Chapter 16

40–GHz Inductor Less VCO

Abhishek Kumar
Lovely Professional University, India

ABSTRACT

In a modern communication system, voltage-controlled oscillator (VCO) acts as a basic building block for frequency generation. VCO with LC tank is preferred with passive inductor and varactor in radio frequency. Practical tuning range of VCO is low and unsuitable for wideband application. Switched capacitor and inductor can widen but at cost of chip area and complex system architecture. To overcome it, an equivalent circuit of the inductor is created. In this work, inductor-less VCO is implemented with CMOS 90nm technology that has center frequency 40GHz and frequency tuning range 37.7GHz to 41.9GHz.

INTRODUCTION

Communication between people found from the beginning of civilization; for communication, the message signal is modulated at the transmitted at a very high frequency; requires the use of a local oscillator. The local oscillator is a crucial component for frequency synthesizer in wireless communication; generate the same frequency for demodulation at the receiver end. Phase-locked loop (PLL) (Long, Foo, Weber, 2004) is an analog circuit can generate high frequency with the mechanism of feedback signal. The inherent block of PLL are (a) phase frequency detector (PFD) compare reference frequency with feedback, generate signal UP if feedback signal lags behind reference otherwise DOWN, it instructs (b) charge pump to produces high or low DC voltage (c) a low pass filter generates a constant voltage $V_{\text{const}}$ (d) VCO takes this analog voltage and generate a clock signal of desired frequency. The oscillator is an electronic circuit can generate the sinusoidal, square, triangular, sawtooth wave, etc with positive feedback. There 2 types of oscillator LC tank oscillator and ring oscillator (Gordon & Voinigescu, 2004). LC oscillator is preferred if the noise is a low and stringent requirement if accurate frequency. LC oscillators are extensively used in the RF circuit. Figure1 presents a block diagram of oscillator (Hess & Walter, 1993) whose oscillation frequency given as $f_{\text{ooc}} = \frac{1}{2\pi \sqrt{LC}}$. Ring oscillator (RO) based VCO extensively uses the delay of each stage, RO (Liu, Chan, Wang & Su 2007) is known for an odd number

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of cascaded delay stage usually implement an inverter along with the output of the last stage is feedback to the first stage. RO has the advantage of the ease of integration, small chip area and high frequency generation (Nagarajan, Seng, Mou & Kumar, 2011).

\[
\frac{Y(s)}{X(s)} = \frac{H(s)}{1 + \beta H(s)}
\]

if \( \beta H(s) = -1 \) at \( s=j\omega \), gain=\( \infty \) the circuit amplifies its own noise eventually begins to oscillate.

Figure 2 shows the output frequency of VCO maintains non-linear relations with a control voltage, \( f_{out} = f_0 + K_{VCO} V_{ctrl} \). Where \( f_0 \) is the frequency of oscillation, \( K_{VCO} \) is the gain of the circuit. Frequency tuning is (Bunch & Raman, 2003) obligatory not to the complete application but also to reimburse for variation of the centre frequency of VCO.

LC-VCO

The active transistor (Mirajkar, Chand, Aniruddhan & Theertham, 2017) provides necessary negative trans-conductance \( 1/G_m \) to reimburse the tank losses. \( R \) is the resistance of the tank circuit. The stable

Figure 1. Block diagram of oscillator

Figure 2. Transfer function of VCO
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