RF RMS Power Detectors (TruPwr™)

The measurement of complex waveforms such as those found in spread spectrum CDMA/W-CDMA and higher order QAM modulation systems has traditionally been a demanding challenge. Analog Devices has developed a range of TruPwr™ detectors that enable the measurement of these complex signals at RF frequencies. The TruPwr™ detectors provide the user with an accurately scaled dc voltage, that is rms equivalent of the input waveform. Within the TruPwr™ range Analog Devices offers products applicable to both wireless and wireline infrastructure applications. and devices packaged in small footprint for portable applications.

Modern communications systems utilize complex modulation schemes to provide increasing data rates. The resulting signals have large and changing crest factors (peak to average ratios). To avoid clipping of these signals, power amplifiers (PAs) must be operated in their linear region where they are less efficient and, thus, consume higher levels of power. Accurate power measurement and control will help extend the battery usage time as well as assure compliance to the local regulatory requirements, such as ETSI and FCC. Measuring the true power levels of complex waveforms can be very difficult. RMS power detectors are the best for this application as they measure the true rms power level of the signal. Log detectors and peak detectors are much more sensitive to crest factors and can introduce errors of 2 dB to 5 dB. Temperature stability is another factor since PAs will drift with time and temperature. Power detectors from Analog Devices exhibit minimal drift over the full –40°C to +85°C range.

The AD8362 is an example of a true rms-responding power detector that has a 60 dB measurement range (see Figure 1). It is intended for use in a variety of high frequency communication systems and in instrumentation requiring an accurate response to signal power. It can operate from arbitrarily low frequencies to over 2.7 GHz and can accept inputs that have rms values from 1 mV to at least 1 V rms, with peak crest factors of up to 6, exceeding the requirements for accurate measurement of CDMA signals. Unlike earlier rms-to-dc converters, the response bandwidth is completely independent of the signal magnitude. The –3 dB point occurs at about 3.5 GHz.

Figure 2 shows a more detailed diagram of the internal structure of the AD8362. The input signal is applied to a resistive ladder attenuator that comprises the input stage of a variable gain amplifier. The 12 tap points are smoothly interpolated using a proprietary technique to provide a continuously variable attenuator, which is controlled by a voltage applied to the VSET pin. The resulting signal is applied to a high performance broadband amplifier. Its output is measured by an accurate square law detector cell. The fluctuating output is then filtered and compared with the output of an identical squarer, whose input is a fixed dc voltage applied to the VTGT pin, usually the accurate reference of 1.25 V provided at the VREF pin.
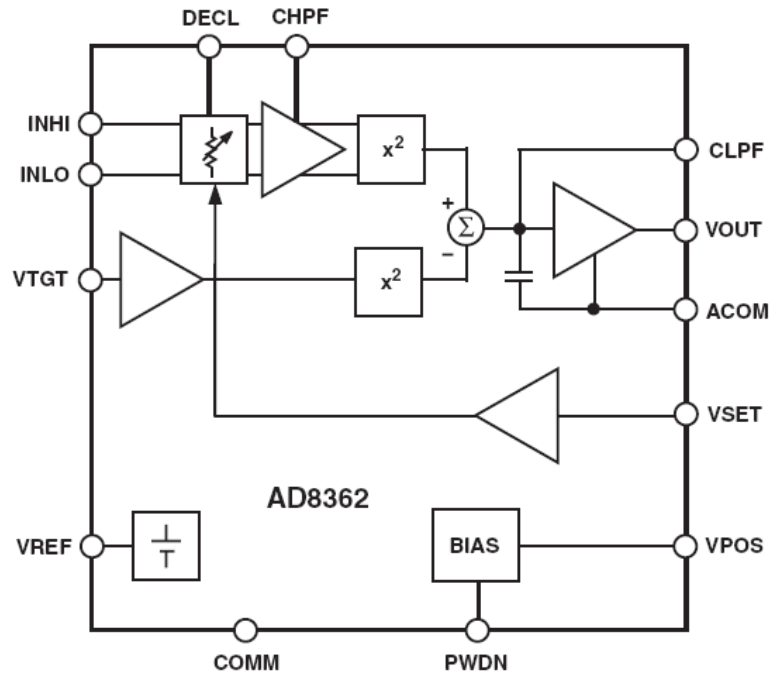
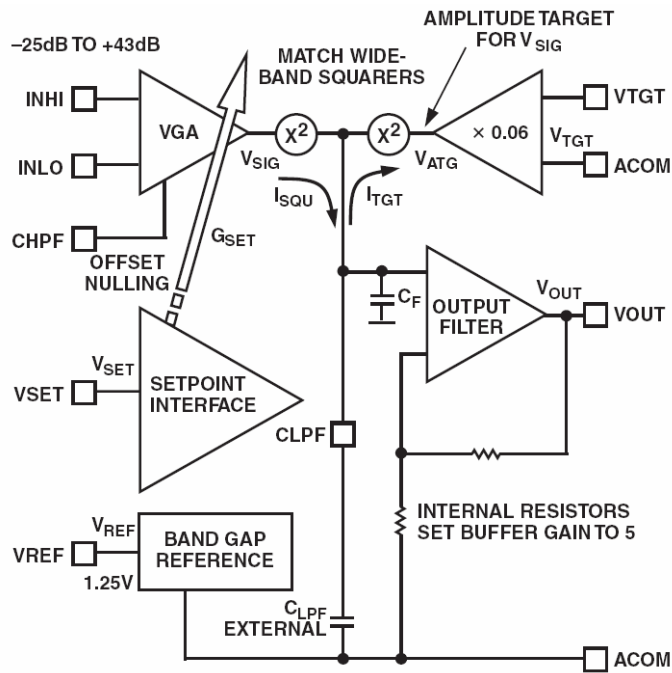Figure 1: AD8362 TruPwr RF RMS Detector Block Diagram

Figure 2: AD8362 Internal Structure

The difference in the outputs of these squaring cells is integrated in a high gain error amplifier, generating a voltage at the VOUT pin with rail-to-rail capabilities. In a controller mode, this low noise output can be used to vary the gain of a host system's RF amplifier, thus balancing the setpoint against the input power. Optionally, the voltage at VSET may be a replica of the RF signal's amplitude modulation, in which case the overall effect is to remove the modulation component prior to detection and low-pass filtering. The corner frequency of the averaging filter may be lowered without limit by adding an external capacitor at the CLPF pin.

The AD8362 can be used to determine the true power of a high frequency signal having a complex low frequency modulation envelope (or simply as a low frequency rms voltmeter). The high-pass corner generated by its offset-nulling loop can be
lowered by a capacitor added on the CHPF pin.

Used as a power measurement device, VOUT is strapped to VSET, and the output is then proportional to the logarithm of the rms value of the input; that is, the reading is presented directly in decibels, and is conveniently scaled 1 V per decade, that is, 50 mV/dB; other slopes are easily arranged. In controller modes (see Figure 3), the voltage applied to VSET determines the power level required at the input to null the deviation from the setpoint. The output buffer can provide high load currents.

The AD8362 can be powered down by a logic high applied to the PWDN pin, i.e., the consumption is reduced to about 1.3 mW. It powers up within about 20 µs to its nominal operating current of 20 mA at 25ºC.
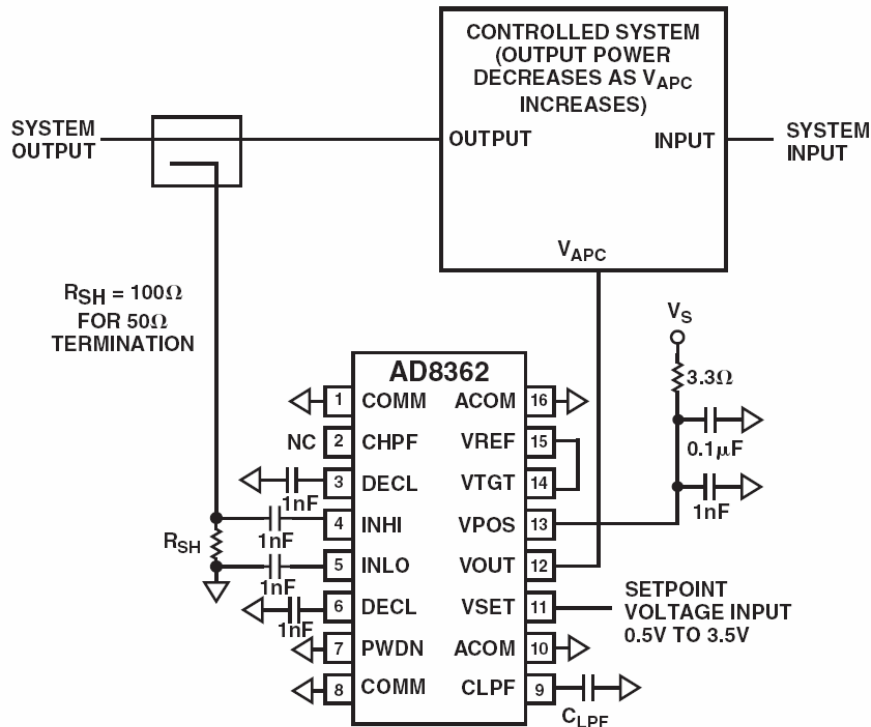

Figure 3: AD8362 Typical Application in Controller Mode

Other similar TruPwr RMS detectors from Analog Devices are the AD8361, AD8363, AD8364, all of which have outputs which are linear in dB. The ADL5500, ADL5501, and ADL5502 have outputs which are linear in volts.

REFERENCES:

1. Charles Kitchen and Lew Counts, *RMS-to-DC Conversion Application Guide, Second Edition,* Analog Devices, Inc., 1986.

2. Hank Zumbahlen, *Basic Linear Design*, Analog Devices, 2006, ISBN: 0-915550-28-1. Also available as *Linear Circuit Design Handbook*, Elsevier-Newnes, 2008, ISBN-10: 0750687037, ISBN-13: 978-0750687034. Chapter 4.