Design of 2.4 GHz Oscillators In CMOS Technology

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Abstract— oscillators are essential components of RF circuits also the integral part of various electronic systems. An oscillator is an electronic device used for the purpose of generating a signal robust, high performance oscillator design in CMOS technology continues to pose interesting challenges. This paper deals with the design of CMOS oscillators more specifically ring, differential LC and voltage controlled oscillator in 90nm and 120nm CMOS technologies, which provides a frequency of 2.4GHz and compares oscillators for the parameters like power, area, frequency etc. Oscillators are designed and simulated using EDA Tool microwind3.1.

Keywords- Differential LC oscillator, Ring oscillator, voltage controlled oscillator, Microwind3.1.

I. Introduction

Wireless communications is a rapidly growing technology that enables people to access networks and services wirelessly. Technologies that are under research and in development phase promise to deliver more services to more users in less time. The wireless approach shows many advantages but also has some disadvantages. Mobility is one of the big advantages of wireless as compared to cabled devices, which require plugging. Another advantage is that new users can easily join or leave the network, move among different networks, create ad hoc networks for a limited duration and then leave. Wireless networks are easy to deploy, and in some cases, they cost less than wired networks. The technological challenges occur in wireless networks are not trifling, leading to some disadvantages as compared to cabled networks, for example lower reliability caused due to interference, data security, higher power consumption, threats because of inherent broadcast properties of the radio medium, worries about user safety due to continued exposition to radio frequency, and lower data rates. Bluetooth (over IEEE 802.15.1), ultra-wideband (UWB, over IEEE 802.15.3), ZigBee (over IEEE 802.15.4), and Wi-Fi (over IEEE 802.11) are four protocol standards for short range wireless Communications with low power consumption, Bluetooth, ZigBee and Wi-Fi uses a frequency 2.4GHz [1]. In all communication systems Oscillators are perhaps the element found everywhere. They found in many analog and RF signal processing systems. During the last few years Wireless and optical communication systems have shown a tremendous growth. This exponential growth has driven the need for more compact, more cost-effective, fully integrated, low noise, low power oscillator. Of all RF blocks, voltage-controlled oscillators (VCOs) have received the most attention in recent years, as evidenced by the large number of publications reporting improved performance [2], [3], [4]. Voltage controlled oscillators play a critical role in communication systems, providing periodic signals required for timing in digital circuits and frequency translation in radio frequency Circuits. Their output frequency is a function of a control input usually a voltage. An ideal voltage-controlled voltage oscillator is a circuit whose output frequency is a linear function of its control voltage. Most application required that oscillator be tunable, i.e. their output frequency be a function of a control input, usually a voltage. A ringVCO has been considered to be a better choice, because of its low power consumption, small chip area and wide tunable frequency range. In recent years LC tank oscillators have shown good phase-noise performance with low power consumption. However, there are some disadvantages. First, the tuning range of an LC-oscillator (around 10 - 20%) is relatively low when compared to ring oscillators (>50%). So the output frequency may fall out of the desired range in the presence of process variation. Second, the phase-noise performance of the oscillators highly depends on the quality factor of on-chip spiral inductors. For most digital CMOS processes, it is difficult to obtain a quality factor of the inductor larger than three [5]. The ring oscillators are free from the complication of the on-chip inductors that required for the LC oscillators. Thus the chip area is reduced. In addition to a wide tuning range; ring oscillators with even number of delay cells can produce quadrature-phase outputs [6]. The phase noise performance of ring oscillators is much poorer in general [6]. Also, at high oscillation frequencies, the power consumption of the ring oscillators may not be low which is a key requirement for battery operated devices [7].

II. OVERVIEW OF OSCILLATORS

A. Ring oscillator

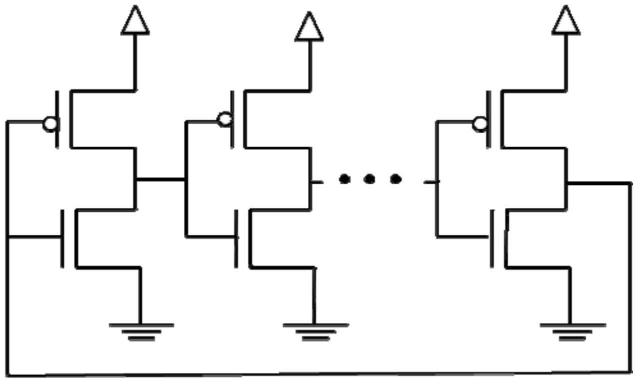

Figure 1. Ring oscillator with odd number of stages

The CMOS ring oscillator circuit made up of a series of CMOS inverters connected in a closed loop as shown in the Fig.1. There has to be an odd number of inverter stages connected for generation of proper oscillations [8]. The current flowing through the transistors of the inverter stages decides the oscillation frequency which in turn depends on the aspect ratio of the devices [9]. It also depends on the number of inverter stages used, rise delay, fall delay of the inverters. The usual implementation consists in a series of five up to one hundred chained inverters.

B. Differential LC Oscillator

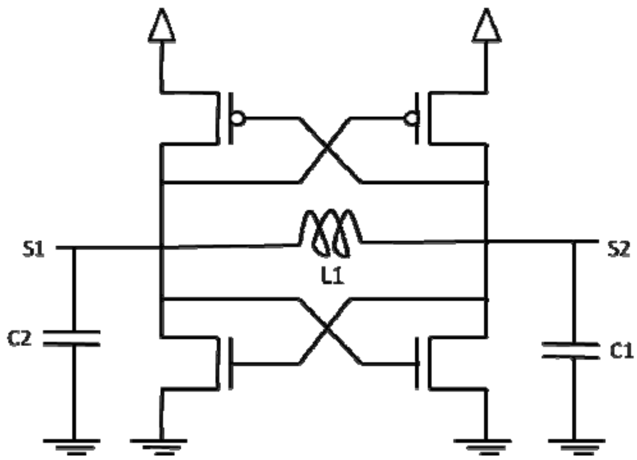

Figure 2. Differential LC oscillator

Fig. 2 shows the conventional differential LC oscillator with symmetric capacitance tank. This differential LC oscillator shown in Fig. 2 can be considered as two C-Colpitts oscillator combined perfect symmetrically such like the image in the mirror But, the perfect symmetric differential combination of C-Colpitts shown in Fig.2 [10]. The differential oscillator shown in Fig. 2. based on the same basic structure(C-Colpitts). The frequency of oscillation depends on the value of inductor and capacitor used.

C. Voltage Controlled Oscillator

The voltage controlled oscillator (VCO) generates a clock with a controllable loop circuits.. The current starved inverter chain uses a voltage control controlled voltage to modify the current that flows in the N1,P1 branch. The current through N1 is copied by N2, N3 and N4. The same current flows in P1. The current through P1 is copied by P2, P2 and P4. Consequently, the change in controlled voltage induces a global change in the inverter currents, and acts directly on the delay [8]. Usually more than 3 inverters are in the loop. A higher odd number of stages are commonly implemented, depending on the target oscillating frequency and consumption constraints

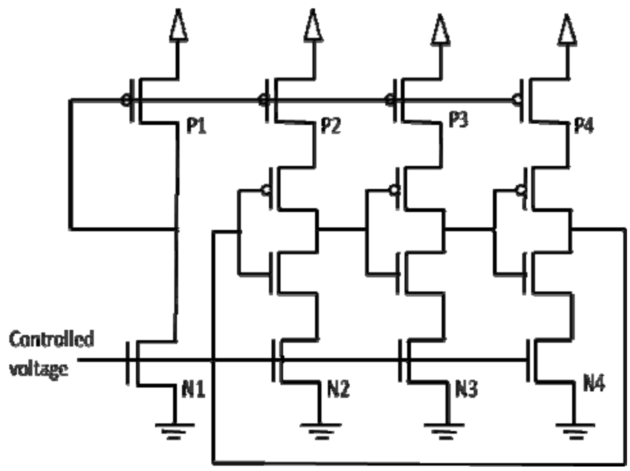

Figure 3. voltage controlled oscillator

III. CIRCUIT DESIGN

A. Ring oscillator

Ring oscillator is designed by connecting the delay stages in a closed loop. Oscillation frequency depends on the propagation delay and number of delay stages. Oscillators are designed using semi custom design methodology. Fig. 4 shows the design of 31 stage ring oscillator. The used inverters are such that it require 31 stages to produce ISM band frequency in 120nm technology and it requires 47 stages in 90nm technology. Fig. 5 shows 47 stage ring oscillator.

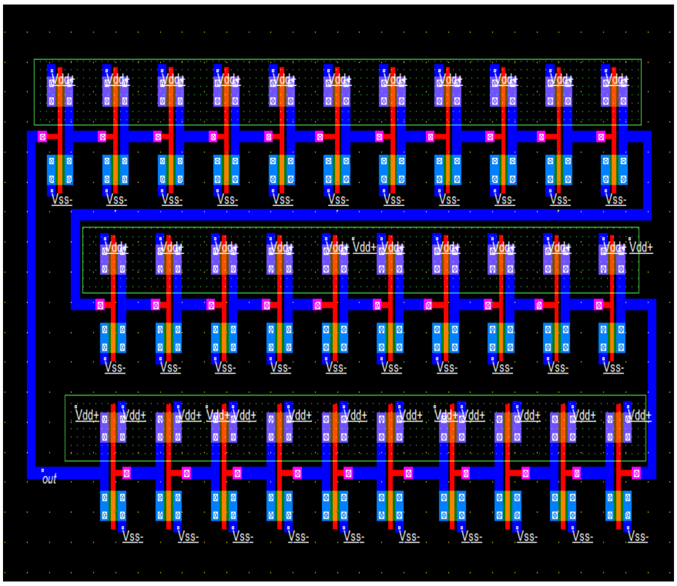

Figure. 4 Layout of 31stage ring oscillator in 120nm technology

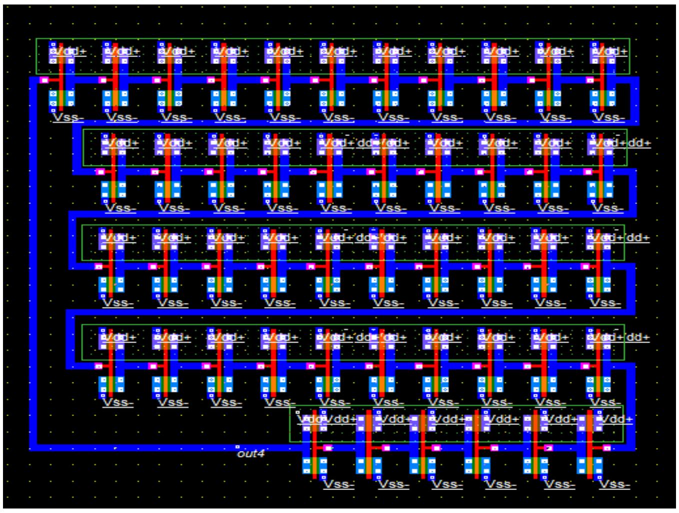

Figure. 5 Layout of 47 stage ring oscillator in 90nm technology

B. Differential LC Oscillator

In the differential LC oscillator the energy is exchanged between the inductor and the capacitor. This exchange of energy produces the oscillations. Oscillation frequency depends on the value of capacitor and inductor. To produce ISM band it requires capacitor and inductor of 0.01pF and 400nH respectively in 120nm technology and 0.01pF and 380nH respectively in 90nm technology

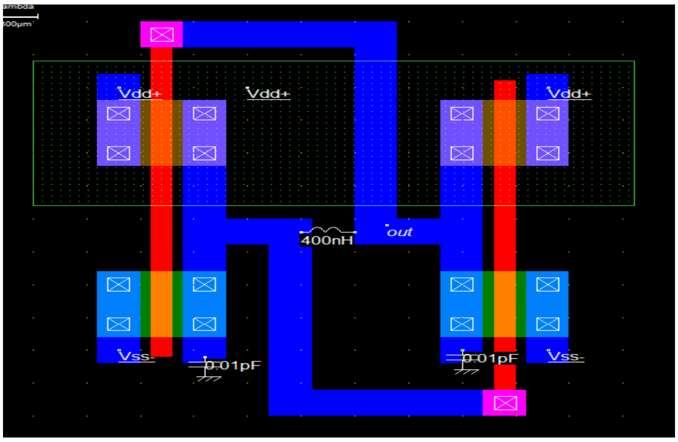

Fig. 6 Layout of Differential LC oscillator in 120nm technology

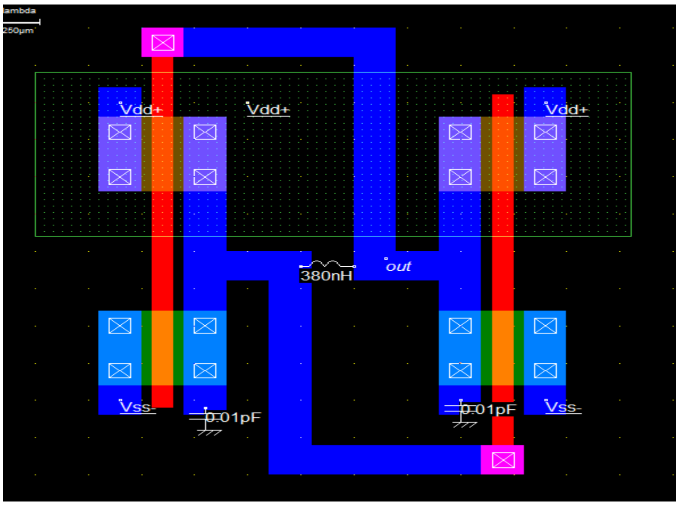

Figure. 7. Layout of Differential LC oscillator in 90nm technology

C. Voltage Controlled Oscillator

Frequency of voltage controlled oscillator can be changed by varying input controlled voltage as upper and lower transistors limit the current to the chain of inverter. The desired frequency is produced when controlled voltage is 0.412v in 120nm and 0.241v in 90nm technology.

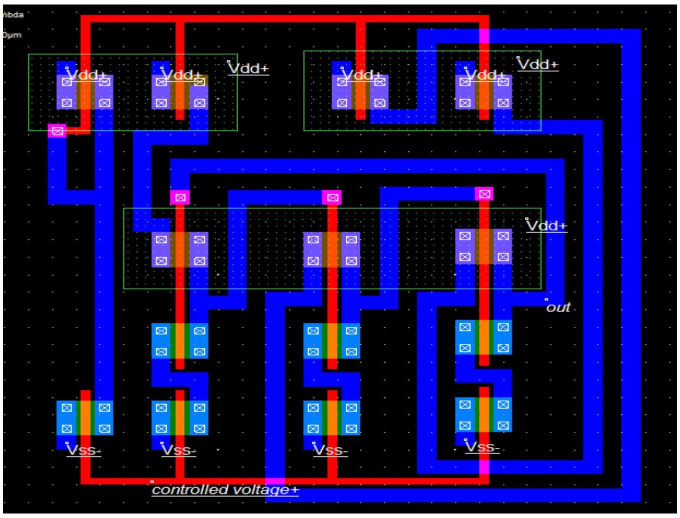

Figure. 8 voltage controlled oscillator

TABLE I: DESIGN PARAMETER

MOS	120NM	90NM
PMOS width	0.600 µm	0.500 µm
PMOS Length	0.120 µm	0.100 µm
NMOS Width	0.600 µm	0.500 µm
NMOS Length	0.120 µm	0.100 µm

IV. THE SIMULATION SETUP

This paper describes the semi custom design of oscillators related to the CMOS 120 nm, 90nm technology and the implementation of this technology in Microwind3.1. The Software Microwind3.1 used in paper allows us to design and simulate an integrated circuit at physical description level. The package contains a library of common logic and analog ICs to view and simulate. It also includes all the commands for a mask editor as well as original tools never gathered before in a single module such as 2D and 3D process view, Verilog compiler, tutorial on MOS devices. You can gain access to Circuit Simulation by pressing one single key. The electric extraction of your circuit is automatically performed and the analog simulator produces voltage and current curves immediately

V. SIMULATION RESULT.

The simulation of Ring oscillator, differential LC oscillator and VCO is given in following figures it shows frequency verses time. The power, area, current consumption is observed for frequency around 2.4GHz. The ring oscillator in 120nm technology requires 31 stages where as in 90nm technology it requires 47 stage to generate 2.4GHz frequency. Differential LC oscillator in 120nm technology require L1=400nH and C1=C2=0.01pF to generate frequency around 2.4GHz where as in 90nm technology it requires L1=380nH and C1=C2=0.01pF. For VCO the measured frequency reaches around 2.4GHz when the controlled voltage is 0.412v in 120nm technology and in 90nm technology it requires controlled voltage equal to 0.241v. If we change the temperature, the device current changes, and consequently the oscillation frequency are modified. Such oscillators are rarely used for high stability frequency generators.

A. Ring Oscillator

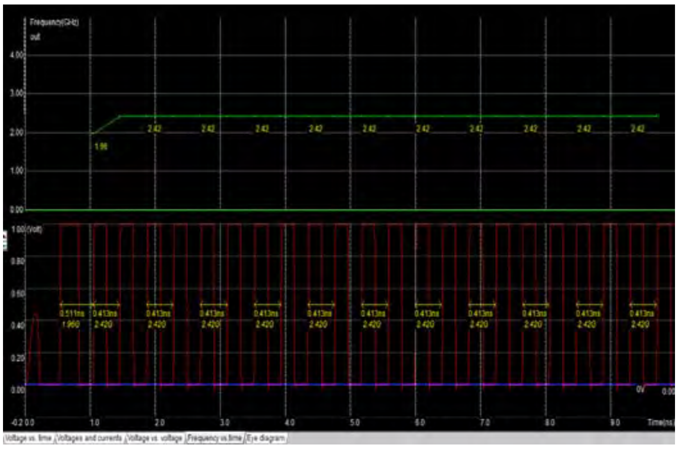

Fig. 9 Layout simulation of ring oscillator in 120nm technology

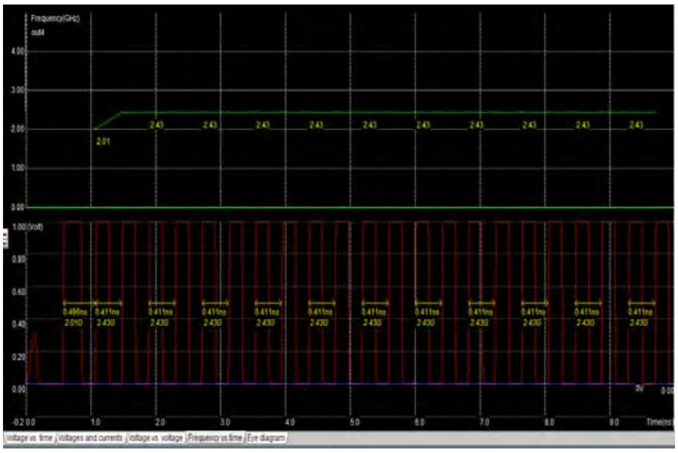

Fig. 10 Layout simulation of ring oscillator in 90nm technology

B. Differential LC oscillator

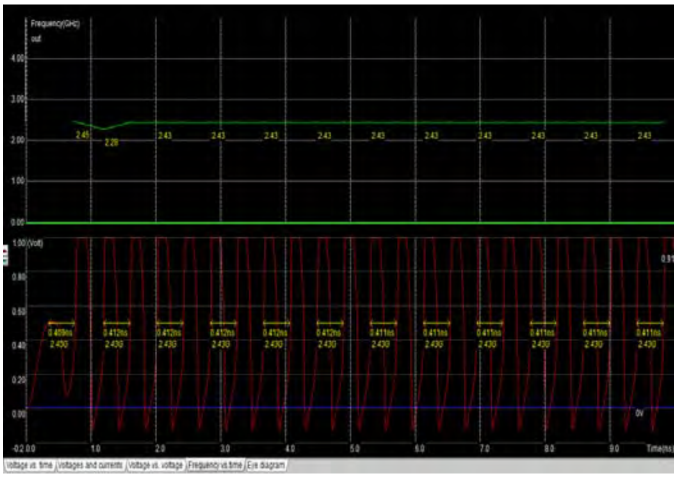

Fig. 11 layout simulation of differential LC oscillator in 120nm technology

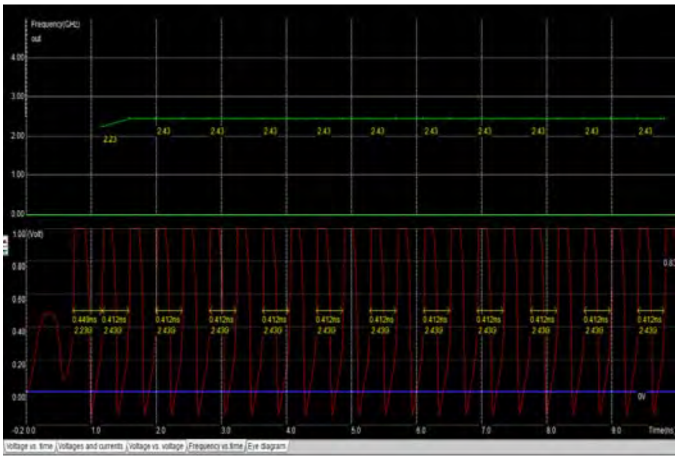

Fig. 12 Layout simulation of differential LC oscillator in 90nm technology

C. Voltage Controlled Oscillator

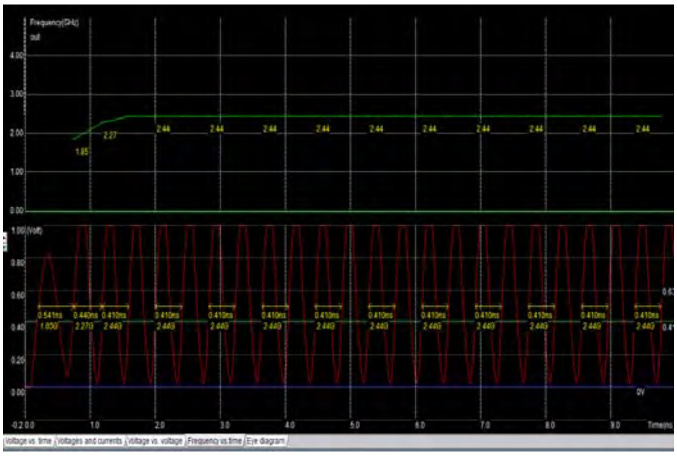

Fig. 13 Layout simulation of VCO in 120nm technology

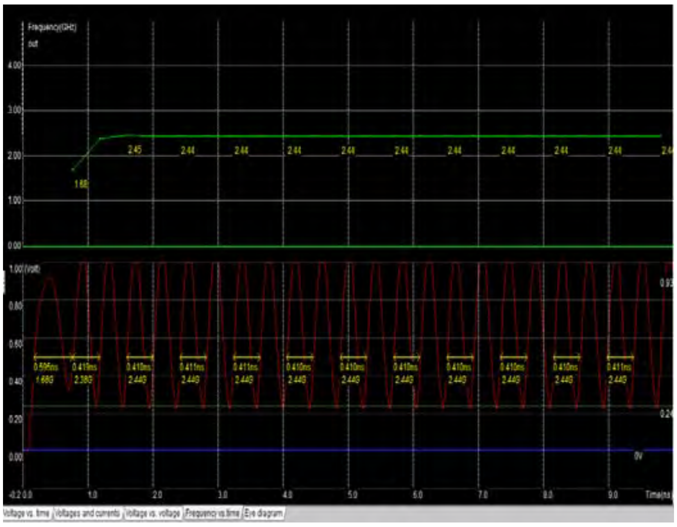

Fig. 14 Layout simulation of VCO in 90nm technology

TABLE II: COMPARISON FOR 120NM TECHNOLOGY

Parameter	Ring oscillator	Differential LC oscillator	Voltage controlled oscillator
Area estimation	Weight=17.0 µm Height=9.5 µm	Width =4.8 µm height =3.6 µm	Width = 7.7 µm height = 8.3µm
Power estimation	P=0.248mw	P = 0.109 mW	P = 59.547 µW
Current estimation	Iddmax=0.298mA iddAvr=0.207mA	Iddmax=0.142mA iddAvr=0.091mA	Iddmax=0.055mA iddAvr=0.050mA
Frequency estimation	2.42GHz	2.43 GHz	2.44 GHz

TABLE III: COMPARISON FOR 90NM TECHNOLOGY

parameter	Ring oscillator	Differential LC oscillator	Voltage controlled oscillator
Area estimation	Weight=14.1 µm Height=13.6 µm	Width =4.0 µm height =3.0 µm	Width = 6.5µm height = 7.0 µm
Power estimation	P=0.386 mW	P = 0.149 mW	P = 63.654 µW
Current estimation	Iddmax=0.435mA iddAvr=0.321mA	Iddmax=0.280mA iddAvr=0.124mA	Iddmax=0.057mA iddAvr =0.053mA
Frequency estimation	2.43GHz	2.43 GHz	2.44 GHz

TABLE IV: SIMULATION RESULT FOR VCO

Voltage(v)	Frequency (GHz) 120nm	Frequency(GHz) 90nm
0.000	2.440	2.436
0.200	2.440	1.150
0.400	2.014	10.616
0.600	9.083	17.153
0.800	12.034	19.417
1.000	13.072	20.367
1.200	13.605	20.833

VI. CONCLUSION

This paper design and compares the ring oscillator, differential LC oscillator and voltage controlled oscillator for generation of ISM band in 120nm and 90 nm technologies. In the estimated design more emphases given on generation of ISM band, power consumption, area, layout design and many more. Oscillators are then compared for area, power, current, frequency. This report is a brief study of ring oscillator, differential LC oscillator and VCO on 120 and 90 nanometer VLSI technologies to achieve some objectives as mention above.

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