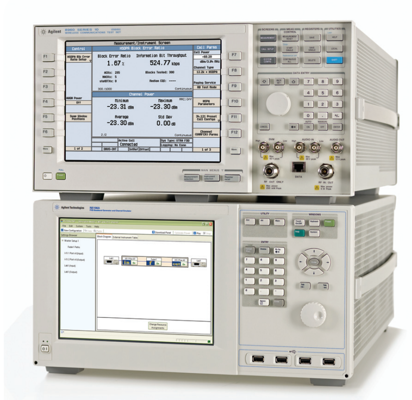

FIGURE 1: *Agilent's PXB provides up to six baseband generators, up to eight faders and more than 20 calibrated configurations up to 4x2 MIMO, which can be re-configured in seconds. The 8960 provides test solutions for mobile devices across the entire lifecycle on a single platform.*

The PXB's fading capability with the 8960 supports real-time fading for W-CDMA/HSPA, GSM/GPRS/EGPRS, cdma2000® and 1xEV-DO technologies. It also supports multiple test configurations including: single-channel fading (SISO), single channel with custom interferers, dual channel for soft handover test, and 1x2 receive diversity (Figures 2 and 3). Being able to test many different radio formats and test configurations drastically drives down the cost of validating receiver performance. Cost savings also come from the reduced setup and test time offered by the PXB and 8960 relative to other commercially available fading solutions. Moreover, the PXB's modular design enables easy, on-site upgrades, while its one-button fading models reduce setup complexity.

The direct digital connection between the PXB and 8960 ensures highly repeatable measurement results and the digital accuracy today's R&D engineers demand. It also eliminates unnecessary signal conversions and maintains the 8960's RF signal quality with automated power calibration that takes just seconds to complete. With such functionality, the PXB's 8960 fading capability is able to offer engineers the performance of expensive RF faders, but at a much lower price point and with reduced setup and test time.

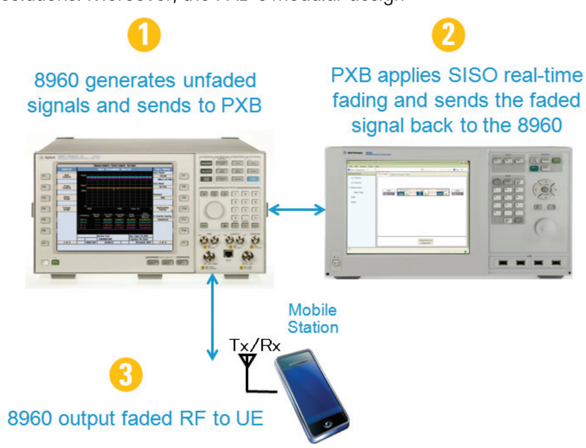

FIGURE 2: *With the single-channel (SISO) test configuration, single-channel fading is applied to the 8960 for user equipment testing.*

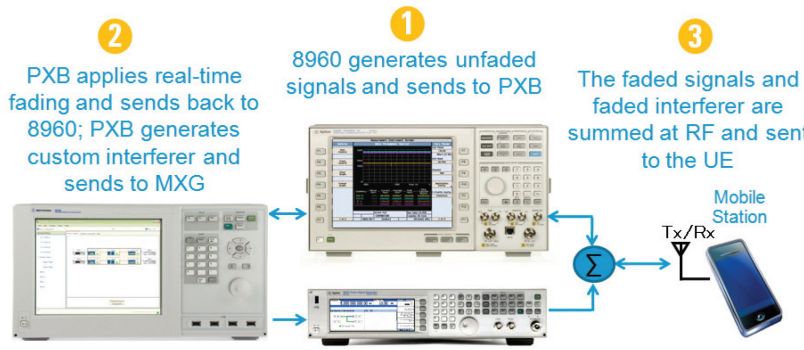

FIGURE 3: *With the single channel with custom interferer test configuration, the PXB applies real-time fading to the 8960 and generates custom interferers.*

Example: Testing to the W-CDMA Standard

Consider that the PXB with 8960 fading is used to perform the BLER test on a W-CDMA mobile phone receiver according to Section 7.3 (Demodulation of DCH in multipath fading propagation), 7.4 (Demodulation of DCH in moving propagation) and 7.5 (Demodulation of DCH in birth-death propagation condition) of the 3GPP TS 34.121-1 specifications. The tests are performed using the single-channel fading test configuration depicted in Figure 2. The block diagram used by the PXB is shown in Figure 4. The BLER measurement runs on the 8960.

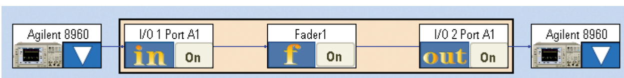

FIGURE 4: *Shown here is the PXB user interface displaying block diagram for the SISO fading setup.*

The Fader1 block on the PXB can be set up to apply fading according to predefined standards-based channel models or can be modified for a customized channel model. Figure 5 shows the predefined options for W-CDMA mobile station standards-based channel models.

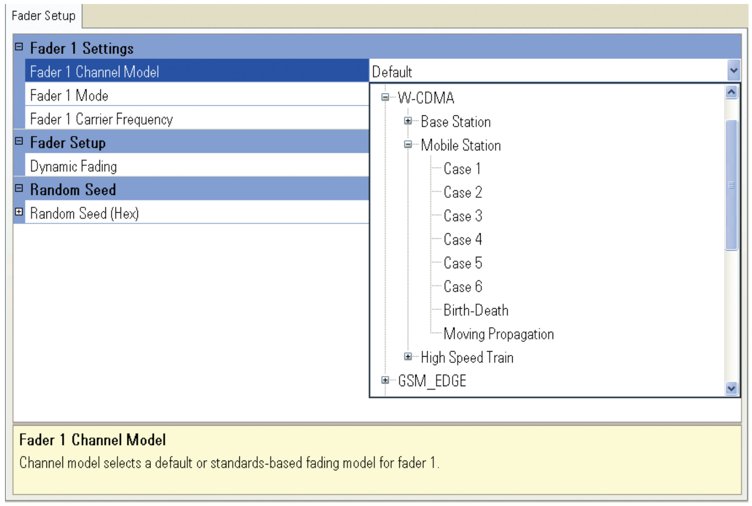

FIGURE 5: *Shown here are predefined mobile station fading models for W-CDMA.*

Based on the channel model chosen, a table showing the fader paths is automatically populated on the PXB. Figure 6 shows the fader paths defined for W-CDMA Mobile Station Case 6. The cases for propagation conditions for multipath fading environments are specified in 3GPP TS 34.121-1 Annex A Table D.2.2.1. Additional paths can be added for customized channel models.

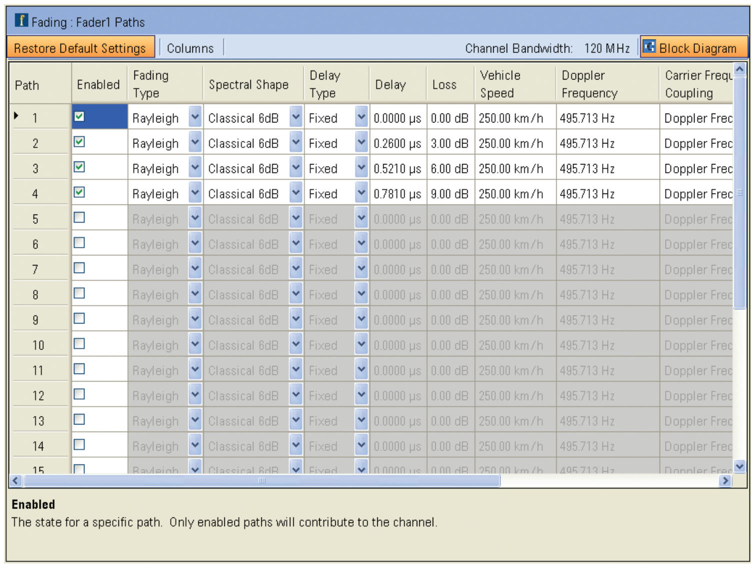

FIGURE 6: *The fader path table for W-CDMA Mobile Station Case 6.*

In each test case, the PXB with 8960 fading demonstrated fading performance similar to other commonly used channel emulators and fully satisfied the performance specification in 3GPP TS 34.121-1. For more details on the performance of the PXB versus RF fading solutions, please see the application note at **http://cp.literature.agilent.com/litweb/pdf/5990-5975EN.pdf**. Figure 7 shows the results of this W-CDMA test case for the multipath fading test (section 7.3) in 3GPP TS 34.12. The blue and green highlighted text shows the results for two different phones that both pass the BLER performance specifications defined by the standards.

Table 7.3.1.11: DCH parameters in multi-path fading propagation conditions (Case 1)

Parameter	Test 1	Test 2	Test 3	Test 4	Unit
Phase reference	P-CPICH				
$\hat{I}_{or}/I_{oc}$	9,6				dB
I_{oc}	–60				dBm / 3,84 MHz
Information Data Rate	12,2	64	144	384	kbps

Table 7.3.1.12: DCH requirements in multi-path fading propagation conditions (Case 1)

Test Number	$\frac{DPCH\_E_c}{I_{or}}$	BLER
1	–14,9 dB	10^{-2}
2	–13,8 dB	10^{-1}
	–9,9 dB	10^{-2}
3	–10,5 dB	10^{-1}
	–6,7 dB	10^{-2}
4	–6,2 dB	10^{-1}
	–2,1 dB	10^{-2}

Test Number	Data rate (kbps)	DPCH_E/ Ior	BLER phone 1	BLER phone 2	SNR (dB)
		-17.9	1.70%	1.72%	9.6
		-14.9	0.30%	0.30%	9.6
1	12.2	-9.9	0.08%	0.00%	9.6
		-13.8	2.00%	2.32%	9.6
		-9.9	0.13%	0.24%	9.6
2	64	-8	0.05%	0.16%	9.6
		-10.5	1.63%	2.40%	9.6
		-6.7	0.30%	0.25%	9.6
3	144	-3	0.05%	0.03%	9.6
		-6.2	2.45%	3.22%	9.6
		-2.1	0.43%	0.75%	9.6
4	384	-1	0.08%	0.40%	9.6

FIGURE 7: *In this example, the PXB with 8960 fading (SISO) is used to test a W-CDMA receiver to Section 7.3 (Demodulation of DCH in Multipath Fading Propagation) of the 3GPP TS 34.121-1 specification.*

Summary of Results

While dedicated RF faders are traditionally used for validating receiver performance, modern communication receivers demand a more cost-effective, digitally-accurate solution. The PXB is a comprehensive diagnostic toolset for designing and verifying receivers. Its direct digital connection to the 8960 makes fading test much more cost-effective and accurate, while also reducing power calibration and decreasing system setup time. Together, the PXB and 8960 solution offer comparable performance to dedicated RF faders along with the digital accuracy and cost reduction critical to today's R&D engineers.

The Power of X

The Agilent N5106A PXB baseband generator and channel emulator is a key product in Agilent's comprehensive Power of X suite of test products. These products grant engineers the power to gain greater design insight, speed manufacturing processes, solve tough measurement problems, and get to market ahead of the competition.

Offering the best combination of speed and scalability, and created and supported by renowned worldwide measurement experts, Agilent's X products are helping engineers bring innovative, higher-performing products to emerging markets around the globe.

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Related Applications

- LTE and WiMAX™ MIMO receiver test
- GPS and A-GPS receiver verification test
- Digital video receiver test
- 2G/3G packet data performance for wireless devices
- Cellular receiver and transmitter test in accordance to 3GPP and 3GPP2 specifications

Related Agilent Products

- MXG Signal Generators
- ESG Signal Generators
- E6701H GSM/GPRS Lab Application
- E6702D cdma2000 Lab Application
- E6703G W-CDMA/HSPA Lab Application
- E6706D 1xEV-DO Lab Application

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