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Design Of Ring And Voltage Controlled Oscillator For Wi-Fi And Zigbee Applications

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Abstract

An improperly designed oscillator for radio frequency (RF) simply degrades performance of wireless communication. In VLSI field the design of a linear and wide range oscillator for RF Application is a challenging work for Electronics Engineers. Radio frequency applications require vastly different oscillators' topologies and performance parameters. This paper describes a performance comparison of Ring oscillator and Voltage Controlled Oscillator for generation of Wi-Fi and ZigBee band. Oscillators are designed in 120nm and 90nm technology and their performance are compared based on the measurement results. The design is implemented in EDA tool microwind3.1 with hi oscillation frequency, low power consumption and low area. Design procedures and simulation results are illustrated.

1. Introduction

For accessing networks and services without cables, wireless communications is a fast-growing technology to provide the flexibility and mobility. Obviously, reducing the cable restriction is one of the benefits of wireless with respect to cabled devices. General speaking, the short-range wireless scene is currently held by four protocols: the Bluetooth, and UWB, ZigBee, and Wi-Fi, which are corresponding to the IEEE 802.15.1, 802.15.3, 802.15.4, and 802.11a/b/g standards, respectively. Wireless fidelity (Wi-Fi) includes IEEE 802.11a/b/g standards for wireless local area networks (WLAN) [1]. ZigBee is one of the newest technologies enabling Wireless Personal Area Networks (WPAN). ZigBee is the name of a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4 standard. The technology is intended to be simpler and cheaper than other WPANs such as Bluetooth [2]. Zigbee operate in 2.4 GHz frequency. 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. Therefore, some extra processing steps may be required [3]. Voltage controlled oscillators play 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 [4]. CMOS technology becomes widely used in RFIC and the CMOS one-chip solutions integrated both of digital and RF circuits start to be provided. The voltage controlled oscillator (VCO) generates a clock with a controllable frequency. The VCO is commonly used for clock generation in phase lock loop circuits. The clock may vary typically by +/-50% of its central frequency [5]. The rest of this paper is organized as follows. Section II briefly introduces the ring oscillator; next, a voltage controlled oscillator is described briefly in section III. Section IV gives simulation setup. Then section V present results obtain in the paper. Finally, Section VI. Conclude this paper.

2. Design of ring oscillator and its oscillation

The ring oscillator is a very simple oscillator circuit, based on the switching delay existing between the input and output of an inverter. If we connect an odd chain of inverters, we obtain a natural oscillation, with a period which corresponds roughly to the number of elementary delays per gate [5]. The fastest oscillation is obtained with 3 inverters (One single inverter connected to itself does not oscillate) [5].

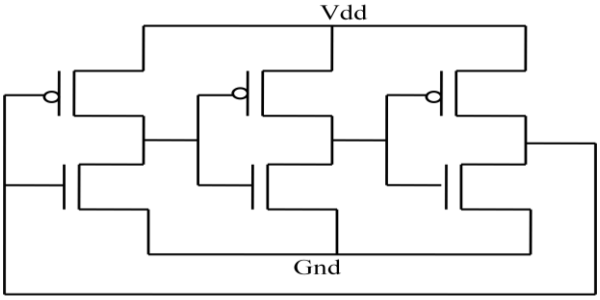

Figure 1: A 3 stage ring oscillator based on an odd number of inverters

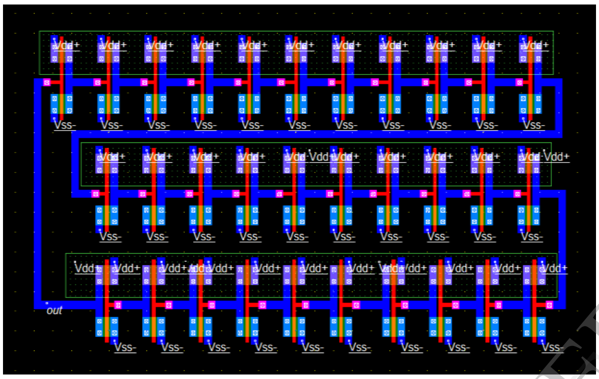

Figure 2: The layout implementation of a 31 stage ring oscillator circuit in 120nm technology

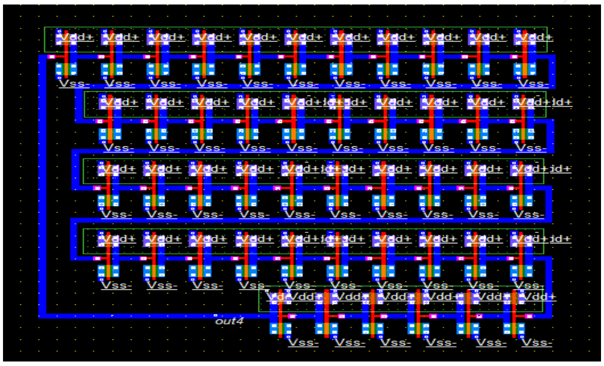

Figure 3: The layout implementation of a 47 stage ring oscillator circuit in 90nm technology

The usual implementation consists in a series of five up to one hundred chained inverters. One inverter in the chain may be replaced by a NAND gate to enable the oscillation. Figure 1 show a three stage ring oscillator based on an odd number of inverters [6]. Ring oscillator in 90nm technology requires more number of stages as compared to 120nm technology for generation of 2.4GHz frequency. In 90nm technology it requires 47 stages where as in 120nm technology it requires 31 stages it is shown in figure

3. Design of voltage controlled oscillator and its oscillation

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. The operation of current starved VCO is similar to the ring Oscillator. Figure 4 Shows a three stage Current-Starved VCO .Middle PMOS and NMOS operate as inverter, while upper PMOS P2 and lower NMOS N2 operate as current sources The current sources limit the current available to the inverter. In other words, the inverter is starved for current [7]

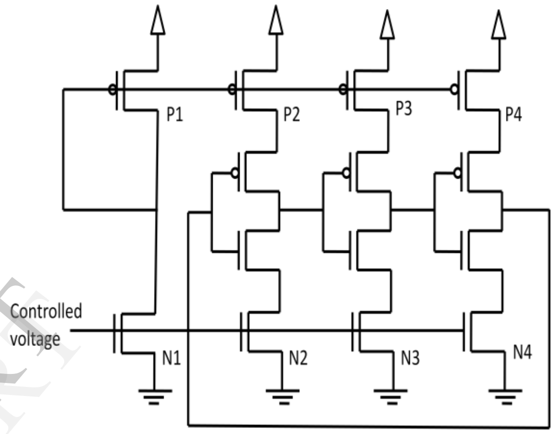

Figure 4: A voltage controlled oscillator

The current starved inverter chain uses a control voltage to modify the current that flows in the N1, P1 branch. The current through N1 is mirrored by N2, N3 and N4. The same current flows in P1. The current through P1 is mirrored by P2, P2 and P4. Consequently, the change in control voltage induces a global change in the inverter currents, and acts directly on the delay. 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 [5].

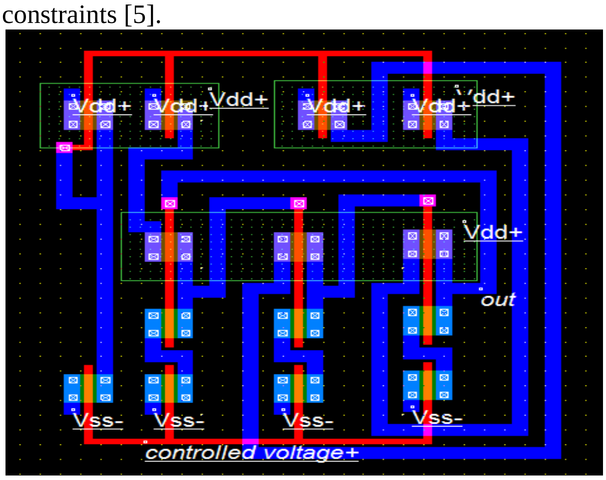

Fig 5: The layout implementation of a voltage controlled oscillator

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 0.241v

4. 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.

5. Experimental Results

The simulation of Ring 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. Ring oscillator in 120nm technology require 31 stages to generate frequency around 2.4GHz where as in 90nm technology it require 47 stages. 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. Variation in output frequency with change in controlled voltage is also observed. Such oscillators are rarely used for high stability frequency generators

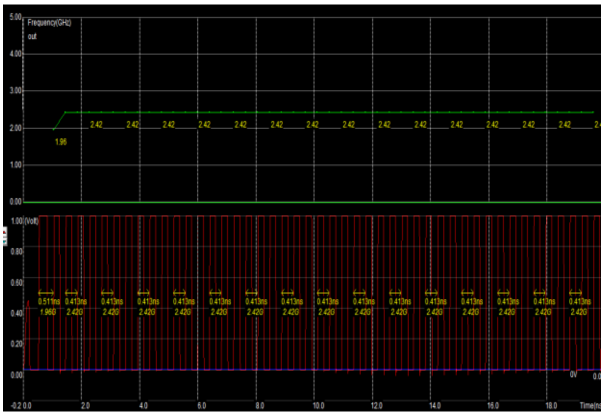

Figure 6: layout simulation of ring oscillator in 120nm technology

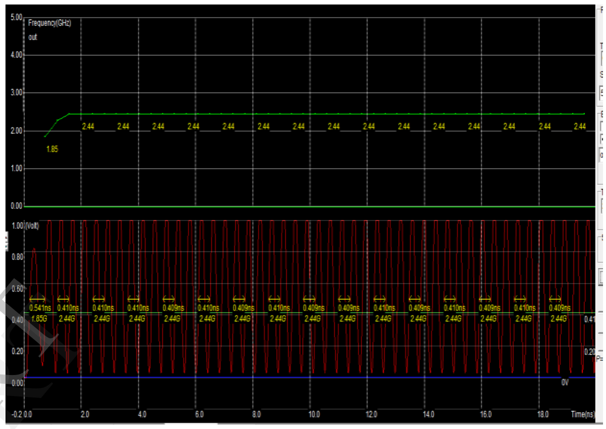

Figure 7: layout simulation of VCO in 120nm technology.

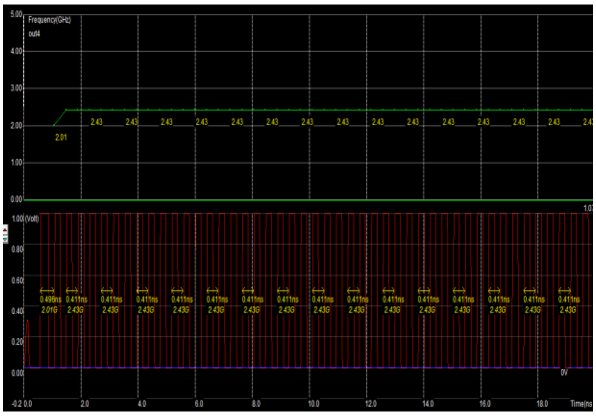

Figure 8: layout simulation of ring oscillator in 90NM technology

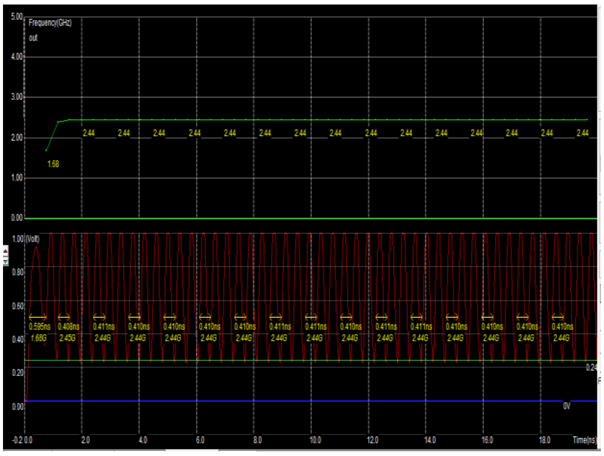

Figure 9: layout simulation of VCO in 90nm technology

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

Table II: Comparison for 120nm technology

parameter	Ring oscillator	Voltage controlled oscillator
Area estimation	Weight=17.0 µm Height=9.5 µm	Width = 7.7 µm height = 8.3 µm
Power estimation	P=0.248mw	P = 59.547 µW
Current estimation	Iddmax=0.298mA iddAvr=0.207mA	Iddmax =0.055mA iddAvr = 0.050mA
Frequency estimation	2.42GHz	2.44 GHz

Table III: Comparison for 90nm technology

parameter	Ring oscillator	Voltage controlled oscillator
Area estimation	Weight=14.1 µm Height=13.6 µm	Width = 6.5µm height = 7.0 µm
Power estimation	P=0.386 µW	P = 63.654 µW
Current estimation	Iddmax=0.435mA iddAvr=0.321mA	Iddmax=0.057mA iddAvr =0.053 mA
Frequency estimation	2.43GHz	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

6. CONCLUSION

This paper compares the ring oscillator and voltage controlled oscillator for generation of Wi-Fi and ZigBee band in 120nm and 90 nm technologies. In the estimated design more emphases given on generation of Wi-Fi and ZigBee 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 and VCO on 120 and 90 nanometer VLSI technologies to achieve some objectives as mention above

10. References

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