A Transceiver IC for Cordless Telephones

Introduction

The RF9904 transceiver is a monolithic integrated circuit that was primarily developed for the expanding 900MHz digital cordless telephone market. Manufacturers require a more integrated approach to their design in order to lower manufacturing costs and increase reliability compared to discrete designs. Channel frequency hopping, direct sequence spread spectrum modulation, or a combination of these two, are utilized in cordless telephone technology. The RF9904 can be used in designs using direct sequence spread spectrum modulation. The device is manufactured in a low cost, commercially available silicon bipolar process. The process features NPN transistors with an f_t of 5GHz, PNP transistors with an f_t of 1GHz, thin film resistors, Schottky diodes, and capacitors.

Product Description

A functional block diagram of the RF9904 is shown in Figure 1. The transceiver includes a transmit BPSK modulator and a receive quadrature demodulator. The LO input is split between the transmit and receive section, each section having LO buffer amplifiers. Only a single external LO source is needed, since direct modulation and demodulation at the carrier frequency are used. The RF9904 operates over the 700MHz to 1100MHz frequency range and has a separate RX and TX power control. They are supplied in an SOIC16 package and require a 4V to 6V supply.

Figure 1: RF9904 Functional Block Diagram

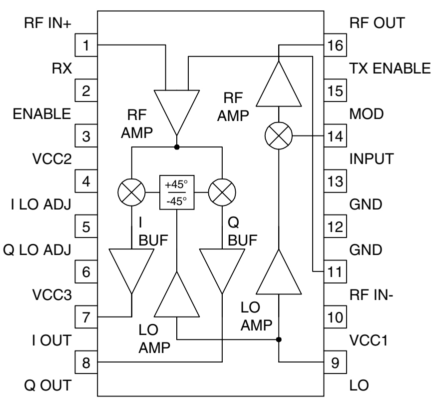


Figure 1. RF9904 Functional Block Diagram

Transmit Section

The transmit section of the RF9904 consists of a LO amplifier/buffer, BPSK modulator and an RF amplifier. The LO input, typically between -6dBm and 0dBm, is split between the transmit and the receive sections. A combination of differential amplifiers and emitter followers provide the gain and buffering required to drive the BPSK modulator. The LO signal is coupled to a set of differential pairs with their collectors cross-coupled. The modulation signal is applied to a lower differential pair and the modulation input can range from 0MHz to 15MHz with up to 0.5V peak-to-peak. The resultant phase of the carrier is shifted 0 degrees or 180 degrees depending on the modulation waveform. The output is a double sideband suppressed carrier signal with typical carrier suppression >25dBc for the maximum input level. The modulation input has an internal 6kΩ resistor to ground and should have a nominal 0V offset. The DC offset sets the carrier suppression and can be between +1V and -1V.

A final stage of RF amplification follows the modulator and has an open collector output. This pin requires an external inductor to V_{CC} for biasing. The inductor can be incorporated into an output-matching network. The maximum output from the chip is -7dBm to -12dBm and in the transmit mode the part draws 12mA.

Receive Section

This section describes the quadrature demodulation function in the receive section. The LO input is first amplified, and then in order to achieve quadrature demodulation, the LO signals to each mixer must be in phase quadrature. A simple, yet accurate method of phase shifting on-chip is to use an R-C network. The network combines a low- and high-pass filter. Each of the networks provides a 45 degree phase shift to the LO signal but in opposite directions, hence the required 90 degrees is obtained. The accuracy of the 90 degree phasing is more dependent on the matching of the R and C rather than their absolute tolerance, while the amplitude balance is exact at only one frequency. Differential amplifier limiters are placed between the phase shifters and mixer LO ports so that the quadrature signals are amplified until they are clipping, removing an amplitude imbalance in the LO drive to the mixers.

The quadrature LO signals are coupled to the top transistors in a modified Gilbert Cell configuration used for the I and Q mixers. The RF input signal is amplified by differential amplifiers, which form the lower part of the modified I and Q mixers. The RF input is single-ended and requires an external DC blocking capacitor.

The I and Q outputs are amplified by differential amplifiers which drive a push-pull output configuration to provide a 50Ω single-ended output. The amplitude error is <0.5dB and the phase error is <1 degree at the nominal operating point of V_{CC} = 5V and an LO input level of -3dBm. There are two external resistors to ground that can be used to adjust the bias on the I and Q LO amplifiers. Typical values for these resistors are between 0Ω and 200Ω. These can be used to adjust the amplitude balance and phase error for non-optimum values of V_{CC} and LO input level. Figures 2 and 3 show amplitude and phase error versus LO input level. These results were taken on an evaluation board that had been optimized for amplitude error across a range of different LO input levels. The same board could have been optimized for phase error with a resulting degradation in the amplitude error. The noise figure is between 10dB and 15dB depending on the RF input network. This means that some form of front-end low noise amplification is required. The current consumption in the receive mode is typically 27mA at 5V.

Figure 2: RF9904 Amplitude Error versus LO Input Level

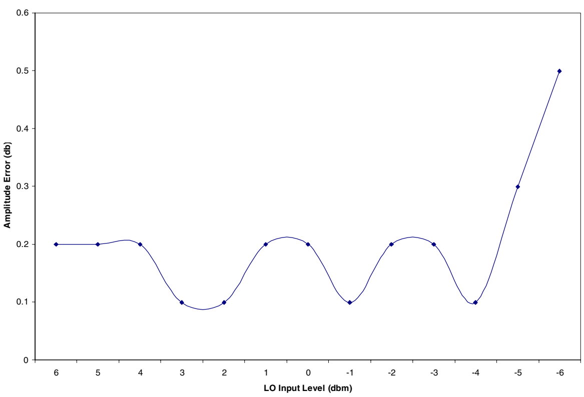
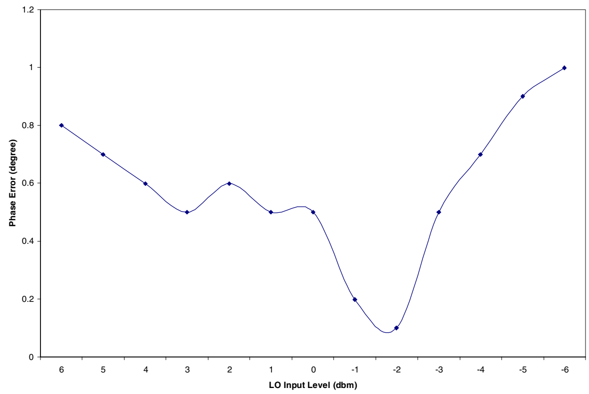


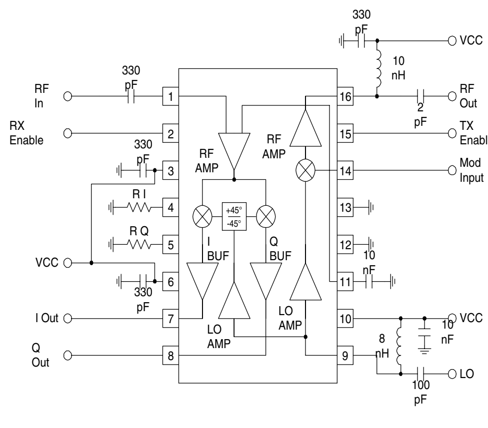
Figure 3: RF9904 Phase Error versus LO Input Level



Application Circuit

The circuit shown in Figure 4 was used to demonstrate typical performance of the RF9904. The RF and LO inputs are DC blocked while a DC block should be used on the modulation input if a DC level of 0V is required and also on the I and Q outputs since a DC level is present there. A pull-up inductor to V_{CC} is required on the RF output and all V_{CC} inputs should be bypassed as close as possible to the device. The switching between the transmit and receive mode is achieved by TX enable or RX enable being set high, typically to V_{CC}.

Figure 4: RF9904 916MHz Application Schematic



Conclusion

The RF9904's easily implemented transmit and receive capabilities make it suitable for many direct sequence spread spectrum applications. It has been used along with a front end IC in high volume cordless telephone manufacturing, helping to reduce system costs and increasing reliability without affecting performance.