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Matched High-Efficiency WLAN PA Powers Up 802.11b Reference Designs

This GaAs HBT WLAN power amplifier is easy to implement and has the features and performance needed for low cost 802.11b and other WLAN products

Present day WLAN solutions require reduced Bill-Of-Material (BOM) costs, usually achieved through a high level of integration. To address the current market needs, RF Micro Devices has added a 50-ohm input/output matched 802.11b WLAN power amplifier (RF5189) to its WLAN PA portfolio. It is a linear, medium power, high efficiency amplifier designed for battery operated WLAN applications such as PC cards, mini PCI and compact flash applications. The RF5189 requires only a few external discrete components for optimal performance, and it has on-chip power detector circuitry for ease of use.

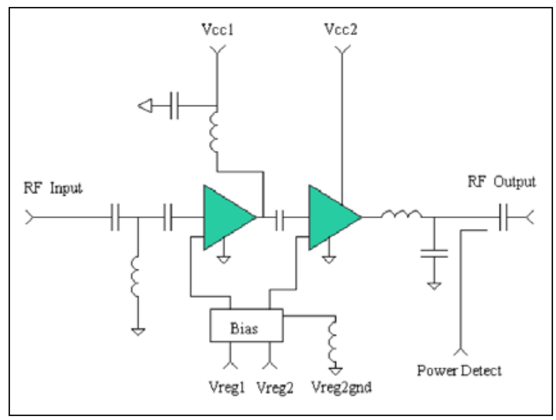

Figure 1 · RF 5189 die schematic.

Circuit Description

RF5189 is a two-stage device with a nominal gain of 25 dB in 2.4 to 2.5 GHz band. The device is capable of delivering more than +21 dBm 802.11b linear output power in 3 volt applications. Figure 1 shows the schematic of the GaAs die.

This product is designed using RFMD's advanced Gallium Arsenide Heterojunction Bipolar (GaAs HBT) Technology. To minimize the die area, stacked, low-loss capacitors are used for on-chip matching. The high pass input match uses an on-chip spiral inductor. The input match configuration was chosen to attenuate the low frequency signals. The two RF stages are biased using a simple current mirror configuration, which provides excellent temperature tracking. The output match comprises a single section low-pass match.

Figure 2 shows evaluation board schematic that uses a few external components for optimal operation of the device. It uses two inductors and four external bypass capacitors. This device is packaged in 12-pin QFN lead frame package.

The on-chip power detector allows a wide detector output voltage range. The detector circuit used in RF5189 is essentially a peak detector circuit that uses a scaled active device for detection. The ratio of the detector device to the RF device is chosen, then biased with inversely scaled ballast resistors. This creates a proportionally scaled bias current in the detector device. The RF output signal is capacitively coupled through a capacitor from the RF output path. The RF impedance at the point where the RF is coupled into the detector determines the dynamic range of the detector voltage: a lower RF impedance results in a smaller detected dynamic range. Since the RF5189 is a matched 50 ohm input/output device, RF is coupled into the detector close to the 50-ohm point to provide

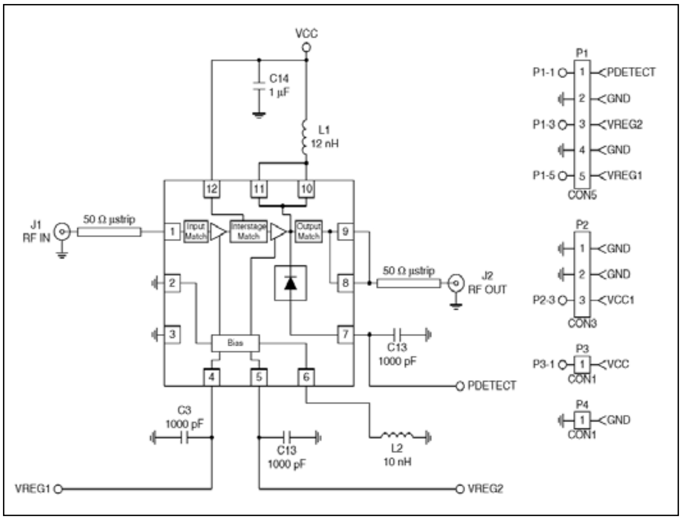

Figure 2 · RF5189 Evaluation Board schematic.

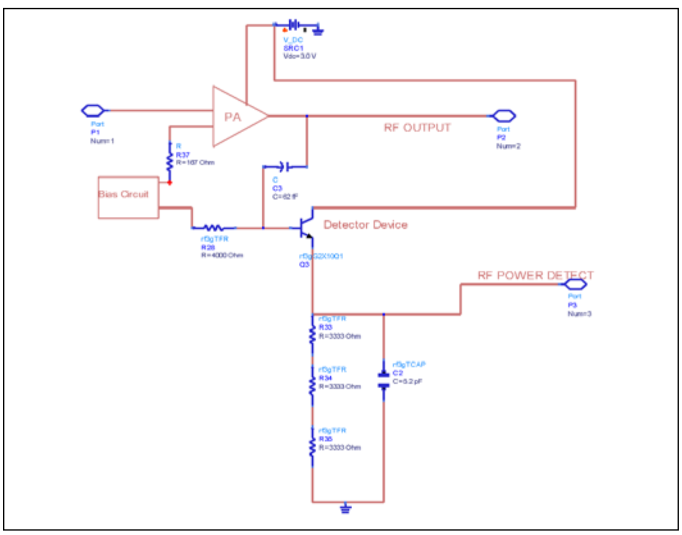

Figure 3 · On-chip RF detector schematic.

the widest available dynamic range. At the detector device emitter is a parallel RC circuit to ground, with the detector voltage sensed at the emitter of the detector. This circuit is implemented on-chip. The detector circuit schematic is shown in Figure 3.

The transmit power control loop at the system level, maintains a constant power output as conditions and time change. This is implemented by sampling the power detector output and subtracting it from a reference signal to generate the error signal. The control loop works to minimize the error signal. At the reference design level, an analog-to-digital converter (ADC) is integrated into the baseband chip and a software algorithm controls the transmitter gain prior to the PA by maintaining the target detector voltage. The target detector voltage is found by calibrating the finished card to an external power

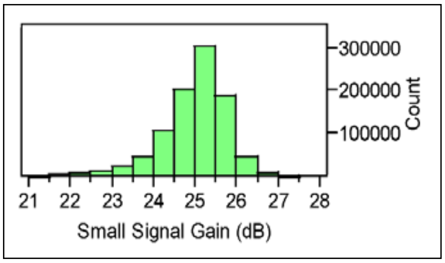

Figure 4 · Small signal gain distribution at V_c = 3 V and V_{reg} = 2.7 V.

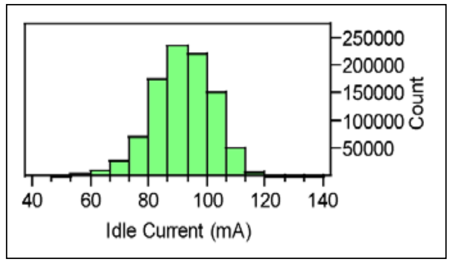

Figure 5 · Idle current distribution at V_c = 3 V and V_{reg} = 2.7 V.

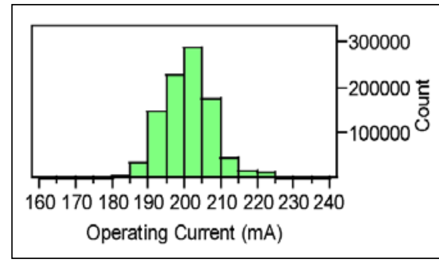

Figure 6 · Operating current distribution at P_{out} = +21 dBm , V_c = 3 V and V_{reg} = 2.7 V.

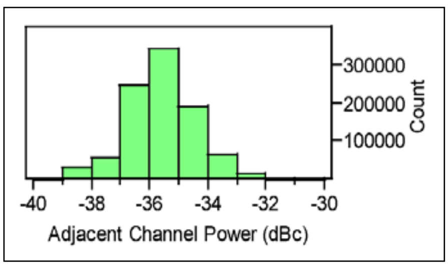

Figure 7 · Adjacent channel power at P_{out} = +21 dBm, V_c = 3 V and V_{reg} = 2.7 V.

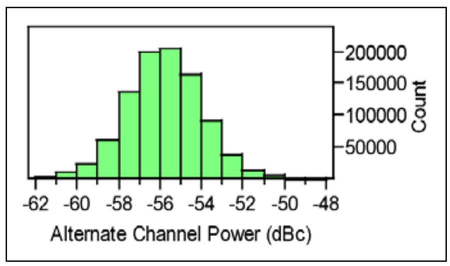

Figure 8 · Alternate channel power at P_{out} = +21 dBm, V_c = 3 V and V_{reg} = 2.7 V.

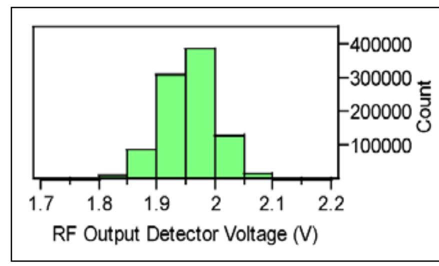

Figure 9 · RF output detector voltage distribution at P_{out} =+21 dBm, V_c = 3 V and V_{reg} = 2.7 V.

meter and reading the power detect ADC magnitude while transmitting the signal.

RF5189 Test Results

RF5189 was brought into production earlier in the year 2003. And, since then this device has been shipped in large volume to our customers. These devices are comprehensively tested in house at the RFMD production test facility in Greensboro, NC. Figure 4 shows the small-signal gain distribution of ~1 million devices tested at nominal V_c = 3 V and V_{reg} = 2.7 V. The mean small signal gain is centered around 25 dB.

The mean quiescent idle current of the devices is 92 mA. Figure 5 shows the quiescent current distribution of these devices.

In production, the devices are tested at linear P_{out} of +21 dBm and associated parameters are recorded. Figure 6 shows the distribution of the operating current at the measured +21 dBm linear output power.

The 802.11b transmit spectral mask requirements call out for less than –30 dBc relative to the the sin*x*/*x* peak for adjacent channel sidelobes and –50 dBc for alternate channel sidelobes. Measurements on the RF5189 hold good for the adjacent channel –30 dBc specification at:

$$(f_c - 22\text{ MHz}) < f < (f_c - 11\text{ MHz}) \text{ and}$$
$$(f_c + 11\text{ MHz}) < f_c < (f_c + 22\text{ MHz})$$

and for the –50 dB alternate channel specification at:

$$f < (f_c - 22\text{ MHz}) \text{ and}$$
$$f > (f_c + 22)\text{ MHz}$$

where f_c is the channel center frequency. The distribution of adjacent and alternate channel power at P_{out} = +21 dBm are shown in Figures 7 and 8, respectively.

The co-located detector circuitry is implemented using the same RF technology and it provides an excellent manufacturing process tracking. Figure 9 shows the distribution of the RF detector voltage at +21 dBm output power.

Conclusion

Although RF5189 has been designed and production tested for 802.11b application, our test results indicate that the linearity of this device is also capable of meeting stringent 64 QAM, 54 MB/sec 802.11g signal requirements at a reduced output power of +18 dBm.

Contributors

Virender Sadhir, Jeff Jones, Mike Goss, Ahmad Abdelmajid and Erol Yurtkuran are the RF Micro Devices engineers who contributed to the application and measurement information contained in this article. For more information, contact:

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