MMIC Differential LC-VCO and Mixer Design for Low Phase Noise and High Output Power in InGaP/GaAs Technology

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Abstract

InGaP/GaAs HBT LC-VCO and mixer were designed and fabricated with the previously proposed Harmonic Noise Frequency Filtering (HNFF) technique. The VCO exhibited a tuning range of 261 MHz and a phase noise of -133.96 dBc/Hz at 1 MHz offset from the 1.721 GHz carrier while the down-conversion co-designed mixer shows a conversion gain of 8.9 dB with an LO power of -10 dBm. It also has a third-order input intercept point (IIP3) of 12.44 dBm, a third-order output intercept point (OIP3) of 21.44 dBm, an input P1dB of 3 dBm, an IF return loss of -26 dB, and an RF return loss of -31 dB. The RF-IF isolation is 57 dB.

I. Introduction

Fully integrated wireless transceivers fabricated using InGaP/GaAs HBT devices are used in many wireless applications, such as cellular phones, global positioning systems, and interference cancellation systems. In this paper, a new technology is developed in which the various signal control techniques are included in the transceiver. The first step in this process is to convert the RF frequency into an intermediate frequency for channel selection. The frequency conversion process is necessary for the quality of the signal as well as the wider communication area. Therefore, the mixer is necessary for this process and it plays a key role in wireless communication [1]. Thus, the VCO and mixer should be designed by considering several parameters such as conversion gain, inter-modulation distortion, operating frequency, frequency bandwidth, noise figure, isolation, phase noise, and output swing [2].

Increasing demand for bandwidth in high performance communication systems places very tough requirements on the spectral purity of local oscillators [3]. Therefore, local oscillators with low phase noise are critical building blocks in high-performance communication systems. Their low phase noise performance enables them to realize an increasing number of channels. Recent, literature has focused on improving phase noise in VCOs [1-4]. In spite of many attempts to improve the phase noise in VCOs, design and optimization of integrated LC VCOs presents many challenges to circuit designers, such as maintaining large tuning range, low current consumption, low supply voltage and low phase noise performance [2-3].

A Gilbert cell topology was chosen here for the design of the mixer. This topology is a fundamental building block which is used in a wide array of IC applications including modulators, demodulators, detectors, VGAs (variable gain amplifiers), and RF mixers. As an RF mixer it can produce positive conversion gain and multi-decade bandwidth operation. It requires low LO (local oscillator) power and is compact in size. Furthermore, its base-band and multi-decade bandwidth performance make it attractive for wideband instrumentation and RF communications [5].

In section 2, the proposed harmonic noise frequency filtering technique plus a VCO design based on the LC tank is presented. Section 3 shows the design of a high output power mixer with buffer. Section 4 briefly describes a VCO and mixer co-design and measured data from the fabricated device are presented in section 5. And finally, section 6 draws conclusions from these results.

II. Harmonic Noise Frequency Filtering (HNFF) VCO Design

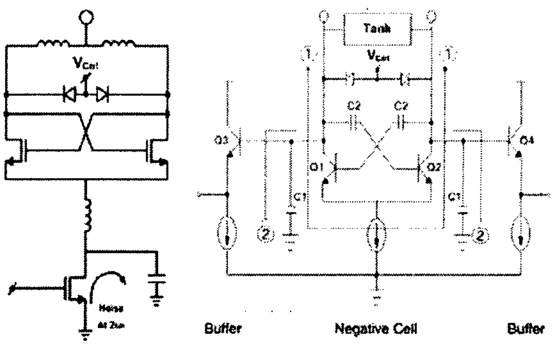

Fig. 1. Noise filtering VCOs; (a) conventional noise filtering VCO, (b) proposed harmonic noise frequency filtering VCO

LC VCOs generally consist of an LC tank and a circuit that generates negative conductance to compensate losses in the LC tank. For the start-up oscillation, the condition $-G_m > 1/R_P$ should be fulfilled. A simplified model of an LC oscillator is a lossy LC tank combined with a noiseless energy restorer that maintains constant oscillation amplitude. The phase noise for this model can be analytically calculated as follows [6]:

$$L(\Delta\omega) = 10 \log\left[\frac{2kT}{P_{diss,tank}}\left(\frac{\omega_0}{2Q_{tank}\Delta\omega}\right)^2\right] \quad (1)$$