RMS detector computes real power of an RF signal

Steve Taranovich - October 06, 2016

The fast-evolving wireless network market is speeding toward 5G access that will bring far larger internet traffic than ever imagined before. LTE-A and 4G can't even come close to providing the needed bandwidth requirements. Microwave wireless backhaul links will need to advance as well in bandwidth because of this large increase in data capacity that will come with 5G.

Frequency bands for 5G access will be 8, 14, 18, 24, 28 GHz and far higher, especially in the higher frequency microwave backhaul needs. Bandwidths will need to be in the 1 and 2 GHz regions, pushing radio designs to the edge of the envelope.

In addition, high order QAM modulation in the region of 2048QAM will be realized. Multi-tone OFDM (Orthogonal Frequency Division Multiplexing) will also help make more efficient use of the spectrum. High order QAM modulation has its problems, like very high peak-to-average waveforms. If you try to measure only the peak power, even adding correction, you will not have a very accurate reading because this does not give you the true power in the waveform. Also, if there are multiple carriers, the peak power does not account for the tonal power in a multi-carrier signal. Errors can add up to several dB. So the need for adding lots of extra headroom for the actual peaks leads to lower transmission power available to the RF amplifier which reduces range and poor reception.

Traditionally, microwave Schottky diodes were employed in designs to measure the peak power at frequencies above 10 GHz. (When I was a circuit designer at General Microwave in the ’80s, I designed high speed PIN diode drivers with super-fast rise and fall times using high speed analog and digital driver components and used microwave Schottky diodes for detector and mixer designs as well. For narrow-band applications, quarter-wave spaced multiple diodes could be used in various switch designs to obtain improved operation—-that gives you an indication of how small these components are (in the order of 1.6×1.1 mm or less). At 10 GHz, a quarter wavelength is 7.5mm and at 100 GHz it is 750 µm.)
Schottky diodes perform well from 0 dBm to +20 dBm, but since Schottkys have an exponential response, lower signals will be less accurate.

The RMS detector

I really appreciate a simple concept, but clever design architecture can effectively enhance a circuit designer's capabilities to improve upon a system performance. That's what we have here from Linear Technology, soon to be a part of Analog Devices. I can't wait to see how that merger will enhance the high speed and RF product solutions to come, especially coupled with the Hittite expertise acquired in a previous acquisition.

Here is where an RMS detector saves the day because they use a root-mean-square function internal to the chip that computes real power of an RF signal. The averaging is done and the DC output will accurately represent the true power of the RF signal within a few tenths of a dB even down to low signal levels—no correction factors, no extra headroom. This solves the need for a Schottky at lower levels.

A 100 MHz to 40 GHz Power detector application

Linear Technology’s LTC5596, a high frequency, wideband and high dynamic range RMS power detector, will give accurate, true power measurement of RF and microwave signals independent of modulation and waveforms. The IC responds in an easy-to-use log-linear 29mV/dB scale to signal levels from -37dBm to -2dBm, with an accuracy better than ±1dB error over the full operating temperature range and RF frequency range, good for 5G wireless access from 200MHz to 30GHz with a flat response of ±1dB. Designers can get a wider frequency range from 100MHz to 40GHz with slightly reduced accuracy at the frequency extremes. The IC’s RF input is internally matched at 50Ω from 100MHz to 40GHz.
With 4G and 5G broadband communications systems, a high order, multi-tone OFDM modulation has to be used to attain higher desired data rates. This is where microwave Schottky diodes were previously needed as the detector element. But their shortcomings when rectifying the RF or microwave signals when measuring only the peak of the waveform will not provide the real power of the signal.

**Accuracy of the LTC5596 over frequency**

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**Schottky’s Exponential Response**

**RMS Detector’s Log-Linear Response**

**Sensitivity improvement of the RMS detector vs. a Schottky-based detector**
This is where an RMS detector shines by performing an analog root-mean-square computation of the waveform, and then averages the result to derive a true power representation of the input signal, regardless of its modulation, number of carriers, and varying amplitudes. The ability to measure the true power is critical for equipment manufacturers to set the proper transmit power to ensure maximum transmission distance and improved transmit range while remaining compliant with regulatory power limits.

Due to a wide bandwidth, the detector can work seamlessly with a minimum calibration being necessary across multiple frequency bands using a common design. Let’s look at an example. This RMS power detector works equally well in a sub-10GHz backhaul microwave link as with a 28GHz version. By using a single design with no recalibration, a significant cost savings is the result for equipment manufacturers. The IC’s wide frequency range and improved sensitivity enables a designer to use it in a wide variety of applications such as radar systems, avionics, wireless infrastructure base stations, satellite communications and test instrumentation.

The RMS detector response at 30GHz

Power supply and ESD capability

The IC operates from a single 3.3V supply, while drawing a nominal supply current of 30mA. The
detector has built-in improved ESD protection and all pins are capable of withstanding up to 3,500V discharge, human body model.

**Temperature ranges**

There are two temperature grades available. An I grade is designed for operation from -40°C to 105°C case. For applications that require a much higher temperature operating environments such as in high power RF power amplifiers, a high temperature H-grade is offered with rated temperature from -40°C to 125°C case. The H-grade is 100% tested over temperature, and is guaranteed to have tight tolerance on its slope and intercept point, reducing part-to-part variations.

**Package size**

Both temperature versions are available in a 2×2mm plastic 8-lead DFN package.

**Pricing**

The LTC5596 I grade is priced starting at $12.50 each in 1,000-pieces quantities, while the H grade starts at $16.95 each.

For more information, visit the Linear Technology [website](#).