

A BASE-BAND TO RF BiCMOS TRANSMITTER RFIC FOR DUAL-BAND CDMA/AMPS WIRELESS HANDSETS

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ABSTRACT

A single chip, base-band to RF, BiCMOS transmitter RFIC (RFT3100) for dual-band CDMA/AMPS wireless handsets is presented. The RFIC contains base-band I/Q modulator, UHF VCO Buffer, IF PLL, VCO, IF and RF VGA's, image rejection RF upconverter, dual driver amplifiers for cellular and PCS bands, and a three wire serial interface to control the chip. The chip operates from a 2.7 to 3.3V supply, a temperature range of -30 to 85° C, and is packaged in a 32 lead 5x5mm bump chip carrier (BCC) package. The chip is fabricated using a 18 GHz (analog NPN ft), 0.5 um BiCMOS process.

INTRODUCTION

The proliferation and coexistence of CDMA cellular and personal communication services (PCS) in the US creates a need for dual-band mobile phones. High levels of integration are required to reduce handset cost and size while providing adequate system performance under all operating conditions. Previously base-band and IF functions were integrated into a single chip while the RF portions were implemented as individual building blocks or partially integrated solutions [1-4]. This paper describes the design of a single chip base-band to RF transmitter RFIC for dual band CDMA/AMPS handsets. A block diagram of the chip is shown in fig. 1.

TRANSMITTER ARCHITECTURE

CDMA transmitter design requires special considerations. The CDMA signal is not

constant envelope, thus requiring linear amplification to meet spectral requirements for adjacent channel emissions. In addition, implementation of open and closed loop transmitter power control [5] requires a variable gain amplifier with 90 dB of gain control range. Further, the CDMA system is full duplex, thus transmitter output noise generated in the receive band must be low enough to not desensitize the receiver while transmitting at maximum output power thus requiring high dynamic range circuits or use of external filters.

A double conversion transmitter architecture was chosen to satisfy design constraints resulting from wide gain control range, limited isolation on silicon IC [6], and low noise. This architecture reduces VGA isolation requirements by dividing the total gain range amongst two VGA's: one operating at RF and the other at the IF. The design constraints for FM analog operation using quadrature modulation requires an accurate base band to IF converter that provides substantial image and carrier suppression.

The ability to add filtering is an advantage of a double conversion transmitter; however, for handsets, the addition of external ceramic, SAW, or L-C filters is costly and consumes considerable board area. Typical designs require IF filtering before the RF upconverter and RF filtering before the driver amplifier to reduce receive band noise and the unwanted RF image. The presented architecture requires only a single IF LC tank filter to reduce receive band noise and IF spurious products. The RF unconverter is an image rejection mixer

backside of the board are power supply by-pass capacitors.

CONCLUSIONS

A single chip BiCMOS transmitter RFIC for CDMA/AMPS dual-band handsets has been presented. The RFIC reduces the amount of board area needed for single and dual-band transmitter applications by using compact packaging and elimination of bulky IF and RF filters. The chip contains a 3-wire serial bus interface for controlling PLL, RF, and bias functions. Dual driver amps for each band provide flexibility to trade off output power, current consumption, and linearity requirements for specific applications.

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REFERENCES

[1] M. Nettles, M. Chang, G. McAllister, B. Nise, C. Persico, K. Sahota, J. Tero, "Analog baseband processor for CDMA/FM portable cellular telephones," *1995 ISSCC Digest of Technical Papers*, pp. 328-329, 1995.

[1] V. Aparin, K. Gard, G. Klemens and C. Persico, "GaAs RFICS for CDMA/AMPS dual-band wireless transmitters," *1998 IEEE MTT-S Int. Microwave Symp. Digest*, pp. 81-84, 1998.

[2] K. Harrington, et al., "Highly Integrated MMIC Upconverters/Drivers for Cellular and PCS CDMA Handsets," *1999 IEEE MTT-S Int. Microwave Symp. Digest*, pp. 77-80, 1999.

[3] K. Carter, et al., "A CDMA/FM Upconverter and Variable-Gain Driver Amplifier Integrated Circuit," *1999 IEEE MTT-S Int. Microwave Symp. Digest*, pp. 81-84, 1999.

[4] TIA/EIA IS-95, *Mobile station-base station compatibility standard for dual-mode wideband spectrum cellular systems*, Telecommunications Industry Association, July 1993.

[5] N.K. Verghese, T.J. Schmerbeck, and D.J. Allstot, *Simulation Techniques and Solutions for Mixed-Signal Coupling in Integrated Circuits*, Kluwer, Boston, 1995.

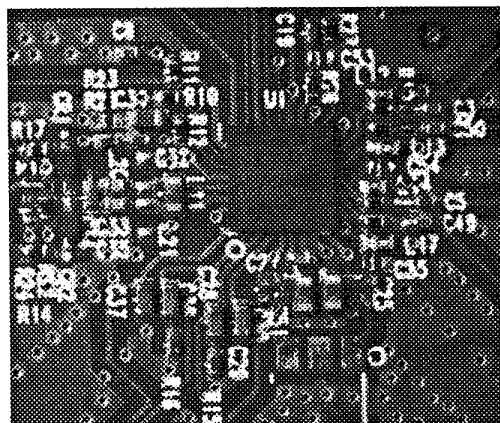


Figure 2: Photograph of RFIC dual-band application circuit.

Table 1: Measured typical RFIC performance at 25°C and 2.85V supply voltage.

Measurement Parameter	Measurement	Comments
Maximum CDMA Output Power at 836 MHz	+12 dBm	
ACPR at 885kHz offset, Channel power in a 1.23MHz bandwidth and ACP in a 30kHz	≤ -52 dBc	Pout = 8 dBm
Maximum FM Output Power at 836 MHz	+14 dBm	
Max CDMA Output Power at 1.88 GHz	+14 dBm	Outputs power combined
ACPR at 1.25MHz offset, Channel power in a 1.23MHz bandwidth and ACP in a 30kHz	≤ -52 dBc	Pout = 8 dBm
Minimum CDMA Output Power	-77 dBm	
Rx Band Noise at 45 MHz Offset (cellular)	-135 dBm/Hz	FM Pout = 10 dBm
Rx Band Noise at 80 MHz Offset (PCS)	-137 dBm/Hz	CDMA Pout = 8 dBm
In-band Carrier Suppression	-45 dBc ≤	
IF Image Suppression	-34 dBc ≤	
RF Image Suppression	-26 dBc ≤	
RF LO Leakage	-17 dBm ≤	
VCO Frequency range	100 to 550MHz	
VCO Phase Noise	-70dBc/Hz ≤ -80dBc/Hz ≤ -90dBc/Hz ≤ -100dBc/Hz ≤ -110dBc/Hz ≤	1 kHz offset 3 kHz offset 10 kHz offset 30 kHz offset 100 kHz offset
Total supply current: Power Down	≤ 60 uA	
Cellular Max Pout	113 mA	Pout = 8 dBm
Cellular Min Pout	67 mA	
PCS Max Pout	107 mA	Pout = 8 dBm
PCS Min Pout	68 mA	