

# FAQs

Louis E. Frenzel  
Communications/Test Editor

## FREQUENTLY ASKED QUESTIONS

### What is an RF detector?

An RF detector monitors or samples the output of an RF circuit and develops a dc output voltage proportional to the power at that point.

### What do you do with an RF detector?

RF detectors are used primarily to measure and control RF power in wireless systems.

### Why are power measurement and control so important?

RF power, rather than voltage, is the primary measure of a wireless signal. In a receiver, signal strength is a key factor in maintaining reliable communications. In the transmitter, the amount of power transmitted is critical because of regulatory guidelines. It's also important for maintaining the range and reliability of the radio link.

### What is the unit of power measurement in RF applications?

The unit of power is the watt. However, it is common in most RF and wireless applications to express power in terms of dBm or decibels related to 1 mW:

$$\text{dBm} = 10 \log [\text{power(mW)} / 1 \text{ mW}]$$

The table shows the relationship between absolute power and dBm. This unit of measurement is usually referenced to an impedance of 50  $\Omega$ .

### What is the main application of RF detectors?

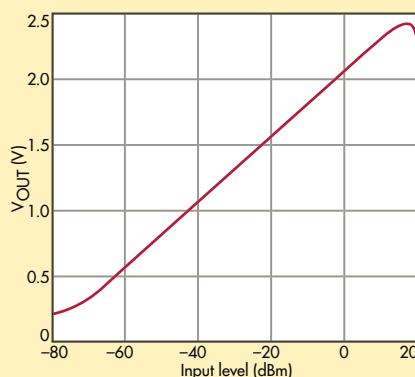
Transmitter output power measurement is the primary application. It is essential to know the RF output power because the application specifies it in most cases, and certain maximum values must not be exceeded according to Federal Communications

Commission regulations. In many cases, the transmitter power is controlled automatically. As a result, the output power is measured and compared to a set point level in a feedback control circuit so power can be adjusted as required.

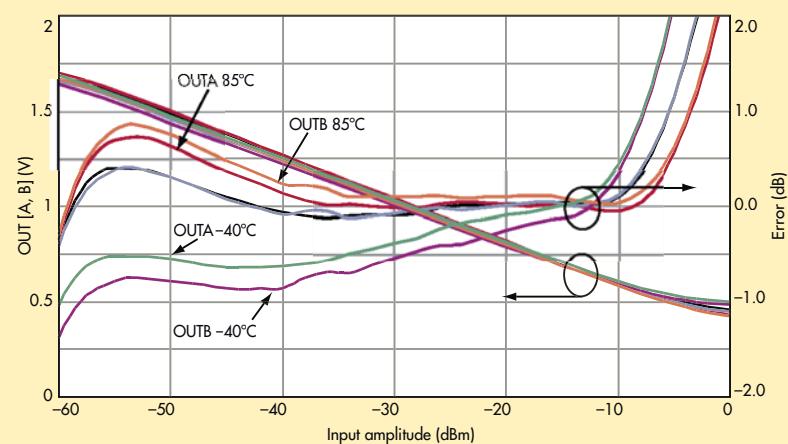
In receivers, power measurement is usually referred to as the received signal strength indicator (RSSI). The RSSI signal typically is used to control the gain of the RF/IF signal chain with an automatic gain control (AGC) or automatic level control (ALC) circuit to maintain a constant signal level suitable for analog-to-digital conversion and demodulation.

### What are some other uses of RF detectors?

Voltage standing-wave ratio (VSWR) measurement and control is another popular application in high-power RF amplifiers. Impedance mismatches (high VSWR) at the antenna cause reflections and lead to loss of transmitted power. Furthermore, high VSWR can damage an amplifier or a transmission line.



1. In a typical output curve for a logarithmic RF power detector, the output is linear over the logarithmic decibel input range.



2. This output voltage and temperature error curve of a dual logarithmic RF power detector includes variations from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  at 2.2 GHz.

When two logarithmic detectors are used, the power gain of a circuit can be measured by subtracting the input reading from the output reading. Normally, a gain calculation calls for dividing the output power reading by the input reading. This is a difficult math operation in analog circuits. But when the quantities are logarithmic, the division can be performed using a simple subtraction. Power amplifier linearization is another common use.

### Are there different types of RF detectors?

There are two basic types: the logarithmic type and the rms type. The log type converts the input RF power into a dc voltage proportional to the log of the input, making the output directly related to decibels. The rms detector creates a dc output proportional to the rms value of the signal.

### What does the output response of a log RF detector look like?

In a typical response curve of a log detector, the output is linear over the logarithmic decibel input range (Fig. 1). The slope of the curve is typically in the 20- to 25-mV/dB range.

### What are the general criteria for selecting one type of RF detector over another?

The type of RF signal to be measured is the most important determining factor in the type of detector to use. For most general power measurement and control applications, the log type is the most useful. For pulsed RF signals, the log type is also best because of the fast response times available. In those applications where the signal has a high crest factor or a widely varying crest factor, the rms type is generally better.

The crest factor is the ratio of the peak to rms value of the signal. For example, higher-order quad-

POWER LEVELS  
AND THEIR dBm  
EQUIVALENTS

Power	dBm
1 W	+30
100 mW	+20
10 mW	+10
1 mW	0
100 $\mu$ W	-10
10 $\mu$ W	-20
1 $\mu$ W	-30
100 nW	-40
10 nW	-50
1 nW	-60
100 pW	-70
10 pW	-80
1 pW	-90

rate amplitude modulation (QAM) signals (e.g., 16QAM, 64QAM, and 256QAM) have high crest factors. In the case of spread-spectrum signals such as those used in CDMA and WCDMA cellular systems and orthogonal frequency-division multiplexing (OFDM) signals such as WiMAX and WiBro, the high crest factor (typically 10 to 13 dB) will change dynamically. In such applications, an rms detector is generally more desirable.

## What about temperature stability?

Temperature stability is an expression of the variation of the measurement accuracy versus temperature. Temperature stability is generally expressed in dB, that is, the voltage variation at the output of the detector converted into dB. Some devices have a worst-case temperature stability of  $\pm 0.5$  dB over their full power range. Some detectors, though, achieve 0-dB temperature stability at the top end of their input range. Figure 2 shows a typical temperature error graph for a dual detector, where the 0-dB crossover point is at an input amplitude of -13 dBm.

## How can designers take advantage of the 0-dB crossover point?

The output of a power amplifier (PA) is sampled with a directional coupler. With the PA at max power, the coupler output should be attenuated down to the 0-dB crossover point of the RF detector. The detector output value is then digitized in an analog-to-digital converter (ADC) and sent to an embedded controller that calculates the power level based on previously stored calibration coefficients.

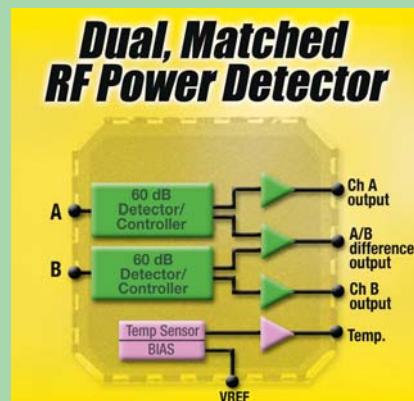
The power level is compared to a set point value. If the measured value is higher or lower than the set point, the controller uses a digital-to-analog converter (DAC) to control the gain of a variable gain amplifier (VGA). This results in a change in the output power at the PA. The near 0-dB temperature drift of the detector at the crossover point enables the ALC loop to very accurately control the PA's output power.

ED ONLINE 17106

## product Q&amp;As



## The industry's most comprehensive, award-winning, RF power detector portfolio



The dual RF power detector/controller precisely measures and controls the gain across the transmitter and receiver signal path within wireless infrastructure equipment. The dual detector is an integration of two detectors to provide accurate, independent, decibel-scaled voltage outputs of both RF input channels. In addition to the two matched output voltages, the dual detector provides a difference output that effectively measures the power gain or loss between the two inputs, and some even provide an accurately scaled temperature output. With two matched detectors, the precise matching of both channels reduces temperature- and part-to-part variations in comparison to discrete designs. With the difference output, the dual detector can accurately control the gain across a transmitter or receiver signal chain as each of the two individual detectors can be set to measure input signals at different frequencies over a 60-dB dynamic range. Specific applications include PA (power amplifier) control and linearization, antenna VSWR (voltage standing-wave ratio) monitoring, transmitter power control, and AGC (automatic gain control) circuits. Better control over the power and gain within a basestation PA allows designers to significantly reduce cost and improve operating efficiency.

## TruPwr™ RMS Detectors

Part Number	Max RF Freq (GHz)	Dynamic Range (dB)	Temp Drift (dB)	Output Response	Voltage Supply (V)	Supply Current (mA)	Package
AD8361	2.5	30	$\pm 0.50$	Linear in Volts	2.7 to 5.5	1.1	SOT-23; $\mu$ SOIC
AD8362	3.8	60	$\pm 1.00$	Linear in dB	4.5 to 5.5	20	16-Lead SOP
AD8364 (Dual)	2.7	60	$\pm 0.50$	Linear in dB	4.5 to 5.5	70	32-Lead CSP
ADL5501	4.0	30	$\pm 0.25$	Linear in Volts	2.7 to 5.5	1.1	6-Lead SC-70

## Logarithmic Detectors

Part Number	Max RF Freq (GHz)	Dynamic Range (dB)	Temp Drift (dB)	Response Time (ns)	Voltage Supply (V)	Supply Current (mA)	Package
AD8302 (Dual w/ Phase)	2.7	60	$\pm 0.50$	60	2.7 to 5.5	19	14-Lead TSSOP
AD8317	10	50	$\pm 0.50$	8	3 to 5.5	20	8-Lead CSP
AD8318	8.0	70	$\pm 0.50$	10	4.5 to 5.5	68	16-Lead CSP
AD8319	10.0	40	$\pm 0.50$	8	3 to 5.5	22	8-Lead CSP
ADL5519 (Dual)	10.0	64	$\pm 0.50$	8	3 to 5.5	56	32-Lead CSP

To view our complete selection of RF power detectors, go to

[www.analog.com/RFdetectors-FAQ](http://www.analog.com/RFdetectors-FAQ).



Visit [www.digikey.com](http://www.digikey.com) to get real-time pricing and availability on our wide selection of Analog Devices parts!

