CC3100/CC3200 WLAN RF Transmit Power Peak and Average Measurements

Application Report

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Embedded Processing Applications

ABSTRACT

This application report considers factors that impact radio-frequency transmit power measurements and, in particular, the difference between peak and average measurements recorded on systems using the Texas Instruments CC3100 SimpleLink™ Wi-Fi® Network Processor and CC3200 SimpleLink™ Wi-Fi® Wireless MCU. The document also describes the situations in which each type of power measurement is typically used.

1 Wireless LAN Transmit Power Measurements

RF transmit power is an important performance parameter for a wireless LAN system. The transmit power value is important because it can impact system regulatory compliance. The transmit power of two systems that are otherwise similar can also provide an indication of which system supports the greatest communication range to the receiver.

In order to compare different transmit power values, it is important to know several characteristics of the measurements. These include understanding:

- If the measurement was made over the air with antennas in place, or if the measurement was made using cables to produce a conducted measurement.
- For conducted measurements, it is important to know the location in the system where the power was measured. Common measurement points are at the power amplifier chip pin or at the input to the antenna.
- The Wireless LAN modulation scheme and physical layer data rate in use during the measurement should also be specified. Common examples include:
  - 802.11b 1 Mbps DSSS
  - 802.11b 11 Mbps CCK
  - 802.11g 6 Mbps OFDM
  - 802.11g 54 Mbps OFDM
  - 802.11n 72 Mbps MCS7
- The frequency and channel where the measurement was taken as well as the channel width (typically 20 MHz)
- The method used to measure the power over time, for example, average power or peak power and the period of time when the measurement was made.
- The ambient temperature when the measurement was made.
- If this is a measurement from an individual system or the result of a series of measurements of many systems presented as a minimum, typical or maximum value.

Reference documents [1]. [2] and [3] describe a variety of techniques for making RF transmit power measurements using lab test equipment from various vendors.

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2 Peak Versus Average Wireless LAN Transmit Power Measurements

If two transmit power figures are compared, it is especially important that they both be measured using the same method. For example, they both be peak measurements or they both be average measurements. Generally, technical documentation such as chip data sheets and system application notes quote average transmit power. Regulatory filings, such as those presented to the FCC in the USA, generally quote peak transmit power figures.

The difference between a peak transmit power measurement and an average transmit power measurement is a strong function of the transmit waveform shape, and in the case of wireless LAN, the transmit waveform shape is a function of the modulation scheme being used.

Table 1 shows peak and average transmit power measurements that were recorded in a conducted test with a probe placed at the antenna port on a CC3100 evaluation system. The individual measurements were taken from a single evaluation system at room temperature operating on channel 7. The average and peak transmit powers were measured for a series of physical layer rates and modulation schemes.

Table 1. Peak and Average Transmit Power Measurements

Physical Layer Rate and Modulation	Average Power	Peak Power
	dBm	dBm
1 DSSS	18.2	20.3
11 CCK	18.6	20.5
6/9 OFDM	17.5	23.0
12/18OFDM MCS 1/2	17.3	22.8
24/36OFDM MCS 3/4	16.1	22.8
48/54OFDM MCS 5/6	14.5	22.7
MCS0_MM	17.4	23.2
MCS7_MM	13.2	22.7

It can be seen from Table 1 that the difference between average and peak measurements varies significantly as the physical layer rate and modulation change. For the case of an 802.11b 1Mbs DSSS waveform, the difference between average power and peak power measurements is 2.1dB. For the case of 802.11n 72 Mbps MCS7 in mixed mode, the difference between average power and peak power is 9.5dB. It can also be seen from the table that modulation rates that have the same peak power have differing average power measurements. For example, 12/18OFDM and 24/36OFDM which both resulted in a 22.8 dBm peak power measurement, support different average power levels.

The change in the difference between the average power and peak power measurements as a function of modulation reflects the change in the Wireless LAN waveform. While the peak and average value of a waveform can be calculated mathematically, there are other system factors that determine the measured difference in peak and average power. One such factor is the change in linearity of the wireless LAN system, as the RF chain is automatically reconfigured for optimal performance as the modulation scheme changes.

Table 1 clearly shows that average and peak power figures differ significantly and that there is no easily computed conversion factor, so measurements obtained using these different methods should not generally be directly compared.

3 References

1. *Fundamentals of RF Microwave Power Measurements*: Agilent April 2001 (http://cp.literature.agilent.com/litweb/pdf/5965-6630E.pdf)
2. *Power Measurements of OFDM Signals* by Briggs, Martinez and Bare (http://www.elliottlabs.com/documents/OFDM.pdf)
3. *Practical Manufacturing Testing of 802.11 OFDM Wireless Devices*: LitePoint : 2012 (http://www.litepoint.com/wp-content/uploads/2014/02/Testing-802.11-OFDM-Wireless-Devices_WhitePaper-1.pdf)

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