# A Review: Performance Comparison of Ring Voltage Controlled Oscillator design using CMOS for wireless applications

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***Abstract: Different set of application requires different set of parameters for a Voltage Controlled Oscillator design. Based on the earlier studies it was discovered that LC based VCO are having low phase noise for same power dissipation. However, as "Go Wireless" has become a trend for consumer electronics and caused a boom of demand for high performance, low cost, fully integrated transceivers, the interest in the VCOs based on the ring oscillators has grown significantly. This paper presents a performance analysis of various techniques used to design a Ring voltage Controlled Oscillator for different applications.***

***Index Terms: CMOS, DC source, Oscillator, VCO.***

## I. INTRODUCTION

An oscillator is a circuit that generates a revolving waveform that is constantly repeated and has almost no information. Oscillators turn a unidirectional current stream from a DC source into a substitute waveform with the optimal recurrence, as determined by the circuit elements. Oscillators arrive in an assortment of plans, each having its own working rule, recurrence swaying, and commotion execution.

With the development of new and updated integrated circuit technologies, communication system and microprocessors are normally working at gigahertz frequencies with low power consumption, low cost and efficient chip area. All Microprocessors and communications system need an oscillator to provide a stable periodic signal to fulfill some functions like synchronization clock for microprocessor and stable frequency signal to modulate/demodulate information signals. A Crystal oscillator generally generates frequency signals below 100 MHz so it is being used as off-chip. So for In the chip, A Voltage Controlled Oscillator is designed to provide higher frequency periodic signals. In addition, the VCO is most important component for the phase lock loop (PLL) that can provide a precise frequency.

## II. CONVENTIONAL RING OSCILLATOR

The conventional ring oscillator consists of inverter as delay stages and number of delay stages is connected with each other in the form of a chain. The output of last stage is fed back to the input of first one. The block diagram of single ended ring *VCO* is shown in Fig. 1. The Barkhausen criteria must be satisfied for oscillation and the oscillator must provide a phase shift of 2π also should possess unity voltage gain. Each delay stage should provide phase shift of π / *N* where N is the number of delay stages. The rest π phase shift is provided by dc phase inversion and for that the number of delay stages should be odd-

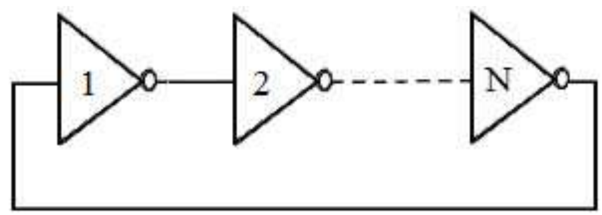


*Fig.01 Single ended ring oscillator*

Equation (1) depicts oscillation frequency for N stage ring *VCO* as:

$$fosc = \frac{1}{2N\tau_d} \quad (1)$$

Where, $\tau_d$ is delay time of each inverter stage.

## III. LITRATURE REVIEW

**Puttaswamy G.C. et al,** worked on Voltage-Controlled Ring Oscillators that were crucial components in many wireless communication systems. VCRO is used in PLL circuit, used to generate the oscillations and increase the speed of the whole system for RF wireless communication such as 60GHz communication systems. This kind of VCRO used in high-resolution oscillators for different applications. The goal of this project was to design a high speed, low power and minimum cell area, Voltage-Controlled Ring Oscillator in CMOS 0.18 micron technology that makes it suitable for wireless application. Designing of particular VCRO there are nine differential amplifier stages in cascading with each other and the output of last stage is again feedback to the input of the first stage. First according to the specification, the design of aspect ratio of the transistors used in our design is done. There were many challenges throughout the design process, including determining the matching requirements of the devices, investigating what percentage of segmentation to be used to design the whole system. For checking the functionality of the whole system a spice code is written using H-Spice by defining all blocks in the circuit as sub circuits, which are delay cell, bias and tuning circuitry. Then a schematic capture is done using schematic composer from virtuoso stating from bottom level to top level [1].

The design of our Voltage Controlled Oscillator (VCO) was implemented using a 9-stage ring oscillator. A slow-slewing saturated topology was used for all nine delay cells of the ring oscillator. From circuit simulations, the oscillating voltage swing is close to 1V. The output frequency varies from 1.884GHz to 1.9GHz by adjusting the tuning voltage from 0.9V to 0V. Therefore, the simulated KVCO is -17.9MHz/V, which is very close to the calculated value of -16MHz/V. The power consumption is of the VCO is 3.2mW at 1.9GHz, and the total consumed cell area is 35.72m*29.80um. Therefore, we have met or exceeded all project specifications. The goals of this project are concluded in this chapter. First, different VCRO architectures were analyzed to determine the optimal topology for the given performance specifications with minimum power consumption. Second, the exact implementation of the chosen architecture was investigated in an effort to use the minimum amount of power. Due to some limitations the speed of the designed 9-stage VCRO cannot able to be measured. After a complete analysis, the block was simulated for functionality verification. Once confirmation of correct operation was achieved, a complete layout was done in order to optimize the area. Simulation results from Spice demonstrate that the VCRO achieves all required performance specifications in terms of accuracy and performance parameters such as minimum cell area and minimum power. The measured phase margin >55 degree and gain 100v/v. Finally, there should be no problems with accuracy as the current source transistors were sized in such a way that matching would not be a problem [1].

**Ashish Raman et al,** they analysed the monograph for a low power voltage controlled ring oscillator, implement using the 1P6M 0.18μm CMOS process provided by TSMC with 1.8 volts power supply. The circuit is a modification of conventional ring oscillator. A tail current improvement is applied to reduce the charging and discharging time. The output frequency ranges from 0.958-4.43 GHz with control voltages of 1 V to 1.8 V. The simulated result of the phase noise is –94.5 dBc/Hz @ 1 MHz. The circuit draws 0.212 mW of power at Vtail = Vctrl = 1V and 0.226 mW at Vtail = Vctrl = 1.8 V from the 1.8 V supply [2].

Their work a 3 stage voltage controlled ring oscillator is designed using 0.18μm 1P6M CMOS technology provided by TSMC which consumes a very low DC power, *Pavg* = 0.226 mW with a frequency range from 0.958 to 4.43 GHz. The phase noise of the circuit is – 94.51 dBc/Hz @1 MHz [2].

**Xuan Zhang et al**, worked on the design of a 1.8 GHz 3-stage current-starved ring oscillator with a process- and temperature-compensated current source is presented. Without post-fabrication calibration or off-chip components, the proposed low variation circuit is able to achieve a 65.1% reduction in the normalized standard deviation of its center frequency at room temperature and 85 ppm/ C temperature stability with no penalty in the oscillation frequency, the phase noise or the start-up time. Analysis on the impact of transistor scaling indicates that the same circuit topology can be applied to improve variability as feature size scales beyond the current deep submicron technology. Measurements taken on 167 test chips from two different lots fabricated in a standard 250 nm CMOS process show a 3x improvement in frequency variation compared to the baseline case of a conventional current-starved ring oscillator. The power and area for the proposed circuitry is 87 W and 0.013 mm compared to 54 W and 0.01 mm in the baseline case. [3].

They have demonstrated a fully integrated, scalable, low power, process-and-temperature-compensated ring oscillator, which does not require any post-fabrication trimming or calibration. The improved frequency accuracy of the ring oscillator is achieved through replacing the single transistor in a conventional current-starved ring oscillator with a process and temperature invariant addition-based current source that is able to scale beyond the current submicron technology node. Measurement results from 167 chips show a 65.1% reduction of the frequency process variation and 85 ppm/ C temperature stability in the proposed ring oscillators. The calibration-free, low-power, CMOS-compatible, compact, and high-frequency design of our ring oscillator makes it a potential candidate in a number of low-cost, low-power RF applications [3].

**Huang Shizhen et al,** worked on the traditional ring voltage-controlled oscillator (VCO) generally uses the method of controlling resistance to change the oscillation frequency. This work describes a 2GHz fully differential ring voltage-controlled oscillator based on 0.18μm CMOS technology. The oscillation frequency is controlled through MOS capacitance in the output of each delay cell. This method has stabile output waveform and linear tuning characteristic [4].

They described a 2GHz fully differential ring voltage controlled oscillator based on 0.18μm CMOS technology. The tuning range is 100MHz, the supply voltage is 3V, and the power consumption of VCO core is 21mW. After further improvement it could be wider tuning range. The design has positive effect on the study and application of the voltage controlled oscillation in the wireless communication systems [4].

**Manisha Saini et al,** They gave a review on some of the differential ring voltage- controlled oscillators (VCO) designs has been presented in this work. Various differential delay cells have been studied and a comparison has been made in terms of oscillation frequency, power consumption and phase noise [6].

Finally they conclude that four different delay cells have been studied and compared in terms of frequency of oscillation, power dissipation and phase noise. Ring oscillators provide a wide range of frequency components. These dual delay cells have the advantages of lower power consumption with lower phase noise. It has been observed that dual delay cells are very stable cells for designing ring based oscillators. These observations are based on different technology parameters [6].

**J. Jalil et al,** worked on a 3-stage ring voltage controlled oscillator (RVCO), designed for active Radio Frequency Identification (RFID) transponders. High frequency local oscillators designed for battery-powered transponders are always crucial concerns for chip designers, as those oscillators consume considerable amount of power. Thus, the primary goal of this research work is to design a low power VCO at 2.45 GHz in the ISM band. In addition, in order to reduce overall oscillator size, ring based architecture has been adopted with easy integration technique. For varying the oscillating frequency from 2.2 GHz to 2.85 GHz, PMOS transistors with fixed value capacitors are utilized. Providing 1.8 V supply, the oscillator dissipates 6.99 mW of power and exhibits phase noise of -112 dBc/Hz at 10 MHz offset. The proposed RVCO is designed in CEDEC 0.18 μm standard CMOS process using Mentor Graphics environment [7].

They conclude that a 3-stage ring VCO has been proposed for active RFID transponder. The post-layout simulated results show that its operating frequency is 2.45 GHz and it is able to work with IEEE 802.11b protocol for low data rate RFID applications due to its tuning range coverage. Moreover, its convincible performances prove to be suitable for low power RF sensors and handy wireless devices [7].

**Ashraf Mohamed Ali Hassen et al,** worked on the voltage controlled oscillator (VCO) may be considered one of the most important building blocks in modern communication applications such as microprocessor clock generation, wired and wireless communications, system synchronization, and frequency synthesis. The search in the field of design for high performance VCOs has been increasingly more important and becomes an active research area. In the past decade, The Researches on VCOs have been based on the areas of higher frequency, lower phase noise, low power, low operating voltage, and increased tuning range. However many of these objectives can be only achieved at the expense of some other objectives. This thesis analyzes the design of high performance ring VCOs. The beginning of the thesis is reviewing the basic ring VCOs. The different designs are also introduced. Finally, the circuit techniques used in a proposed VCO based on the new technique is designed and simulated in 65nm CMOS SOI process. The results of proposed device are compared and confirmed the usability of the new ring VCO cell topology. Finally, a conclusion of the proposed design of high performance ring VCOs is explained [8].

They found that VCO was the one of the most important building block in modern communication systems. This work analyzed the design of high performance ring VCO. Through simulation, great results from the proposed design were obtained. The proposed design of ring VCO was concentrated from maximum oscillation frequency and tuning range perspective. Also the Proposed design achieved a large tuning range with acceptable phase noise and low operating voltage which are good results in the domain of search. This work had positive effect on the study and application of the voltage controlled oscillation in the wireless communication systems [8].

**Comparision**

| Reference | Process Technology | Frequency | power consumption |
|---|---|---|---|
| [3] | 180nm | 1.884GHz to 1.9 GHz | 3.2mW |
| [5] | 180nm | 0.958GHz to 4.43GHz | 0.226mW |
| [8] | 250nm | 1.8GHz | 0.275mW |
| [10] | 180nm | 2GHz | 21mW |
| [14] | 180nm | 2.2GHz to 2.85GHz | 6.99mW |

## IV.CONCLUSION

In this paper, we gave an outline of the thriving examination field of VCO. We analyzed works of different researchers. Also, much work depends on clever oscillators in light of arising innovation equipment, for example, Ring oscillator-based processing frameworks. A few contextual analyses showed the utility and guarantee of VCO for specific sorts of issues. VCO is a vital structure block in present day correspondence frameworks. Finally we conclude that ring oscillator is best for power consumption. In future We will design a ring Oscillator (Voltage Controlled Oscillator) with additional control circuit for controlling output frequency of the Ring VCO and analyze for the two most critical issues of an Integrated Circuit design, namely Speed (Highest frequency of operation) and Power consumption.

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