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A fully integrated dual-band VCO by 0.18 μm CMOS technologies

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Abstract

A dual-band monolithic voltage-controlled oscillator (VCO) has been fabricated by using the 0.18 μm 1P6M CMOS technologies. The switching transistors concept used in the tank circuit realizes the dual-band VCO operation. In order to reduce the phase noise, the pMOS transistors were used in the VCO design. The dual-band VCO demonstrates the phase noise (100 kHz offset) of −98 dBc/Hz at 2.6 GHz and −91 dBc/Hz at 5.2 GHz.

Keywords: CMOS; Dual-band; VCO

1. Introduction

Recently, the implementation of monolithic voltage-controlled oscillators (VCOs) using the standard CMOS technologies attracts a lot of interest in wireless communication systems [1–4]. Besides, the applications of the 2.4 and 5.2 GHz wireless local-area network (WLAN) are gaining more interest. The compatibility and high data rate requirement have led to the desire of integrating the 2.4 GHz/5.2 GHz dual-band transceiver design. Therefore, a VCO with a wide tuning range or a VCO operating at both bands is demanded. This design becomes even more challenging, while a high tuning range is necessary to provide the required frequency band with a low dc supply voltage.

In addition, low phase noise is also the major issue in the VCO design. Although the pMOS transistors suffer for their low mobility, however, the lower $1/f$ noise level and less hot carrier effect in pMOS transistor may provide an alternative solution in the VCO design [5]. In this work, a switching transistor concept is proposed and realized in a 2.4 GHz/5.2 GHz dual-band VCO by the advanced 0.18 μm CMOS technologies. Using the switching transistors, we can change the configuration of the inductor network resulting in the variation of inductance in the tank circuit. This operational mechanism provides the necessary oscillation frequency bands for both 2.4 and 5.2 GHz applications.

2. The design of the dual-band VCO

In this study, a -G_m oscillator based on the cross-coupled configuration is presented in conjunction with the pMOS inversion-mode varactors. Fig. 1(a) shows the circuit schematics of the dual-band monolithic VCO circuit. It basically consists of a tank circuit and a cross-coupled gate structure (M_1, M_2). The cross-coupled transistors form a feedback loop providing a sufficient negative resistance over these two frequency bands to cancel the resistive loss in the LC tank circuit.

The gates of the switching transistors (M_5 and M_6) are determined by the switch voltage (V_s). For a high switch control voltage, i.e. 2 V, the switching transistors are on, resulting in a lower in-parallel inductance consisting of the L_1 and L_2, and it selects the high-band oscillation frequency. On the other hand, for a low V_s value, the switches are off, and the inductor L_1 is not active. As a

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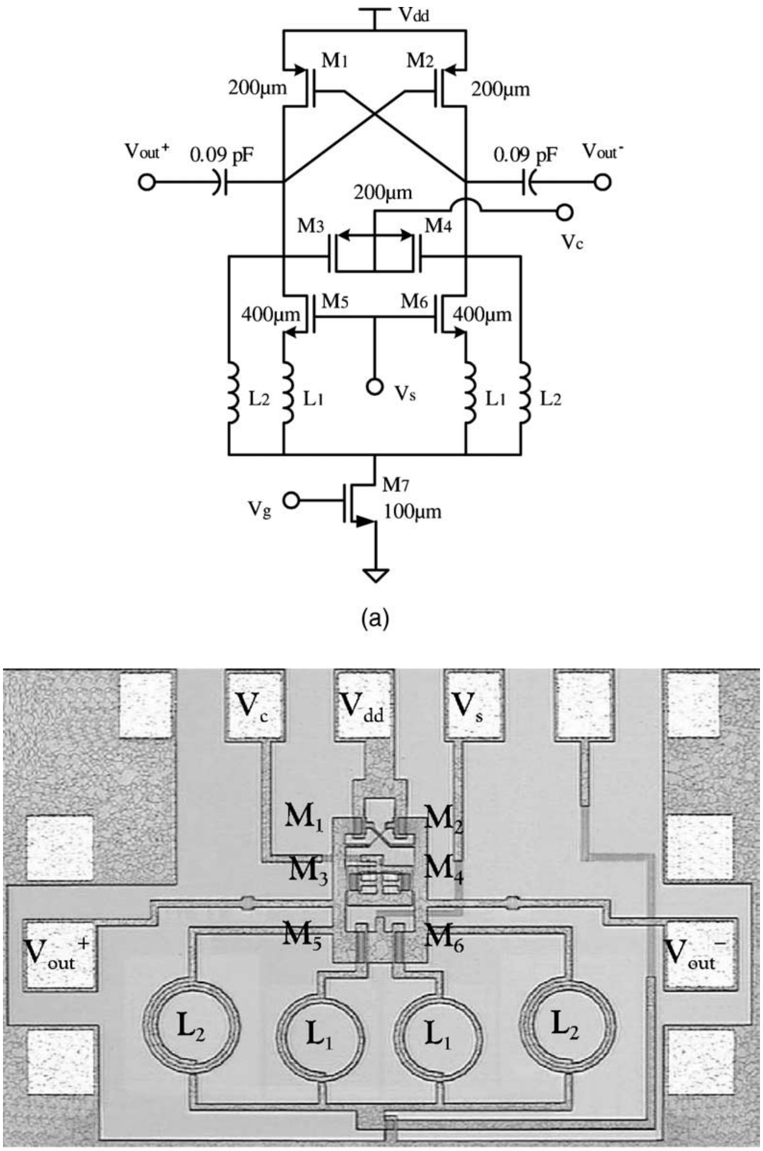

Fig. 1. Circuit schematics of a monolithic CMOS dual-band VCO (a), die photograph of the dual-band VCO fabricated by 0.18 μm technologies (b).

result, the inductance is high in the tank circuit and the VCO operates in the low-band. As shown in Fig. 2, when the transistors M_5 and M_6 are off, the inductance of the tank circuit is about 1.41 nH, which allows the VCO oscillating in the 2.6 GHz band. When the transistors M_5 and M_6 are on, the inductance of the tanks is down to 0.51 nH, and the VCO operates in the 5.2 GHz band. By controlling the voltage of the switching transistors, the inductance of the tank circuit can be controlled, which generates the different oscillation frequencies. In addition, the fine-tuning of the VCO in each band is accomplished by using the varactors. The varactors are implemented by pMOS transistors (M_3 and M_4), where the source, drain and body terminals are connected together. Based on this configuration, it causes a $V_{SG} > |V_{TP}|$, and the pMOS transistor can be therefore treated as an inversion-mode varactor [4], where the oscillation frequency can be adjusted by controlling the substrate bias (V_c) of transistors M_3 and M_4.

To achieve a low phase noise in the VCO output spectrum, the quality factor Q of the resonator is essential, which is influenced by the parasitics of the spiral