An RF Power Measurement Solution for Multi-antenna MIMO Transmissions

Application Note

Abstract

The MIMO wireless connectivity method has been widely used in today's broadband data transmission equipment. However, with the revision of the ETSI EN 300 328 v1.8.1 test standard, new requirements for multi-channel RF power measurement have been defined which also could be leveraged to other test standards like EN 301 893.v1.7.1. Conforming to these new RF power measurement requirements presents the following test challenges:

- Up to 4 measurement channels have to be synchronous at all antenna outputs
- At least a 1 second measurement duration have to be provided for non-FHSS devices running into Non-adaptive mode
- At least a 1 MSa/s measurement rate have to be used
- Up to 4 million data samples of detection power of the burst signal have to be obtained

In this paper, a new RF power measurement solution that addresses the revised EN 300 328 v.1.8.1 and EN 301 893 v1.7.1 requirements is discussed which features the Agilent Technologies U2020 X-Series USB peak power sensor and Agilent U2531A 2 MSa/s USB modular data acquisition (DAQ) unit.

Test Requirements

The European Telecommunications Standards Institute (ETSI) is an independent, non-profit organization whose mission is to produce telecommunications standards for today and the future. ETSI is responsible for the standardization of information and communication technologies (ICT) within Europe. These technologies include telecommunications, broadcasting, and related areas such as intelligent transportation and medical electronics. Manufacturers of wideband data transmission systems used in wireless local area networks (WLAN) and *Bluetooth* devices have to prove compliance to the specifications defined by ETSI.

The EN 300 328 v1.8.1 (2.4 GHz) and EN 301 893 v1.7.1 (5 GHz) test standards specify new MIMO, beamforming, and adaptivity test requirements. More specifically, these standards defined new multi-channel synchronous power measurement procedures for a single test system, as well as procedures to support test cases and dynamic frequency selection (DFS). As such, R&D and test labs need a regulatory test system for wireless devices operating in the 2.4 GHz and 5 GHz bands.

EN 300 328 v1.8.1 RF Power Measurement Challenges

Version V1.8.1 of the ETSI standard specifies a special type of power measurement. The power measurement must be fully time-synchronized and in compliance with the standard for up to four channels and have up to 4 million data samples of detection power of the burst signal, allowing it to characterize devices with multiple input multiple output (MIMO) and beamforming capability. The power measurement rate must be > 1 MSa/s and for non-frequency hopping spread spectrum (FHSS) devices support at least a 1 s measurement time.

Paragraph 5.3.2 in the standard defines a power measurement procedure where the following parameters have to be measured: RF output power, duty cycle, Tx sequence, Tx gap, and the medium utilization (MU) factor based on the RF power samples data within burst analysis. Currently there is no existing test systems ready to meet the requirement of this ETSI standard.

Test Solution Block Diagram

To address the challenges presented by the new power measurement procedures, there is a new test solution that performs the certification tests in line with the ETSI EN 300 328 V1.8.1 standard. Using this solution during the design and development stage, manufacturers of wideband data transmission systems can now verify whether their new products will meet the new certification requirements.

Figure 1 shows a block diagram of the test solution. It includes a custom power test set (see Figure 2) equipped with four Agilent U2020A X-Series USB peak power sensors and two U2531A USB modular DAQ units in order to form a four simultaneous digitizer with 14-bit resolution and a sampling rate of up to 2 MSa/s/ch with 4 MB/ch memory. This allows the synchronized recording of the four analog signal outputs from the peak power sensors, fulfilling the new ETSI requirement to perform fully time-synchronized power measurements for up to four channel antenna ports.

In addition, the new test solution software supports calibrated power (dBm) from digitizer voltage, and records power versus time for further RF burst analysis. The RMS and maximum RF output power, duty cycles, the maximum Tx sequence, the minimum Tx gap, and the medium utilization factor also can be automatically measured and calculated.

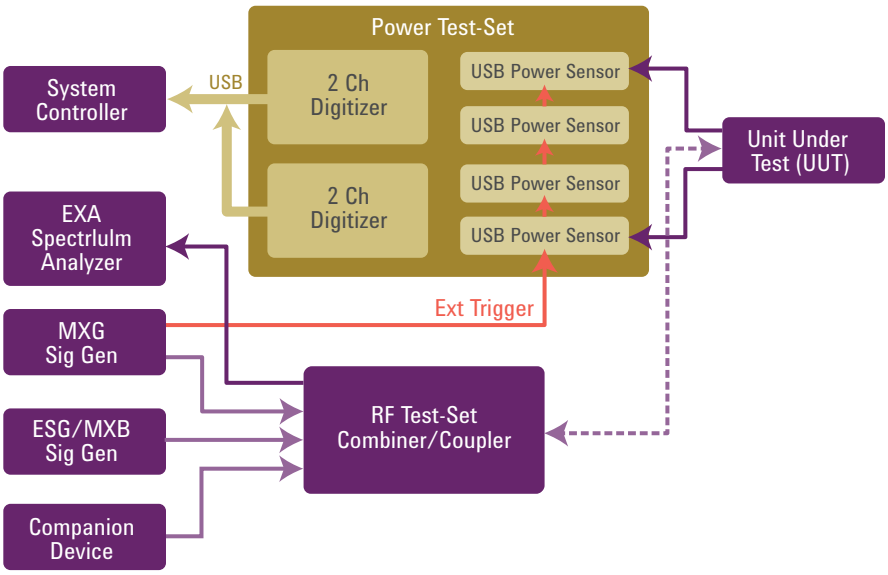


Figure 1. Test solution configuration to support new ETSI requirements

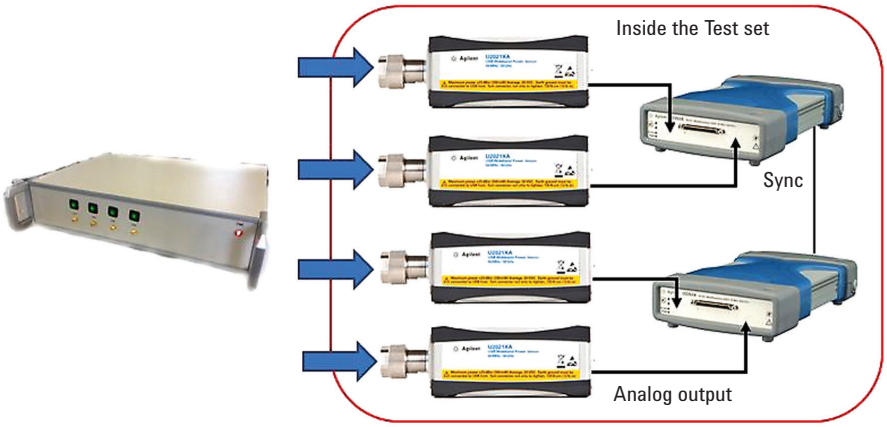
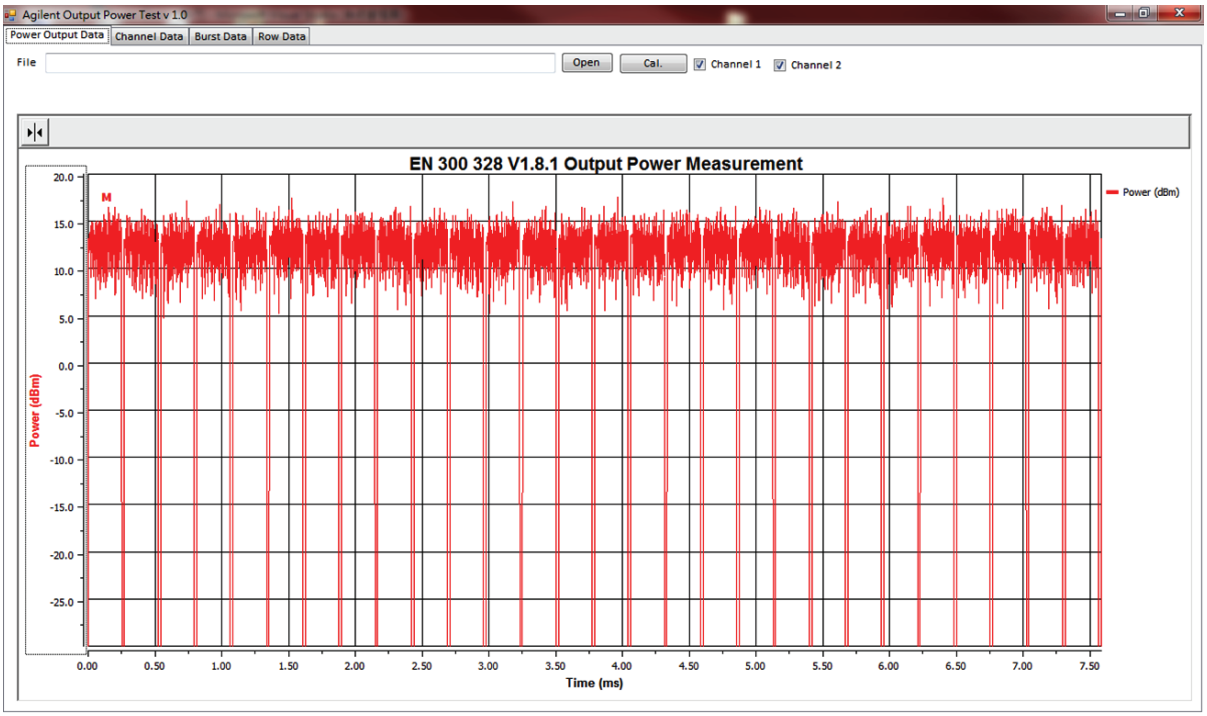
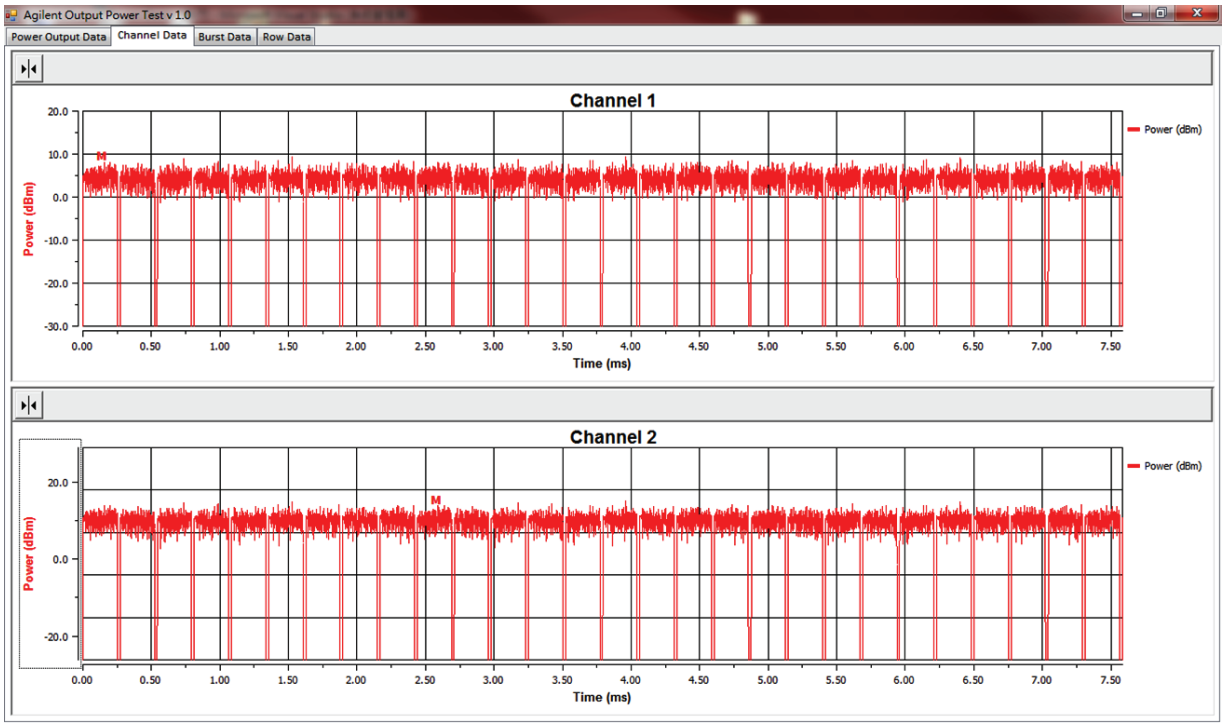


Figure 2. The custom power test set included in test solution for meeting new ETSI standards

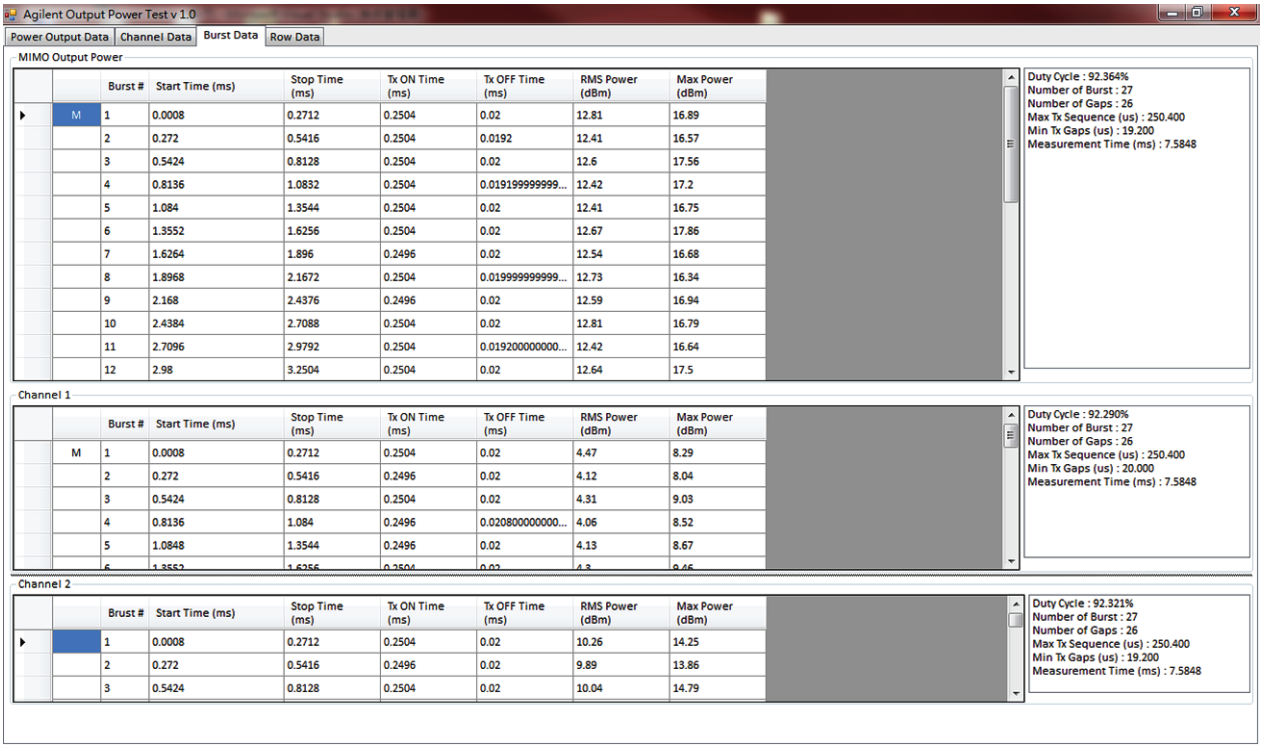
The following are examples of the measurement results provided by this test solution.



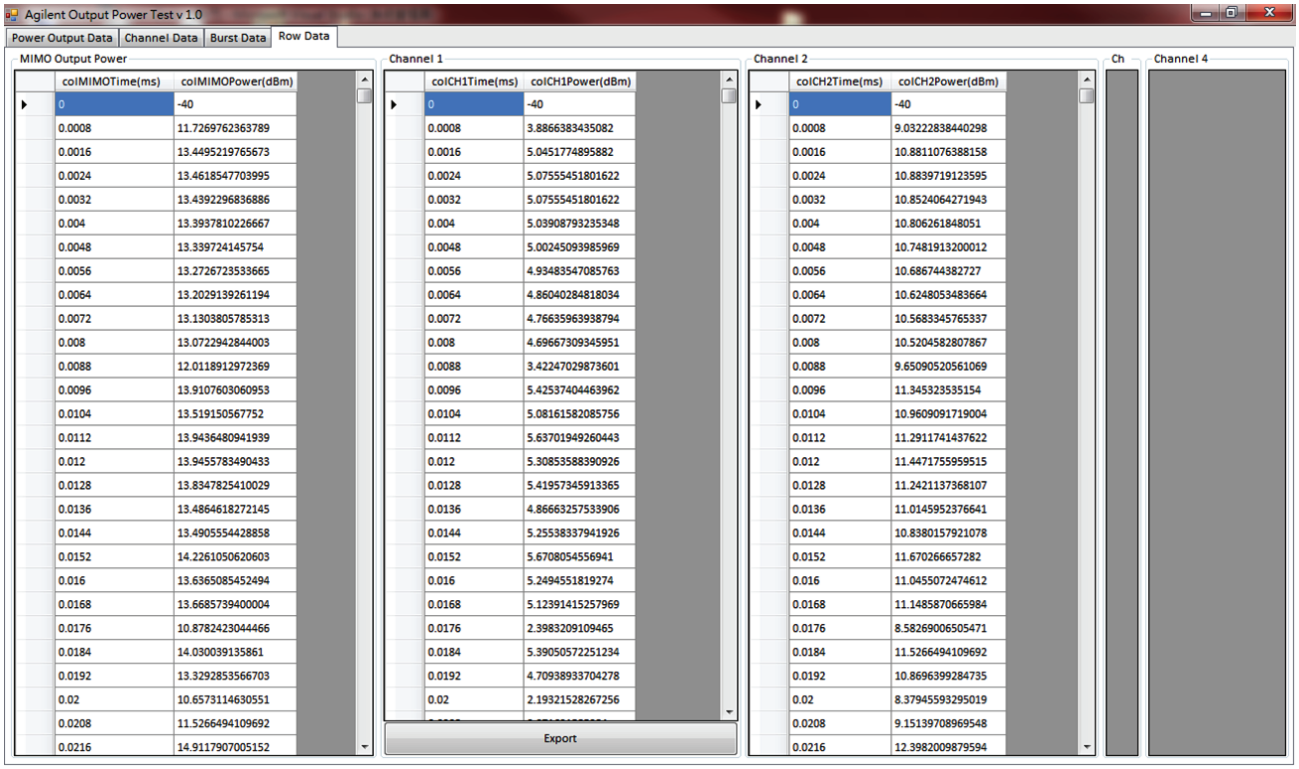
RF output power UI (combined MIMO 2X2)



RF output power synchronous



Non-adaptive testing parameters



MIMO power raw data results

MIMO Synchronous Power Measurement

MIMO is the simultaneous use of multiple antennas at both the transmitting and receiving ends of transmissions to improve spectral efficiency. MIMO technology offers tremendous performance improvement for wireless local area networks (WLANs) and other cellular technologies. MIMO synchronous power measurement requires multiple, time-synchronized power measurements be obtained in order to comply with the ETSI EN 300 328 V1.8.1 standard requirement. The new RF power measurement solution with a combination of four Agilent U2020X-Series units and two U2531As does 1 MSa/s with up to 4 seconds synchronous record length under MIMO conditions. The test software has a built-in user interface (UI) that allows users to select Config1, 2X2, or Config2 3X3 or 4X4 MIMO power measurements and could be extended for 8 antenna in 802.11ac in the future (see Figure 3).

However, the new 300-328 v.1.8.1 test standard regulates the 2.4 GHz band that covers both WLAN (MIMO) and Bluetooth (single in, single out (SISO)) and necessitates that both connectivity technologies have larger memory to support power measure over a longer length of time. Using the U2020 X-Series USB peak power sensor and U2531A modular DAQ solution is still the best way to cover this test requirement.

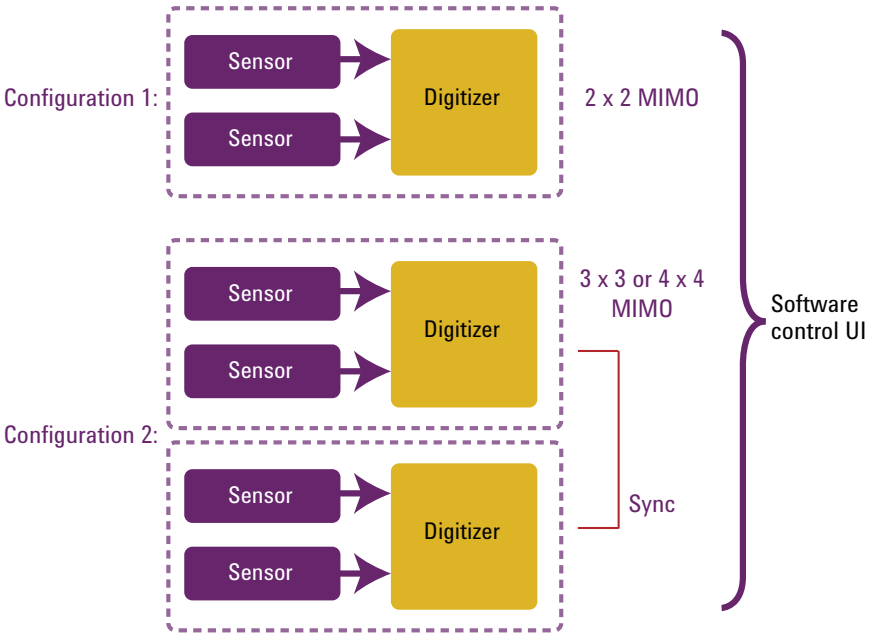


Figure 3. MIMO 2X2, and 3X3 and 4X4 power measurement configurations

Agilent U2020 X-Series USB Peak Power Sensor

The Agilent U2020 X-Series USB peak power sensor is a high performance USB power sensor with an additional 30 MHz video bandwidth capability for measuring average, peak, and peak-to-average power burst signals. An external trigger enables accurate triggering of small signals close to the signal noise floor. The U2020 X-Series USB peak power sensor comes with built-in trigger in/out connections. This feature allows the USB sensors to connect to an external trigger signal from a signal source or device-under-test (DUT) via a standard BNC-to-SMB cable. The sensors also come with recorder/video-output features, providing multi-channel power measurement synchronization capabilities, accuracy, and flexibility.

Meeting the new power measurement requirement to capture 1 MHz sampling waveforms from the power sensor requires at least 1 MB memory per second. However, the USB peak power sensor has a 96 K memory with an 80 MSa/s capability, limiting its ability to capture un-decimated data only up to 1.2 ms.

The USB peak power sensor has an analog video output and automatically converts the AC level without the trigger, thus the Agilent U2531A USB modular DAQ units are used to record the data. The U2020 X-Series USB peak power sensor captures the maximum, peak, and average power points whereas the U2531A USB modular DAQ measure duty cycle and timing sequence check.

Agilent U2531A USB Modular Data Acquisition (DAQ)

The Agilent U2531A Series USB modular simultaneous sampling multifunction data acquisition (DAQ) provides analog input sampling rate coverage of up to 2 MSa/s for each channel, and up to four channels of 14-bit resolution. Two U2531A modular DAQ units support four multi-channel measurements with 1 MSa/s for each channel, thus complying with the new standard. The dedicated analog-to-digital conversion (ADC) capability of the U2531A also allows the simultaneous sampling of data to be carried out for power measurement analysis.

Conclusion

The new requirements for RF power measurement of multi-antenna MIMO transmissions can be addressed with combination of the Agilent U2020 X-Series USB peak power sensor (four units) and Agilent U2531A USB modular DAQ (two units). This solution meets the measurement requirements defined according to the revision of the ETSI EN 300 328 v1.8.1 test standard.

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