Low Cost, Low Voltage Power Amplifier for ISM Applications

Abstract

RF Micro Devices introduces a new low cost, low voltage power amplifier manufactured in an advanced Silicon bipolar technology. The power amplifier operates from 400MHz up to 1GHz and delivers 0.5W at 3.6V with a gain of 21dB. The analog gain control provides 40dB of range. This power amplifier is intended for cost-sensitive applications, such as the final output stage for a 900MHz ISM band cordless phone or as a driver for 400MHz mobile phones. The device operates from a single 3.6V power supply without the need for a negative voltage. The on-board gain control also doubles as Power Down control, and the device draws less than 10µA of supply current when in the power down mode, eliminating the need for a supply side switch. The part is packaged in a thermally enhanced, industry standard 16-lead SOIC with fused leads. Pricing is very competitive at less than $2.

Introduction

Cordless phone manufacturers are under constant pressure to reduce the cost of handsets, and at the same time to improve performance. Phone designs which operate with a low voltage (thus a smaller and lighter battery) and use highly integrated electronics (thus smaller and cheaper) are the most likely to succeed in this market. Spread spectrum handsets operating in the 915MHz ISM band offer a clear advantage over their VHF predecessors. The users of spread spectrum handsets are less likely to experience line interference compared with the 45MHz handsets. Electronic noise from appliances, computers and other electronic devices, along with typically poor range, are characteristic of the old 45MHz cordless phones. These problems do not exist in the 900MHz spread spectrum phones due to the digital modulation. The FCC rules Part 15 allow up to 1W of transmitted power in this band. However, battery life and talk time are reduced as the output power is increased. Cordless phone manufacturers have generally kept their output power levels around 250mW in order to get the best trade-off of talk time versus handset range. Allowing 3dB for loss for filtering and an RX/TX switch between the PA and the antenna, the output power required from the PA is 500mW. Some cordless phones also implement a power control function to maximize talk time.

Ideally suited for this 900MHz application is the RF2104, a new power amplifier from RF Micro Devices. This integrated PA is also well suited for lower frequency applications, such as a driver amplifier for 400MHz mobile phones and base stations. This Low Voltage PA amplifies a +6dBm input signal to +27dBm of output power, drawing about 350mA of current from a single 3.6V supply. With the proper output matching circuit, similar performance can be achieved at voltages as low as 2.7V. Higher power levels of up to 1W are also possible, but with less ruggedness into output load mismatches. When the power control pin is reduced to 0.5V, the PA draws less than 10µA of supply current when the input RF power is removed, eliminating the need for a supply side switch. The RF2104 is packaged in a thermally enhanced version of the standard 16-lead SOIC with fused leads. When compared to and implemented with discrete components, the RF2104 greatly reduces the component count, overall size, performance variations, and most importantly, the overall cost.

RF2104 Theory of Operation and Application Information

The block diagram for the RF2104 is shown in Figure 1. The IC is a two-stage power amplifier with

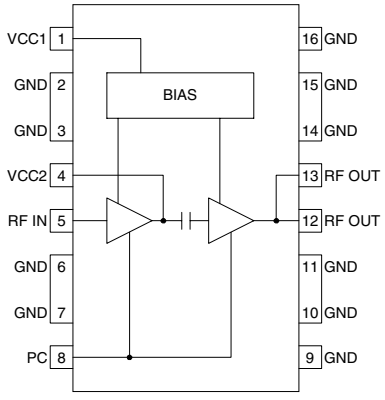


Figure 1. Block Diagram and Pinout for RF2104

26dB of small-signal gain that operates between 2.7V and 6.0V. With an input drive level of +6dBm, the PA delivers over +27dBm with an efficiency of about 40 percent from a 3.6V supply. A power down feature is implemented with a single pin interface (Pin 8); when this pin is at less than 0.5V, the PA draws less than 10µA provided the input RF power is turned off (when the RF input is still at +6dBm the device draws about

4mA due to self-biasing of the input stage). When the voltage on the power control pin is increased to a nominal value of 2.5V, the PA is set for maximum output power. This pin draws about 1mA of current when set to 2.5V. Pin 1 is connected to the battery voltage and is used to supply base current to the RF transistors.

The ground for the device is achieved through the four large pins on both sides of the device. These pins should be connected directly with vias to the PCB ground plane. The RF output is brought through Pins 12 and 13, which are used for the output signal, as well as to feed the bias current to the final stage.

The amplifier operates in Class AB mode. When the power control is set for maximum output power, the idle current is 250mA. When an RF signal is applied to the input, the output stage self-biases, and draws about 350mA of DC current.

Interstage Matching

Pin 4 is the supply voltage for the first stage. The inductance between this pin and the bypass capacitor sets the frequency of the small-signal gain peak. A short PCB trace between the pin and bypass capacitor, together with the internal bondwire inductance, conveniently realizes this inductance. Moving this capacitor away from the device shifts the gain peak to a lower frequency.

Input Matching

The input of the RF2104 is internally matched to 50Ω. The input is DC coupled and requires a blocking capacitor. A series capacitor and shunt inductor can be added to the input to improve the VSWR. Without external matching, the return loss of the input is about -10dB.

Output Matching

The optimum load impedance to the device is 5Ω. With this impedance, power levels over 1W can be achieved. However, if the device has to operate into high mismatches at the output, which is generally the case in hand-held equipment, it is recommended to reduce the maximum output power and increase the load impedance. The output pins also provide the bias for the output stage. A stripline or inductor to the V_{CC} is required. Because the impedance at the output is low, a small inductor or short stripline can be chosen. It is not necessary to use a quarter wave stripline; a line or inductor that provides an impedance of more than 50Ω is sufficient. Details of the implementation of those matching circuits can be seen in Figure 2. Note that several of the bypass capacitors are only required on the test board connected with long wires to the test equipment. In a practical phone design, capacitors (C2, C4, C6, C8) can be eliminated.

RF2104 Performance

A full data sheet can be obtained from RF Micro Devices.

The performance of the RF2104 has been characterized using a low-cost, 30mil FR-4 printed circuit board. Evaluation boards for 915MHz and 830MHz are available. The application schematic and layout drawing for the PA for 915MHz operation are included in Figures 2 and 3.

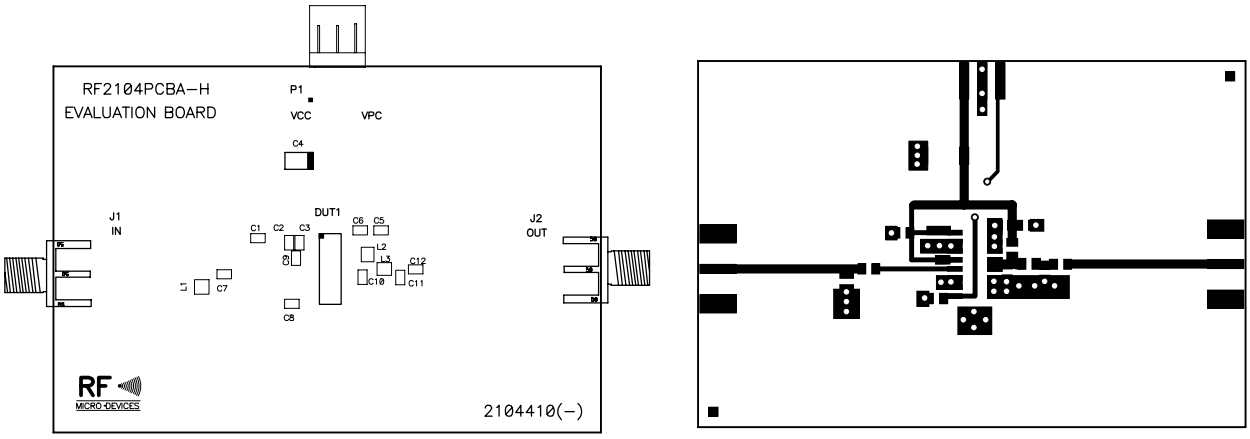
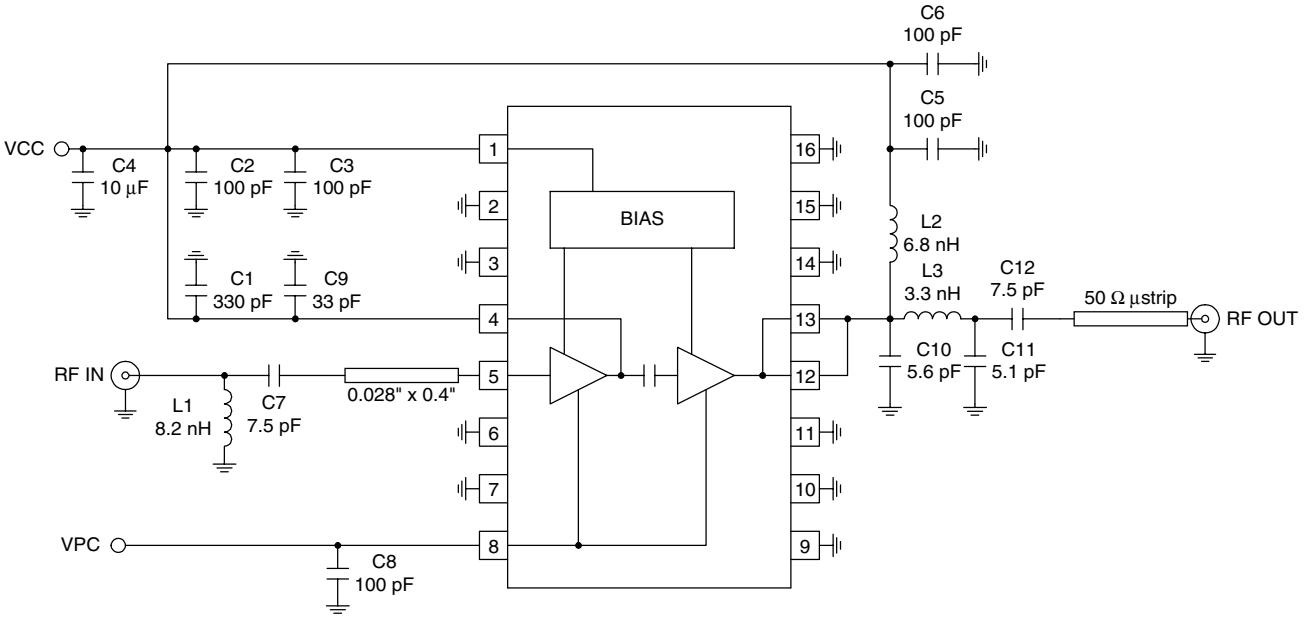


Figure 3. Test board layout for the RF2104 for 915MHz operation



Note: Efficiency is affected by actual position of C9 and C10; C9 is mounted close to DUT and C10 mounted away from DUT.

Figure 2. 915MHz test circuit of the RF2104

Some typical performance curves are shown in Figures 4 and 5.

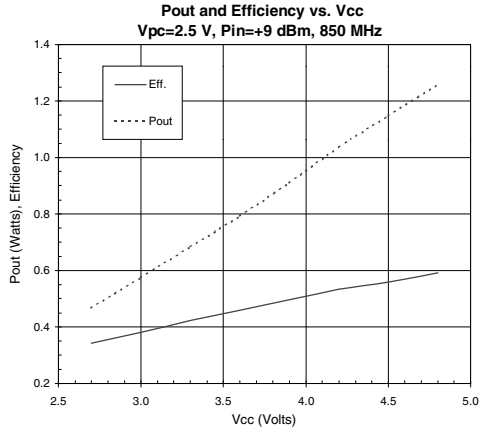


Figure 4. Typical performance of the RF2104

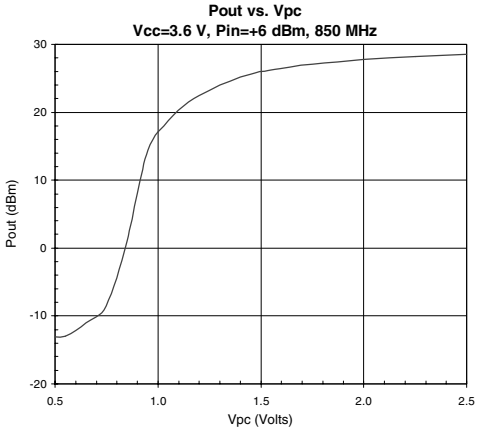


Figure 5. Typical performance of the RF2104

Conclusion

The RF2104 Power Amplifier is introduced by RF Micro Devices. With a +6dBm input level, this IC amplifier delivers 0.5W operating from a single supply from 2.7V to 5.5V. Additionally, the PA offers a convenient analog power control function. The RF2104 has applications in any analog or digital communication system that requires a low-voltage, low-cost PA. Specifically, this IC was designed for 900MHz cordless phones and 400MHz industrial radios, where the device will simplify the transmitter design, reduce overall component count, and reduce cost. Using discrete matching components, the size required for this PA is less than 0.4 square inches. The price of the RF2104 is less than $2.

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