MIMO receiver tests using only one signal generator

MIMO (multiple input multiple output) is an effective technique for boosting data rates. It therefore forms an integral part of modern mobile radio standards such as 3GPP Release 7 and EUTRA/LTE, as well as wireless local (802.11n) and regional (WiMAX) radio networks. There are two MIMO concepts: diversity and multiplexing. This article explains the two concepts and shows how to perform MIMO receiver tests with the R&S®SMU 200 A or the R&S®AMU 200 A.

Diversity

A signal traveling from a transmit to a receive antenna is subject to reflection, which causes multipath propagation of the signal. The propagation paths in part add up constructively, i. e. they amplify each other, and in part destructively, i. e. they cancel each other out. All paths between a transmit and a receive antenna taken together are referred to as a channel. If the above type of superposition is present, the channel is referred to as a faded channel. If receive antennas are closely spaced, the incoming signals are correlated, i. e. they have traveled through similar fading channels.

A receive diversity or SIMO (single input multiple output) system has one transmit and usually two receive antennas. If the fading channels are sufficiently different, the combination of several receive signals will yield a better signal-to-noise ratio because the receiver can compensate destructive superposition at one antenna by using the signals at the other antenna.

A transmit diversity or MISO (multiple input single output) system usually contains two transmit antennas and one receive antenna. Identical data contents with different coding (space time coding) are sent via the two transmit antennas. If parts of one signal are lost due to destructive superposition, the data contents can be retrieved from the other signal. For this, the fading channels must be sufficiently different from each other.

Multiplexing

Multiplexing systems transmit different data contents simultaneously on the same carrier frequency via several antennas. The signals are received in parallel by the receive antennas, which results in an increase of the overall data rate (FIG 1). A challenging task for a multiplexing system is to distinguish between the different signals at the receiver. As with diversity systems, this can be done on the basis of the different transmission channels. By way of channel estimation, the characteristics of the individual fading channels are determined. Based on this information, the receiver can differentiate between the transmit antennas and pick up the two data contents simultaneously.

Complex measurement tasks

Diversity as well as multiplexing systems only work if the fading channels between the transmit and the receive antennas are sufficiently different. Since the antennas are closely spaced, similar fading channels will result, which reduces system efficiency. To simulate similar fading channels, the fading simulator has to correlate the attenuation characteristics of the fading channels with one another. This means that performance tests on MIMO receivers require not only several vector signal generators but also a multichannel fading simulator. The R&S®SMU 200 A vector signal generator and the

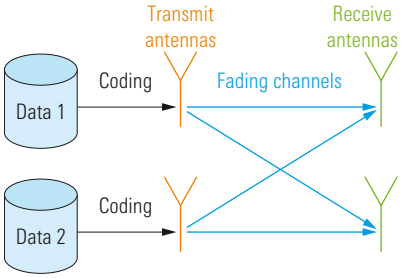

FIG 1 Block diagram of a 2 × 2 MIMO multiplexing system. Two different data contents are emitted via two transmit antennas. The four blue arrows represent four different fading channels to the two receive antennas.

R&S®AMU 200 A baseband signal generator and fading simulator (page 4) are the only instruments on the market to combine these complex functionalities in a single unit. The user can configure signals and define fading conditions conveniently via the generator's intuitive user interface. This also does away with any cabling between signal generators and fading simulator.

2 × 2 MIMO systems

Tests on 2 × 2 MIMO systems require four fading channels and two signal sources (FIG 1). Using the R&S®SMU-K74 or R&S®AMU-K74 option, it is now for the first time possible to perform such tests with a single unit. FIG 2 shows the block diagram for a 2 × 2 MIMO test on the R&S®SMU 200 A user interface. Each block represents a functionality that is configured in the associated menu. The baseband blocks on the left symbolize the two transmit signals, and the four fading blocks the fading channels, which are shown as blue arrows in FIG 1. The two RF blocks on the right can be used to configure the RF parameters of the two signals.

To simulate fading channels that are similar to one another, the attenuation characteristics of the fading channels can be mutually correlated. With four fading channels, correlation is configured by means of a 4 × 4 matrix. FIG 3 shows the window for entering the matrix elements on the R&S®AMU 200 A and the R&S®SMU 200 A. Each matrix element correlates one fading channel with another. The matrix elements are complex numbers, since correlation is defined by both magnitude and phase. The phase value is derived from the phase angle between the antennas. The R&S®SMU 200 A not only offers the standard matrix assignments defined in the test specifications; it also allows users to create matrix assignments of their own. Thus, the instrument is already prepared to handle future expansions.

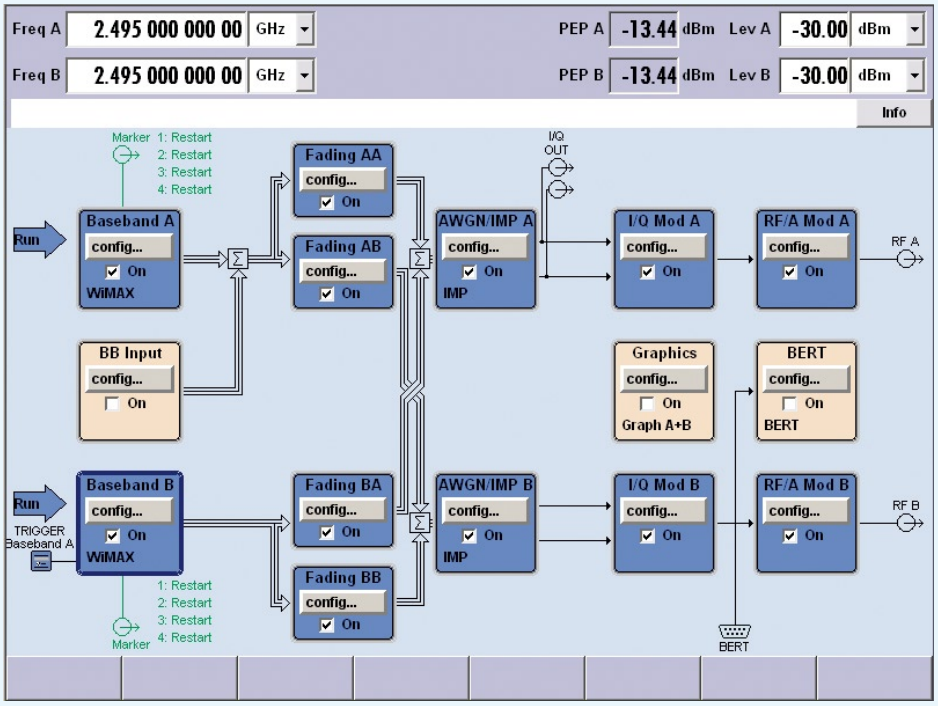

FIG 2 The R&S®SMU 200 A user interface for 2 × 2 MIMO tests, showing the signal flow from the generation of the two signals on the left via the simulation of the four fading channels up to the two RF outputs on the right.

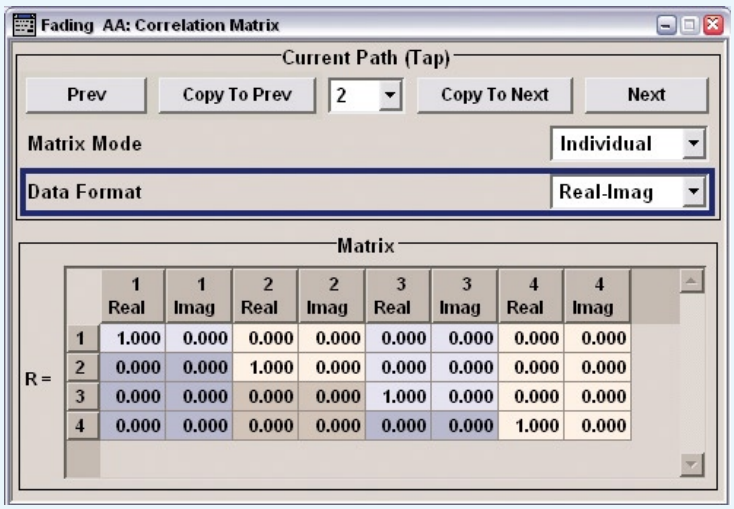

FIG 3 Correlation matrix. The display can be switched between real and imaginary components or polar format.

Summary

Featuring a dual-path concept and an integrated multichannel fading simulator, the R&S®AMU 200 A and the R&S®SMU 200 A are ideal for tests on diversity systems. The R&S®SMU-K74 and R&S®AMU-K74 options simulate up to four fading channels, thus allowing tests on 2 × 2 MIMO receivers by means of a single instrument. This eliminates the need for cabling as well as level adjustment between signal generators and fading simulator.

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