Agilent 8560E/8590E Spectrum Analyzers

Comparing Power Measurements on Digitally Modulated Signals

Product Note

Measurement Software Personalities

Measuring the power of digital CDMA signals is not as straightforward as the procedure employed when measuring their analog counterparts. While there are several ways to perform these in-channel and out-of-channel measurements, a spectrum analyzer and software-implemented power detection makes the measurement correctly, accurately, and quickly. The Agilent Technologies 8590 E-series and 8560 E-series spectrum analyzers can perform these measurements alone, but when the 8590 E-series is complemented by measurement software personalities such as the Agilent 85725C for CDMA, the process is easier and more reliable results are obtained. However, there are differences between measurements made by the instruments alone and with the personalities that are important to understand.

In particular, the measurement personalities allow total linear power to be averaged over multiple sweeps in order to achieve more repeatable results, while the spectrum analyzers alone require the average to be calculated manually.

The Measurement

Whether adjacent-channel power is being measured by the spectrum analyzer alone or with the addition of a measurement personality, the algorithm shown in Equation 1 (below) is used:

$$P = 10 \times \log\left[B_s \times \frac{(1/n)\times\sum_{i=1}^{n}\left(10^{\frac{P(i)}{10}}\right)}{NBW} \right]$$

where:

P = total power in the channel bandwidth

BS = channel bandwidth

NBW = equivalent noise bandwidth of the spectrum analyzer

n = number of sample points within the channel bandwidth

P(i) = power reading on spectrum analyzer at trace element *i*.

The instrument first calculates the instantaneous power values of the trace elements by antilogging the dBm values. These values are summed across the channel bandwidth and the average over the number of trace elements is calculated. The instantaneous power at every trace element is measured using a selected filter that has a resolution bandwidth from 0.5 to 3.0% of the channel bandwidth.

In order to obtain the true spectral density (mean power normalized at 1 Hz), the power average is divided by the equivalent noise bandwidth. The total power in the bandwidth is then obtained by multiplying the result by the channel bandwidth and then converting it back to dBm for display. The instrument also displays the power spectral density (dBm/Hz).

It is important to remember that video averaging is not the same as averaging several measurements. In fact, video averaging should not be used when measuring noise-like signals, such as digitally modulated signals, because it will introduce errors into the measurement. This is because video averaging (or video filtering) averages the logarithmic values of the trace elements. For noise this error is –2.51 dB when the video bandwidth is much less than the resolution bandwidth or the number of video averages is high. Noise-like signals can have different statistics than noise, so this error can be different and it cannot be post-corrected since it is unknown. When making power measurements on noise-like signals, the video bandwidth must be at least three times the width of the resolution bandwidth.

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Although video averaging is often used in the field when making power ratio measurements, the signal in the main channel (modulated carrier) and the adjacent channel are considered to have the same statistics, which is often not the case.

In theory, when making power measurements, the results obtained with multiple sweeps must be changed to linear power before they can be averaged. However, the error produced when performing a "dB-average" on intermediate results is trivial, unlike the errors made in performing a "dB-average" on individual data points. Consequently, the error introduced by averaging the logged values of the power measurements over multiple sweeps is insignificant as well. When using the power measurements built into the spectrum analyzers (without the measurement personalities), the average over several traces can be calculated manually from the results obtained with multiple sweeps.

Other Differences

The measurement personalities used with the 8590 E-series spectrum analyzers select the analyzer's settings to optimize the measurement. For instance, to optimize dynamic range, a different reference level can be used for adjacent-versus-main-channel spans. In addition, some measurement personalities allow measurements to be made in a single sweep (one that spans the total frequency range of interest) or in multiple sweeps (one per channel involved in the measurement). The single-sweep ACP measurement is faster, but several sweeps increase the reliability of the measurement. While selecting a span as narrow as the adjacent channel maximizes the number of trace elements in the channel and increases measurement repeatability, it also produces a smaller frequency error. The 8560 E-series and 8590 E-series spectrum analyzers (without the personalities) do not have this feature. In the case of the 8560 E-series spectrum analyzers there are mitigating factors that reduce the need for it. For instance, they have more trace elements (600) and better frequency accuracy. In addition, the measurement personalities and the 8560 E-series instruments accommodate burst signal, while the 8590 E-series (without a measurement personality) do not.

Agilent 85725C and ACPR

While two-tone intermodulation distortion measurements are commonly employed in evaluating analog signals, they do not accurately characterize the performance of complex CDMA signals. A better method, called Adjacent-Channel Power Ratio (ACPR), provides a much better picture. The ACPR measurement compares the power in the RF channel to the power at several offset frequencies.

To make this measurement, the 85725C CDMA personality software automatically sets the instruments to their optimum values and performs all necessary calculations. It calculates the main channel power using the algorithm described in Equation 1, and power at the offsets is calculated in two different ways depending on the method selected by the user.

The first, Integration Bandwidth (IBW), method performs the ACPR measurement according to Qualcomm™ recommendations. However, an alternative method called the Resolution Bandwidth (RBW) method developed by Agilent Technologies makes the measurement faster. The difference between the two is as follows:

- Integration Bandwidth Method (IBW):
  The algorithm in Equation 1 is used for both the main and adjacent channels, but with different integration bandwidths for the different offsets. The user can change the settings of the integration bandwidths.

- Resolution Bandwidth Method (RBW):
  The algorithm in Equation 1 is used for the main channel, but for the power at the offsets, a specified resolution which is 30 kHz by default and zero span are used. The resolution bandwidth can also be changed by the user. The dBm values of the trace elements are converted into linear power and averaged. Several readings can be taken over time and averaged for greater repeatability, and the result is converted into dBm. The personality corrects for the equivalent noise bandwidth of the RBW filter.

After the main channel power and power at the offsets are obtained, ACPR is calculated and displayed in one of the following formats:

- Ratio of total power in the main channel (dBm/1.4 MHz) to power at the offsets (dBm/30 kHz, dBm/12.5 kHz, or dBm/1 MHz). The RBW method uses the same bandwidth for all offsets (dBm/30 kHz). The integration and resolution bandwidths can be changed by the user. The result is displayed in dBc.
- Ratio of power in the main channel normalized to 30 kHz (dBm/30 kHz), and power at the offsets normalized to 30 kHz (dBm/30 kHz). The result is displayed in dB. A different normalizing bandwidth can also be selected.

The 85725C measurement personality lets the user toggle between power density and power ratio results if desired.

When performing channel-power measurements with the 8590 E-series spectrum analyzers, the CDMA personality can also display the power-averaged spectrum when the instrument's DSP Options 151 and 160 are employed. The CDMA personality also prompts the user to perform a near-to-noise correction for channel power measurements. The user is prompted to disconnect the input signal and terminate the analyzer input with a 50-ohm load in order to calculate the analyzer's noise floor. The measured noise level will be subtracted from the measured power level to obtain more accurate readings for signals that are within 15 dB of the noise floor.

Summary

Channel power and adjacent-channel power ratio measurements can be made by the 8560 E-series and the 8590 E-series spectrum analyzers alone, or when used with measurement personalities such as the 85725C, which are tailored specifically for CDMA power measurement. The main difference between the two methods is that the personality software automatically averages the total linear power over multiple sweeps, which increases measurement repeatability. Nevertheless, either method produces satisfactory results.

The measurement personality also has the benefit of making the measurement process easier, since all instrument functions and settings are controlled automatically according to accepted practice. This reduces measurement time and decreases the likelihood of error.

References

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4. Agilent 8560 E-series User's Guide, Adjacent Channel Power Measurement–Stepping Through a Burst Signal ACP Measurement.

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