

Integrated VGA Aids Precise Gain Control

An integrated VGA circuit with fixed-gain amplification and variable attenuation is useful for power leveling in both receivers and transmitters, even at high intermediate frequencies.

ain control is necessary in mobile-communications systems because of the wide range of transmitted and received signals. A base station for Global System for Mobile Communications (GSM), for example, must receive and demodulate signals from about -15 dBm to less than -104 dBm, even when in-band blocking signals can be as large as -13 dBm. The goal of the automatic-gain-control (AGC) circuitry

tionship between gain control voltage and gain is always desirable, in receiver (Rx) applications the ability to a constant signal level to the

in these systems is to provide a relatively constant input level to the analog-to-digital converter (ADC). Although gain control can be implemented at RF, intermediate frequency (IF), or baseband frequencies, most gain control operates at IF. While a precise reladeliver a constant signal level to the subsequent stages is generally more critical. Because of this, an analog or digital level detector is an important component for setting precise gain levels in mobile-communications systems.

Although mobile-communications



1. Gain control is instrumental in receivers and transmitters, in order to maintain precise power levels.

PHILLIP HALFORD Applications Engineer

Analog Devices, 804 Woburn St. MS-122, Wilmington, MA 01887; (781) 937-1834, e-mail: phillip.halford@analog.com, and

EAMON NASH Applications Engineer

Analog Devices, 804 Woburn St. MS-122, Wilmington, MA 01887; (781) 937-1239, e-mail: eamon.nash@analog.com.

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88

terminals must be able to transmit over a large power range, such as 75 dB in wideband code-division-multiple-access (WCDMA) systems, a large range of power control is also needed in the base station. Network operators must be able to vary cell sizes by fixing the nominal or static base-station power at system installation. In the case of GSM, the nominal base-station power can be adjustable over a





2. The AD8367 X-AMPTM architecture provides precise linear-in-dB gain control over a wide dynamic range.

12-dB range. If the base station has a fixed-gain power amplifer [PA] (which is generally the case), the nominal output of the base station must be set by varying the input signal to the PA (Fig. 1).

In addition, the transmit power will vary depending upon the distance to the mobile unit. Also, time-divisionmultiple-access (TDMA) systems such as GSM and IS-136 require orderly power ramping. This adds another 40 to 50 dB to the power-control range of

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the base station. In the case of a CDMA or WCDMA base station, the signal power out must be varied as the call loading in the cell varies.

In transmit applications where the output will be constantly varying for any or all of the previously stated reasons, the relationship between the gain of a variable-gain amplifier (VGA) and its gain-control voltage becomes important in the struggle to set the correct power. For example, if the VGA has a gain-control relationship that is linear, temperature-stable, and flat within the band of interest, a simple two-point VGA calibration will be sufficient. Using the calibration data, the base-station controller can confidently set the power and ignore changes in temperature and frequency. Without such linearity, however, a number of calibration points will be needed across the frequency band of interest. And if the performance varies as a function of temperature, additional calibration points will be needed to account for these temperature-dependent variations of gaincontrol voltage.

An AGC circuit typically consists of a variable attenuator followed by fixed-gain amplifiers. By integrating these functions on a single chip, it is possible to develop VGAs with high performance levels while dramatically shrinking the overall size of the circuitry. One development goal for a new generation of VGAs from Analog Devices

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was to meet performance requirements for a variety of cellular base-station systems over a wide range of IFs, even though achieving a temperature-stable, linear-in-dB gain-control range at high frequencies represents a significant challenge. For example, IFs in single-conversion superheterodyne Rxs for cellular base stations can be as high as 380 MHz. One of those integrated VGAs, the model AD8367, integrates a variable atttenuator with a 45-dB range (0-to-45-dB attenuation) with a very linear fixed-gain amplifier (Fig. 2).

The AD8367 is based on the company's patented X-Amp[®] architecture (named after the exponential nature of the gain-control function). The precise linear-in-dB scaling [i.e., (gain (in dB)/(VAGC (in V) is constant] significantly simplifies AGC design in cellu3. Temperature-stable, linear-in-dB gain control allows for precise setting of gain over a wide dynamic range.





93

MARCH 2002

lar base stations compared to the use of discrete VGAs or PIN-diode attenuators with cascaded gain amplifiers. The main signal path consists of a voltage-controlled 0-to-45-dB attenuator followed by a 42.5-dB fixed-gain amplifier. The AD8367 is designed to operate

optimally in a 200- Ω system.

In addition, the AD8367 has an integrated squarelaw detector for the AGC function.



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4. As gain increases, the AD8367's noise figure improves while the OIP3 remains fairly constant.

In AGC mode, the gain-bias pin provides the received-signal-strength-indication (RSSI) control and the output signal is leveled 354 mV RMS (1 V p-p for an unmodulated sine wave). This circuit is particularly useful if an Rx must handle signals with different modulation formats. A good example of this would be a modern GSM base station that must receive both Gaussian minimum-shiftkeying (GMSK) and eight-state phaseshift-keying (8-PSK) modulation (EDGE) signals.

The integration of attenuator followed by fixed-gain amplifier is an ideally suited to Rx AGC circuits, since the input third-order-intercept (IIP3) and the noise figure track dB per dB with the gain setting (Fig. 3). When the input signal is strongest, the gain is at a minimum and the IIP3 and noise figure are at maximum levels. When a received signal is weakest, the gain is at a maximum and the IIP3 and noise figure are optimum for the weak signal, thereby maintaining a wide signal dynamic range. The output third-order-intercept (OIP3) and output power at 1-dB compression are independent of the gain and temperature, which is another significant advantage over discrete VGAs, which can suffer drifting output power levels with temperature and gain settings (Fig. 4).

The AD8367 is packaged in a 14lead thin shrunk small outline package (TSSOP) and is characterized for operating temperatures from -40 to +85°C. It operates on a single voltage supply from +3 to +5 VDC. The integrated device has a 3-dB bandwidth of 500 MHz, and has been thoroughly evaluated at common IFs such as 70, 140, 190, and 240 MHz. Evaluation boards and samples are now available.

94