Log-amp performs advanced RF controls

By Ken Yang

The logarithmic amplifier (log-amp) is often used as an RF power-sensing device. Because of its low cost and wide dynamic range, it is commonly employed as a demodulator in ASK and FSK radio receivers. Today, the log-amp has expanded its role to include automatic gain and power-control loops.

The basic purpose of a log-amp is to convert an RF input signal to an output voltage proportional to the log of RF power. Modern log-amps accomplish this task with exceptional dynamic range, and their operation is simple. Inputs are single-ended or differential, and the detector outputs connect to the non-inverting terminal of an internal op-amp or transconductance amplifier. The integrated op-amp allows a user-adjustable slope and an easily implemented closed-loop operation for power-control applications. Output voltage is proportional to the log of the input power. Thus, the RF input power is calculated as follows:

$$P_{RFIN} = \frac{V_{OUT}}{SLOPE} + P_{INT} \qquad \text{Eq. 1}$$

$$V_{OUT} = SLOPE\,(P_{RFIN} - P_{INT}) \qquad \text{Eq. 2}$$

where P_{RFIN} is the RF input power in dBm, P_{INT} is the zero-volt intercept point in dBm, and SLOPE is the detector slope in mV/dB.

RF transmitter applications should maintain constant output power regardless of part-to-part variations or changes in supply voltage and temperature. That capability is important for power amplifiers operating near the saturation region (P1 dB compression point), where the gain drops as output power increases.

An automatic gain- or power-control loop employs a log-amp as shown in Figure 1, where a directional coupler connects the power-amplifier output to the log-amp input. The log-amp then monitors the output power and provides a dc voltage output to the error amplifier, which compares against a reference level. The error-amplifier output drives the power amplifier's gain input until the dc voltage derived from the output power equals the reference voltage applied at SET. Operating in a closed loop, the power amplifier maintains a constant output power that is independent of external variations. Output power is easily changed, however, by changing the reference voltage at SET.

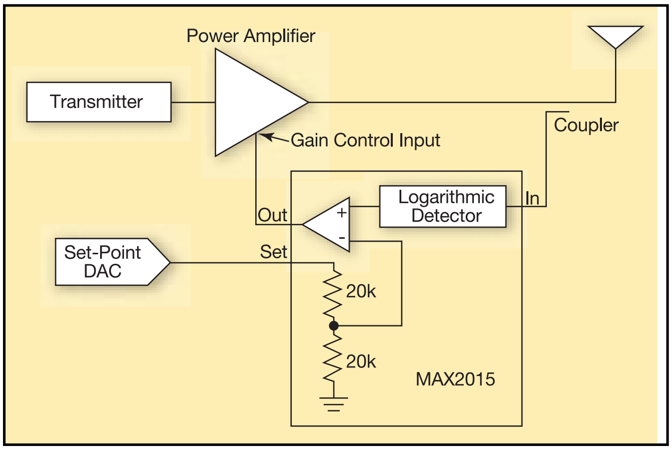

Figure 1. Operating in a closed loop, the power amplifier output is maintained constant by the MAX2015 even while operating near the compression point.

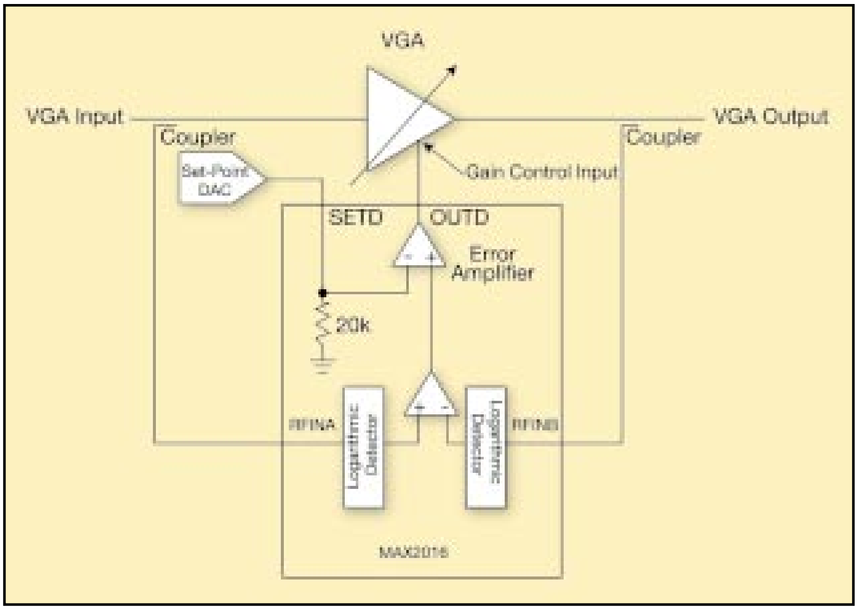

Figure 2. This dual log-amp regulates the variable-gain amplifier (VGA) to maintain a constant gain.

For applications that must regulate gain instead of power, the Figure 2 circuit maintains constant gain in the face of changes in supply voltage, temperature and output power. By monitoring the input and output power using two log-amps, you achieve gain regulation. Internal to the MAX2016 is a difference amplifier that produces a voltage proportional to the power difference or gain, and that voltage is fed to the error amplifier for comparison. The error-amplifier output then drives the AGC input of the power amplifier to maintain constant gain.

Steady advances in integrated circuit technology have enabled log-amps to expand their role beyond that of simple power detection and demodulation. They now perform advanced RF controls such as power-control loops and gain-control loops. Such RF control systems ensure that a system is operating with peak performance. RFD

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