Signaling tests on WLAN 802.11ax devices

Unlike production applications where calibration and testing of a WLAN product's transmitter and receiver can be performed in non-signaling mode, measurements in signaling mode are an absolute must in development and quality assurance. Such measurements are now possible for the new IEEE 802.11ax standard.

In non-signaling mode, the device under test (DUT) is remote controlled via an electrical cable. This special operating mode supports time-optimized calibration and testing of the transmitter and receiver. These tests require a suitable T&M instrument equipped with a signal generator and analyzer, such as the R&S®CMW100 communications manufacturing test set. When using this time-optimized test and measurement method, it is understood that a custom remote control program is required for each chipset to be tested, that a wired remote control interface must be available, and that the test is not performed under real operating conditions. There is a clear risk that the device could behave differently during subsequent normal operation. This risk can be minimized by first testing the WLAN radio component in signaling mode during development and quality assurance. The T&M instrument emulates either an access point (AP) or a WLAN station (STA), and the DUT connects to the emulated AP or STA like it would under normal operating conditions. Contact is generally made with a coaxial cable via the antenna connection. Using standard-compliant signaling, the DUT can be placed in any desired operating state required for the measurements. Typical examples include:

- Verification of receiver quality based on a packet error rate (PER) measurement
- Determination of the transmitter's RF properties by measuring the transmitted power and analyzing the modulation accuracy (EVM)
- Performance measurements (data throughput)
- Protocol analyses [1]

Such measurements were also required by earlier WLAN standards. The latest version (IEEE 802.11ax) has introduced a number of new methods involving additional test requirements [2] that require the use of a flexible tester that supports signaling, such as the R&S®CMW270 or R&S®CMW500.

One of WLAN's weak areas is related to the carrier sense multiple access with collision avoidance (CSMA/CA) method as previously implemented up to the 802.11ac standard. The objective of this method is to ensure interference-free operation of multiple WLAN stations with one AP by only allowing a single station to transmit at any one time. An STA may transmit only if the channel is not in use for a specified wait time. This method is also known as listen-before-talk (LBT). However, there is still a risk of the transmission colliding with the transmission of another concurrently waiting station that also thought the channel was free. A collision leads to data loss, which leads to a repetition of the procedure and a new transmission. The more WLAN stations involved, the more drastic the increase in the wait times and the lower the efficiency of the available radio channel. The orthogonal frequency division multiplexing access (OFDMA) method, which with 802.11ax can also be used for WLAN, provides a significant improvement. The available bandwidth is divided into resource units (RU) that the access point dynamically assigns to its allocated stations on demand (Fig. 1).

The AP also informs the STA about the modulation coding scheme (MCS) to be used. For T&M instruments that assume the AP role, it is now possible for the first time to restrict the transmitter measurement for a WLAN station to a specific MCS in signaling mode.

Uplink OFDMA synchronization

One of the prerequisites for efficient parallel operation of multiple WLAN ax stations is proper synchronization. Triggered by the AP, all stations must start transmitting within ±0.4 μs, (Fig. 2). Compliance with this tolerance must be measured.

Multi-user channel distribution

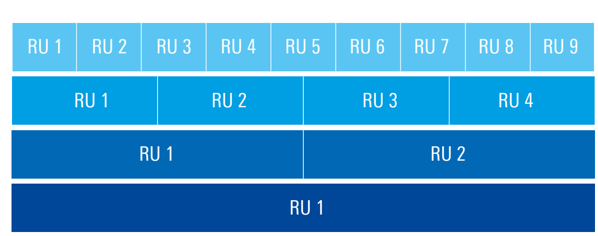

Fig. 1: In multi-user mode, a 20 MHz channel (for example) is divided into resource units (RU) that can be combined in different sizes.

Unused tone error

To minimize mutual interference during parallel operation of multiple STAs, the IEEE has set upper limits for the permissible spurious emissions in the adjacent spectrum. Similar to an adjacent channel leakage ratio (ACLR) measurement for cellular technologies, compliance with these limits must be verified with an unused tone error measurement.

Dynamic power control

Dynamic power control is also new in the 802.11ax standard. Excessive field strength differences between the different STAs at the AP receiving antenna would hinder proper OFDMA operation. This problem can be prevented if the STAs adjust their transmitted power so that all signals arrive at the AP with approximately the same field strength. The AP lets the STAs know what power it is transmitting, and the STAs then perform a receiver signal strength indication (RSSI) measurement. Based on the result, each STA can derive the path attenuation on the link to the AP. The AP also tells all stations the desired target RSSI at its receiving antenna. The STAs then send their data packets with the desired signal strength plus the calculated path attenuation. When multiple STAs transmit in parallel to the AP, the transmitted power of each STA is adapted continuously to the prevailing conditions.

Whereas until now WLAN stations mostly transmitted statically with the maximum allowable power for their country, the transmit level range has increased significantly in 802.11ax – with consequences for the calibration of transmitted power in production. Not only has the dynamic range for the transmit level increased, WLAN 11ax also has more stringent requirements for the accuracy of the transmitted power and RSSI measurement depending on whether the device is low-cost or high-end (the standard distinguishes between two quality classes: A and B).

New test solution for 802.11ax

When verifying the new WLAN features introduced with 802.11ax, developers are faced with tests and measurements they cannot adequately perform in non-signaling mode. What they need is a tester that can configure the DUT via signaling. Equipped with the R&S®CMW-KS657 software option, an R&S®CMW270 or R&S®CMW500 can emulate an 802.11ax access point with up to 80 MHz bandwidth in SISO mode and test STA in all operating modes (single-user and multi-user). The previous WLAN tests as well as the specialized 11ax measurements are supported. The R&S®CMWmars message analyzer can also be used to record and monitor all protocol messages exchanged between the tester and DUT in real time.

The use of 802.11ax will provide a clear boost in efficiency, especially in locations with high WLAN user density such as airports, exhibition halls, sports stadiums and shopping centers. This decisive advantage should help speed up acceptance of the new standard and write another chapter in the WLAN success story.

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Uplink OFDMA synchronization

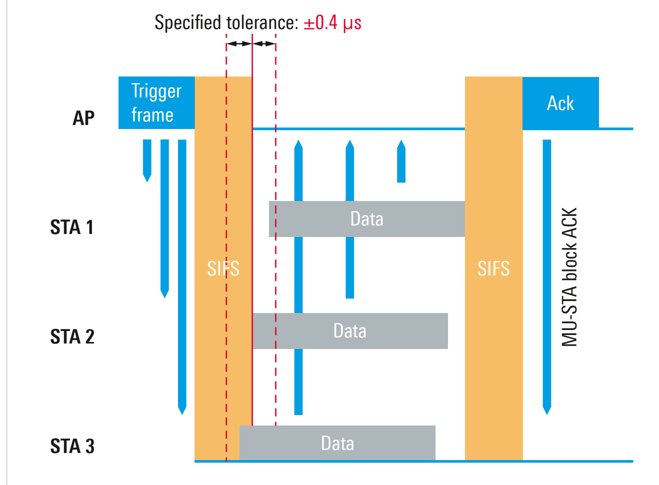

Fig. 2: Starting with the AP's trigger signal, all STAs must synchronously transmit their data packets to the AP within a time of departure accuracy of 0.4 µs.

References

[1] Thomas A. Kneidel: WLAN signaling with the R&S®CMW270 and R&S®CMW500 testers. NEWS (2011) No. 204, pp. 6 to 8.

[2] Dr. Michael Simon: WLAN 802.11ax speeds up communications in multi-user scenarios. NEWS (2017) No. 217, pp. 24 to 29.