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Manufacturers' Efforts Simplify Power Measurement for Specific Standards

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Power measurement can be complex when testing for compliance with standards established for specific wireless systems

There are dozens of wireless communication standards currently active in product development and system deployment. A key measurement in development and production testing is power—but the prescribed methods, test signals, frequency span and allowable limits can be daunting for an engineer to study before attempting to create a test setup.

Fortunately, the most knowledgeable experts on measurement techniques are the engineers at test equipment companies. They have done the necessary study concerning standards-based power measurement and have included that information in instrument instruction manuals, application notes, and even formal tutorials in multimedia or interactive webinar formats.

Even better, the necessary setups for major wireless standards may be included in the operating software of the test equipment. Although usually an extra-cost option, these "personalities" are almost always worth the investment. Advanced users will likely expand them to include specific features unique to the wireless products they are developing and/or manufacturing.

Peaks, Pulses and Bandwidth

A CW power measurement is easy; all that is needed is a calibrated power meter and a set of attenuators to reduce power as necessary to stay within the meter's range. It doesn't matter whether the power meter is thermocouple or diode based, only that it is properly calibrated.

However, modern wireless systems almost always require non-CW measurements, such as peak power (usually with a specified modulating signal), power during the "on" time of a transmitted signal, or power level at various offsets from the operating channel. In addition, wide bandwidth power measurements are required for compliance with general interference protection regulations such as FCC Part 15.

Some pulsed power and peak power measurements can be made using diode-based traditional-design power meters. If the on-off duty cycle of a pulsed signal is constant and accurate, the peak power can be calculated mathematically from an average power reading. If the peak-to-average ratio of a signal is held constant ("whitened") using a pseudorandom code, mathematical methods may be applied to more complex modulation types. However, there are many systems with nonrepetitive signals that do not have this level of predictability.

One manufacturer's application note [1] describes the issue for a common wireless system (GSM) as follows:

"The RF envelope is in the form of 542.8 µsec pulses which are located within a 576.9 µsec timeslot, each containing 147 bits of information. The power-versus time relationship for each pulse is controlled within narrow limits for both turn-on and turn-off. This is necessary to prevent interference between adjacent time slots which are assigned to different transmitters. A GSM transmitter has only 28 µsec to ramp up to full power, a 70 dB dynamic range, while remaining within a specified power/time profile. The profile defines limits for overshoot and rise-time as well as fall-time. A peak power video bandwidth of at least 1 MHz is required to assure compliance with the profile." And GSM is less complex than many newer and broader bandwidth systems!

The solution for pulsed measurements for TDMA-based wireless systems is a sampling power meter, which must be based on a diode detector, since thermocouple detectors have too long a time constant. The power meter must have the appropriate RF bandwidth for the operating frequency, a video (detected output) bandwidth that exceeds the signal's occupied bandwidth, and it must have a fast sample-and-hold circuit with on-off times that do not alter the power reading.

Finally, baseband processing, such as internal amplifiers, analog-to-digital converters (ADCs), etc., must have a response equal to or greater than the detector's video bandwidth.

Measuring Complex Signals

Complex signals that do not have mathematically-defined duty cycle or peak-to-average characteristics require different measurement techniques. For these signals, their amplitude must be followed in real time, using a spectrum analyzer for the modulated RF signal, often in conjunction with a modulation analyzer that provides further data about the baseband characteristics.

The first task is to understand the limitations of spectrum analyzer based power measurement. With a "classic" swept local oscillator analyzer, these will include the effective noise bandwidth of the internal IF filters, baseband processing and detection circuitry, plus the effects of sweep time (averaging, or integrating, time). References [2] and [3] address these issues. Spectrum analyzer instruction manuals include this basic information as well.

Modern spectrum analyzers help reduce measurement uncertainty for complex signals in several ways. First, new models and upgrades offer increasing instantaneous bandwidths, where a 20 or even 40 MHz wide swath of spectrum is digitized with a high speed ADC. Sampling time is small relative to the variations in the modulated waveforms, so they can be accurately analyzed in both time and frequency domains.

Powerful post-processing, including multiple FFTs and statistical analysis, simplifies the evaluation of data. High speed memory saves all measurements over a segment of time, permitting a look "backward" in time to see events that precede the "trigger." Disk storage allows users to save the actual digitized signal, not just the measurement data, which permits re-processing with different analytical tools.

The complexity of measurements and instruments means that many engineers will not become experts until they have several months of experience. This is where the expertise of the instrument manufacturers is essential. Guidelines such as application notes and preset measurement personalities allow test engineers to be productive immediately.

Bluetooth® Example

Using Reference [4], we can review the power measurements required for the Bluetooth wireless standard:

Output Power—Power measurements are performed in the time domain (Figure 1), because the Bluetooth signal is a series of bursts. The test instrument is set up to find or calculate the various parameters noted in the figure.

Power Density—Measures peak power density in a 100 kHz bandwidth, to determine flatness error.

Power Control—Tests the calibration of level control circuits, including power levels and power control step sizes, at three frequency channels.

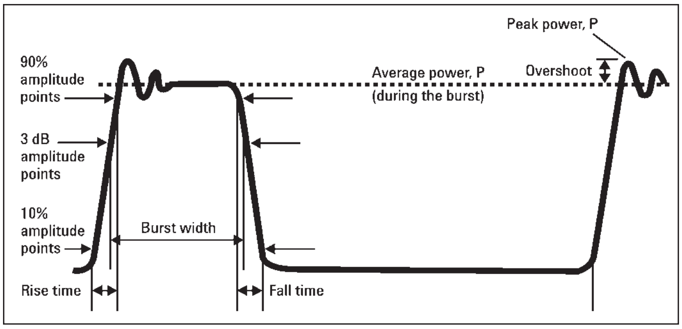

Figure 1 · Bluetooth power vs. time. (After Fig. 12 in (4).)

EDR Relative Transmit Power—EDR (enhanced data rate) transmissions have both GMSK and DQPSK modulation. This measurement assures that the transmission power of each type is in the acceptable range.

Transmit Output Spectrum—Measurement beyond the radio's operating bandwidth is made to assure that out-of-band transmissions are minimized. A predefined spectral mask requires emissions to be –20 dBc at ±550 to 1450 kHz from the operating channel, –20 dBc in adjacent channels, and –40 dBc at a 20-channel offset. The following measurements fulfill this requirement.

Frequency Range—Power density is measured to assure that the signal is –80 dBm/Hz EIRP below 2400 MHz and above 2483.5 MHz. The result must combine measured data with antenna performance.

–20 dB Bandwidth—Measures occupied bandwidth between the –20 dBc points, using the specified test signals and power levels.

Adjacent Channel Power—Measures power level in first and second adjacent channels, as noted above.

Summary

Standards-based power measurements require specialized knowledge. Fortunately, this knowledge is available through the literature and applications support of the companies that make power measuring instruments.

References

1. Richard Blackwell, "Digital Sampling Power Analyzer for GSM and CDMA," Application Note, Boonton Electronics, www.boonton, com.

2. "Agilent 8560E/8590E Spectrum Analyzers: Comparing Power Measurements on Digitally Modulated Signals," Literature No. 5968-2602E, Agilent Technologies, www.agilent.com.

3. Steve Murray, "Understanding the Perils of Spectrum Analyzer Power Averaging," Keithley Instruments White Paper, www.keithley.com/products/rfmicrowave.

4. "Bluetooth® Measurement Fundamentals," Lit. No. 5988-3760EN, Agilent Technologies, www.agilent.com.