design FAQs

RF Detectors For Wireless Devices

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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 Ω.

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.

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.

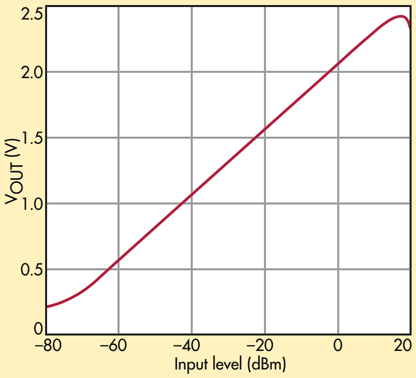
What does the output response of a log RF detector look like?

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.

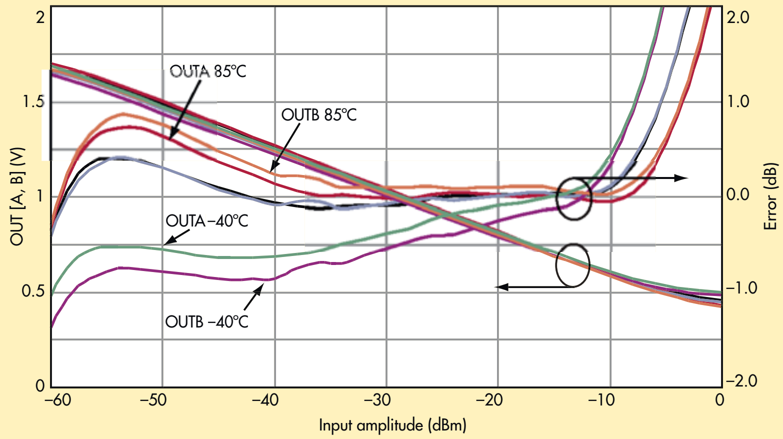
What are the general criteria for selecting one type of RF detector over another?

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-



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°C to 85°C at 2.2 GHz.

POWER LEVELS AND THEIR dBm EQUIVALENTS

Power	dBm
1 W	+30
100 mW	+20
10 mW	+10
1 mW	0
100 µW	–10
10 µW	–20
1 µW	–30
100 nW	–40
10 nW	–50
1 nW	–60
100 pW	–70
10 pW	–80
1 pW	–90

rature 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 ±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.

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