Solutions for

MIMO Receiver Test

Accurately Testing MIMO Receivers Under Real-World Conditions

Application Note

Overview

Today's wireless mobile devices face a common challenge—to match the data capacity of their wired counterparts. Multiple-Input Multiple-Output (MIMO), a smart antenna technology promising higher data rates with increased spectral efficiency and increased data throughput without additional bandwidth or transmit power, is helping the mobile communications industry achieve this goal. Since commercial wireless systems operate in high multipath environments, they benefit greatly from the multipath characteristics of MIMO antenna systems.

Despite its appeal, MIMO is very complex. Ensuring its optimal operation requires the R&D engineer to accurately test the MIMO receiver once it's implemented in a wireless system. A primary challenge here lies with fading, which degrades system performance in Single-Input Single-Output (SISO) systems, but has the opposite affect in MIMO systems. To take full advantage of MIMO's improvement in system throughput, the engineer must accurately model the system's wireless channels to better understand the effects of antenna spacing, polarization, radiation pattern, and angular spread. These four key phenomena directly affect channel correlation in a MIMO system and therefore impact system throughput. With this information, R&D engineers can accurately characterize how a MIMO receiver will behave under real-world conditions.

Problem

The benefits of MIMO technology come at the cost of increased complexity. For the R&D engineer trying to develop and integrate robust MIMO receivers, that translates into a key challenge: how to accurately test the receivers under real-world conditions and early enough in the design cycle to easily find and fix any problems. Testing MIMO receivers directly in a "real" wireless environment is neither effective nor practical due to factors like channel sensitivity and mobility requirements. Other solutions are available, but must be augmented with third-party faders, an approach that leads to an extensive manual power calibration problem stemming from poor power accuracy. Today's R&D engineers demand a better alternative to MIMO receiver test—one that is specifically designed to handle MIMO complexity and can adequately simulate real-world conditions.

Agilent Technologies

Solution

It is now possible to quickly and accurately test MIMO receivers under real-world conditions using a specialized solution that marries the signal source, the noise source and the fader together in a fully-integrated solution. In contrast to solutions offering signal generation only, this fully-integrated solution provides a highly versatile platform for testing standards-based MIMO receivers (e.g., LTE and WiMAX™) that enables quick and accurate isolation of issues early in the lifecycle. For today's R&D engineers, the benefits of such a solution are obvious—reduced development cycle time, minimized design uncertainty and equipment and lab setup time, maximized equipment investment and investment longevity, and maximized performance and scalability.

The PXB Baseband generator and channel emulator from Agilent Technologies is a fully-integrated solution for testing MIMO receivers in realistic wireless channels and conditions (Figure 1). Delivering channel emulation capabilities for the latest LTE and WiMAX standards, it quickly replicates real-world MIMO conditions and channels, and generates realistic fading scenarios including path and channel correlations—capabilities which are critical to maximizing receiver performance, minimizing design uncertainty and reducing development cycle time.

In MIMO systems, low correlation between the transmit and receive antennas is absolutely critical to realizing MIMO's promised throughput improvement. Phenomenon like antenna spacing, polarization, radiation pattern, and angular spread each affect channel correlation to a certain extent and therefore must be accurately modeled (Figure 2). The PXB accomplishes this task via an antenna parameter setup menu which the engineer uses to set antenna parameters (Figure 3). It then calculates the correlation associated with these parameters and populates the resulting coefficients into a correlation matrix.

FIGURE 1: *The N5106A PXB Baseband generator and channel emulator provides up to 4 baseband generators (BBGs), 8 faders, the industry's widest bandwidth of 120 MHz, custom MIMO correlation settings (e.g., predefined channel models, antenna pattern and correlation matrix), and supports testing and troubleshooting of 2x2, 2x4, and 4x2 MIMO.*

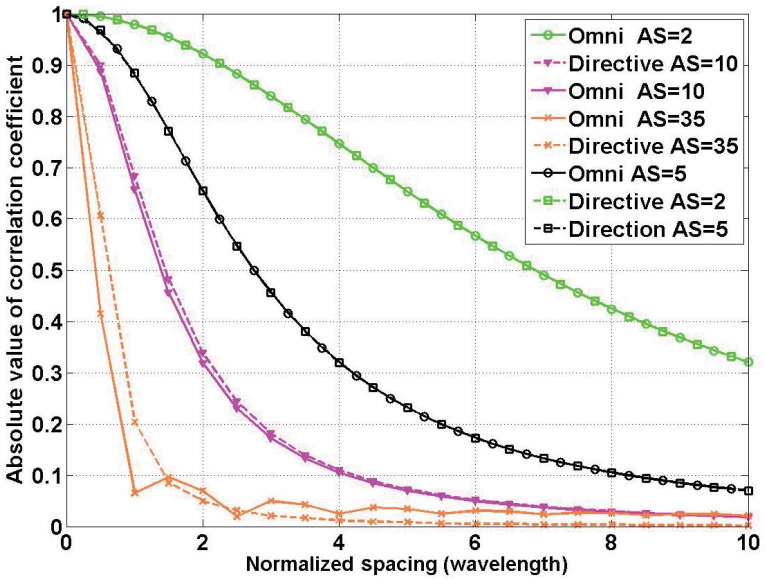

FIGURE 2: *This graph illustrates throughput performance of a MIMO system based on the channel correlation of various properties. Both the theoretical measurements of these properties and their effect on system performance are shown. While radiation pattern does not play a large role in correlation, antenna spacing and the angular spread of the antennas do have a large effect on correlation.*

In addition to providing flexible channel emulation and fading of internally generated signals, the PXB also supports fading of, and noise addition to, RF inputs coming from a user device as well as versatile signal creation. Agilent's MXA signal analyzer acts as the RF input to the PXB, while the Agilent MXG or ESG signal generator provide RF output from the PXB. Digital IQ output is provided by the Agilent N5102A digital signal interface module. Agilent's Signal Studio signal creation software runs in the PXB and provides the engineer with up-to-date standards-compliant signal creation.

Using the PXB, R&D engineers can accurately simulate real-world conditions in the lab that more quickly test corner cases and stress devices beyond standards requirements. They can also test co-existence to ensure design robustness earlier in the design process. Three key capabilities which enable the PXB to quickly and accurately test MIMO receivers under real-world conditions are:

- Allows R&D engineers to set up correlation properties based on standards-based channel models using drop down pre-defined settings as per the standard definition.
- Allows coefficients resulting from MATLAB® simulations of correlation properties to be put directly into the PXB's correlation matrix (Figure 4). The engineer can then set the correlation between each of the faders' channels or paths within the channels (e.g., channel-to-channel or path-to-path correlation).
- Provides R&D engineers with the flexibility to set the correlation between transmit and receive antennas based on the antenna setup. The PXB also allows them to define the spacing and radiation pattern of the antennas in order to calculate the correlation matrix.

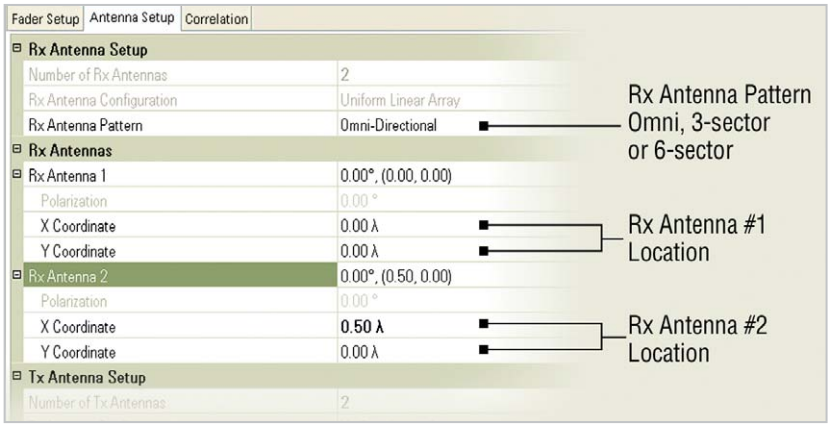

FIGURE 3: *All antenna parameters affect channel correlation and therefore must be modeled using the antenna parameter setup menu shown here.*

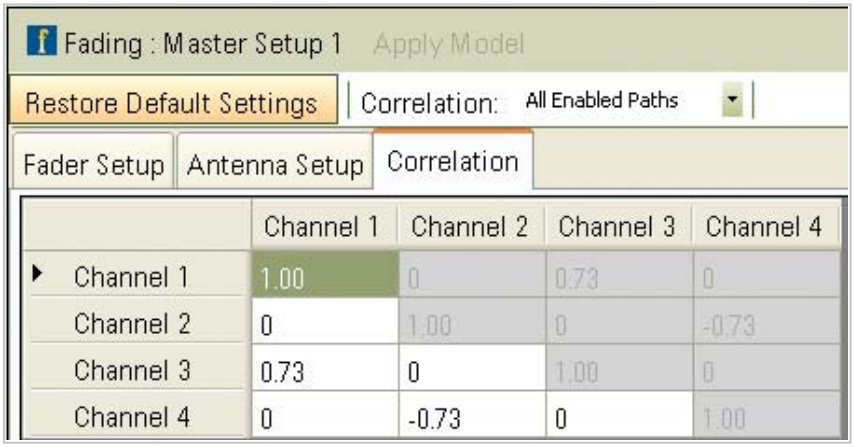

FIGURE 4: *Using the PXB's correlation screen, the engineer can set path-to-path correlation or channel-to-channel correlation for all paths within each fader.*

Summary of Results

Despite the array of performance improvements offered by MIMO technology, its complexity makes accurately testing MIMO receivers challenging. While there are solutions available to address this task, a flexible solution like Agilent's PXB Baseband generator and channel emulatorr provides a greater benefit. By replicating real-world MIMO conditions in the lab, R&D engineers can now use it to quickly and accurately isolate issues early in the lifecycle; thereby minimizing design uncertainty and maximizing receiver performance.

The Power of X

The Agilent PXB Baseband generator and channel emulator, MXG Signal Generator and MXA Signal Analyzer are key products 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.

To learn more about Agilent's suite of X products please visit:
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Related Applications

- Multi-channel performance signal generation
- Co-existence and interference testing
- Baseband generation and RF channel emulation
- General purpose R&D

Related Agilent Products

- N5182A MXG RF Vector Signal Generator
- E4438C ESG RF Vector Signal Generator
- N5102A Digital Signal Interface Module
- Signal Studio
- N9020A MXA Signal Analyzer

N5181A MXG Analog Signal Generator

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