New WLAN test solutions

Every new WLAN standard extends the list of properties that have to be measured. The testers in the R&S® CMW family provide developers and production specialists with all the measurement functions they need.
MIMO measurements on WLAN radio components

MIMO multi-antenna technology helps modern radio systems achieve higher data throughput provided that all RF paths perform as intended. The R&S®CMW100 communications manufacturing test set supports all common measurement methods needed to analyze the performance of WLAN radio components.

The use of multi-antenna systems can increase the coverage range and boost the data throughput compared to single-antenna systems. MIMO transmitters simultaneously send different signals (streams) on the same frequency via separate antennas (Fig. 1). Successful decoding of these signals on the receiving end requires relatively spatially independent transmission channels between the transmitting and receiving antennas, such as is the case with multipath propagation. In order for the complex mathematical algorithms to be able to reconstruct the signal, certain minimum requirements must be satisfied with regard to the spectral purity of the transmitters and the sensitivity of the receivers. Both must be tested in development and also to some extent in production. For transmitter testing, there are three methods that differ in terms of test depth and equipment complexity. All of these methods are supported by the R&S®CMW100 communications manufacturing test set (model K06).

**Receiver testing**
The MIMO receiver test is performed simultaneously on all receiving antennas. Each antenna is connected to a separate signal generator – a vector signal generator or the R&S®CMW100 tester’s internal generator. The ARB waveform files required for each generator can be created on a PC with the R&S®WinIQSIM2 software tool. Once all of the generators have been synchronously started, a packet error rate measurement is performed. Suitable remote control programs determine whether the device under test (DUT) successfully decodes the data packets in non-signaling mode.

**Transmitter testing**
For transmitter tests, three methods are available for verifying the RF properties in non-signaling mode, depending on the desired test depth.

**Composite MIMO TX measurement**
With this method, all MIMO signals transmitted in parallel (up to eight) are combined in a power combiner and the sum signal is transmitted to an R&S®CMW100 for analysis (Fig. 2). Although the MIMO antennas transmit different bit

---

**Fig. 1:** 4 x 4 MIMO systems have 16 transmission channels that can be used to increase the data rate for a single user or to simultaneously provide coverage for multiple users.

**Fig. 2:** Test setup for the composite MIMO TX measurement. A WLAN device with four antennas is connected to the R&S®CMW100 via a power combiner.
sequences, the analyzer is able to determine the transmitted power of each antenna from the sum signal in a single measurement step (if the DUT is suitably configured) and provide a quality assessment for the sum signal in the form of the error vector magnitude (EVM) value. The composite MIMO TX measurement is the method of choice for production because it quickly verifies MIMO performance without a lot of test equipment and finds faulty antenna connections.

Switched MIMO TX measurement
For the switched MIMO TX measurement, each transmitting antenna is connected to a port on one R&S®CMW100. All antennas are switched in rapid succession and analyzed individually (Figs. 3 and 4). The antennas continuously transmit different bit sequences, but the same sequence for each channel. These bit sequences are the basis for detailed analysis of the RF properties on all transmit paths. Even an 8 × 8 MIMO TX system can be analyzed with just one instrument.

True MIMO TX measurement
In contrast to the sequential switched measurement, the true MIMO TX measurement is performed simultaneously on all channels. It is therefore not necessary to repeatedly transmit the bit sequences. However, the speed advantage comes at a high hardware cost since a separate R&S®CMW100 is required for each transmitting antenna (Fig. 5). The measurement results are consolidated by the control PC connected to the system.

Fig. 3: Results of a switched 4 × 4 MIMO TX measurement.

Fig. 4: Test setup for the switched MIMO TX measurement. Each antenna in the DUT is connected to a port on one R&S®CMW100. The ports are switched in rapid succession to the test set’s analyzer.

Fig. 5: The true MIMO TX measurement requires a separate R&S®CMW100 for each MIMO antenna. A control and evaluation PC for managing the test sets is always required (not shown here).
Multi-user MIMO and beamforming

Instead of simultaneously sending multiple MIMO data streams to a single user to boost the data throughput, the data streams can be distributed among multiple users – a scenario that can be analyzed with both the switched and the true MIMO TX measurement (Fig. 6).

To implement multi-user MIMO (MU-MIMO), the receiver requires as many receiving antennas as in the single-user case to ensure reliable channel separation. For smartphones that have a maximum of two MIMO antennas due to their compact size, this would limit MU-MIMO to two users. One possible solution is to use beamforming to augment or suppress the propagation of individual signals in certain directions by exploiting the radiation patterns of multi-antenna systems (Fig. 7). Each user then receives only their intended data stream with high field strength. Based on this technique, even a user with only one receiving antenna can successfully decode their intended data stream in an 8 × 8 MU-MIMO scenario.

Summary: The R&S®CMW100 offers the right measurement solution for receiver and transmitter testing in every MIMO scenario.

Thomas A. Kneidel