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RESEARCH ARTICLE

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COMPARATIVE ANALYSIS OF FREQUENCY FOR RING, DIFFERENTIAL LC AND VCO OSCILLATORS USING CMOS 45NM TECHNOLOGY

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Abstract

Oscillator are the integral part of any communication system. In this paper, we proposed a comparative analysis between physical design simulation result and the calculated results of frequency for Ring, Differential LC and VCO oscillators. The physical design is mainly implement to find out and analyzed the various parameters such as Power Consumption, number of stages, phase noise, Frequency swing and Frequency tuning range of oscillators. The presented results are obtained using CMOS EDA tool Microwind with 45nm technology with supply voltage of 1 V and IO VDD as 1.80 V with BSIM4 MOS modelling. The results of simulation indicated that implementation using CMOS technology, gives very high frequency range of oscillators. The frequency range for the designed types of oscillators can be manipulated with the design trend. The frequency range for Ring oscillator is found to be 9.51 GHz to 24.57 GHz for 5 stages, for differential oscillator is found to be 2.47 GHz to 4.08 GHz and for current starved VCO is found out to be 5.60 GHz to 10.78 GHz.

Introduction:-

With the continuous advancement in VLSI technology, more and more signal processing functions are implemented in the digital domain for low cost, low power consumption, higher yield, & higher re – configurability [2]. In VLSI design, the complexity increases with the increase in number of transistors in a processors results in increase in power consumption and stability [3] [7].

Today's communication systems, processors and computing devices require circuit of low power consumption, small size, high speed and low fabrication cost [1]. An oscillator is an electronic device used for the purpose of generation of a signal with specific frequency [1] [2] [3] [4]. Oscillators are useful in many of the electronic equipment. Their

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role is to produce a periodic logic or analog signal with the stable and predictable frequency.

The typical Ring Oscillator is nothing but the odd number of inverters stages connected in a ring like structure where the output of first is connected as a input to the next and the output of the last in fed back as input for the first inverter [1]. This will lead to generate natural oscillations results in frequency. The output frequency is equal to the inverse of the propagation delay of all the inverters [7]. A LC circuit is a resonant circuit, tank circuit or tuned circuit consisting of L and C connected together [10]. It is used for the generation of signals at a particular frequency. Frequency is controlled using L and C components [10] [11].Voltage Controlled Oscillator (VCO) is an oscillator where output signal can be varied over a range, controlled by the input DC voltage [3] [4].

The proposed work provides the physical design implementation for three types of oscillators. Almost all the work done earlier in designing the CMOS oscillators is basically done with the virtual load on the output side. Many designers finds it difficult to design the active and passive component on the transistor level in CMOS technology, as it increases the complexity and violet the rules of optimization parameters. The proposed work will be with the actual capacitor design on the loading side considering the intrinsic layer values and externally applied. The proposed work also gives the sustainable output comparison between the simulated results and the calculated results. So, the designs can be verified with the base of calculations.

The typical parameters for 45 nm Technology are given below.

Table 1:- Key Features of 45 nm Technology.

Parameter	Definition	Value
VDD	VDD	0.85-1.2 V.
TOXE	Gate oxide Thickness	3.5 nm
PHI	Surface Potential	0.15 V
GAMMA	Bulk threshold Parameter	0.4 V^0.5
Gate dielectric	Gate dielectric	SiON, HfO2
W_min	Channel Width	80 nm
L_min	Channel Length	40 nm

Proposed Physical Design:-

CMOS Ring Oscillator

The role of ring oscillators is to create a periodic logic or analog signal with a stable and predictable frequency [1]. The ring oscillator is a very simple oscillator circuit, based on the switching delay existing between the input and output of an inverter.

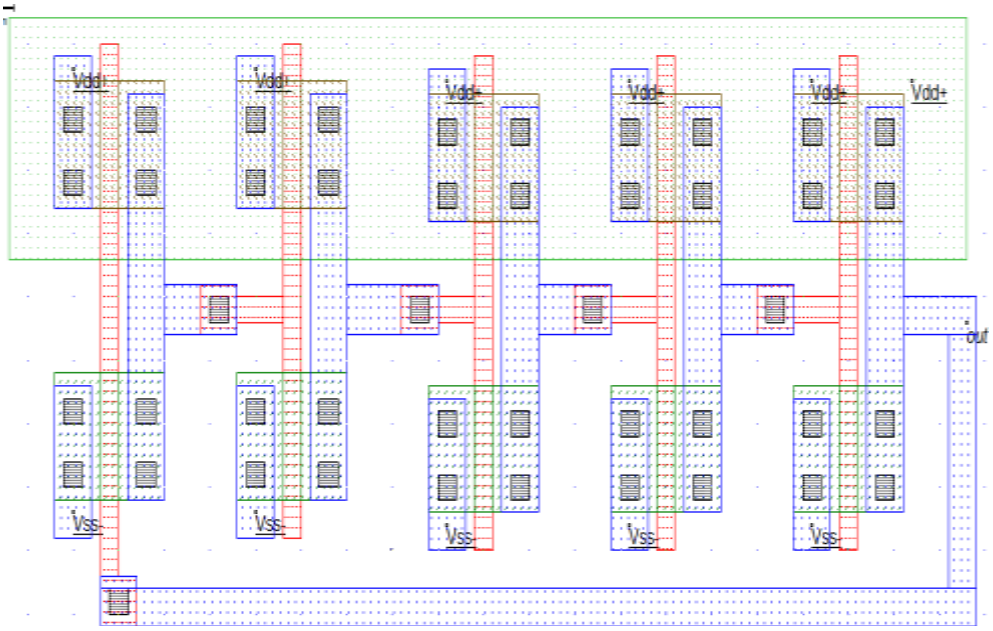

Figure 1:- Physical design of Ring Oscillator.

Table 2:- Transistor parameters for 45 nm Technology.

For NMOS	For PMOS
Width (W) = 0.200 um	Width (W) = 0.200 um
Length (L) = 0.040 um	Length (L) = 0.040 um
Current Imax is 0.147 mA	Current Imax is 0.086 mA

For on paper calculation of oscillating frequency for 5 stages,

$$\bullet \quad fosc = \frac{1}{2Nstages(tD)}$$

Where, fo= frequency of oscillations, N = number of stages, tD =propagation/ Switching Delays

$$\bullet \quad fosc = \frac{1}{2Nstages((tDhl+tDlh))}$$

Where, $rdhl$= output propagation delay for high to low, $rdhl$=output propagation delay for low to high

$$\bullet \quad fosc = \frac{1}{2Nstages((tDhl+tDlh))}$$

Putting the values, F_osc = 24.64GHz.**(Calculated Frequency for 5 stages RO).**

CMOS Differential LC Oscillator

CMOS Differential LC oscillators are commonly used in radio frequency circuits because of their good phase noise characteristics and their ease of implementation. Differential LC oscillator the operating frequency is decided by the capacitor and inductor value [1] [10]. The operating frequency is given by:

$$fo = \frac{\omega 0}{2\pi} = \frac{1}{2\pi\sqrt{LC}}$$

The LC oscillator designed here is based on the resonant effect of a passive inductor and capacitor circuit. The physical design of differential LC oscillator shown in figure 4; where the inductor L1 resonates with the capacitor C1 connected to S2, combined with C2 connected to S1.

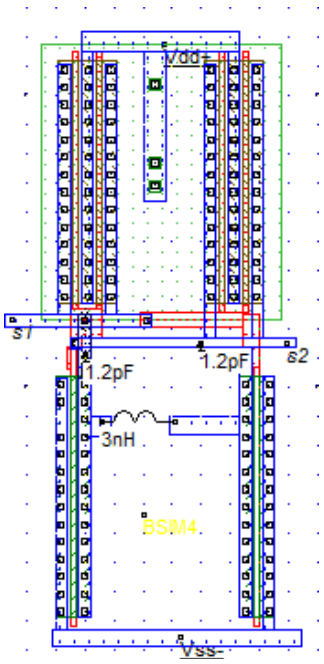

Figure 2: Physical design of CMOS Differential LC Oscillator

For calculating Frequency of oscillations, L= 3 nH, C= 1.2 pF each

$$fo = \frac{1}{2\pi\sqrt{3nH * 0.5pF}}$$

Putting the values**,** F_osc = 4.11 GHz.**(Calculated Frequency)**

A. Voltage Controlled Oscillator:-

A voltage-controlled oscillator (VCO) is an electronic oscillator designed to be controlled in oscillation frequency by a voltage input. The most popular type of the VCO circuit is the current starved voltage.A voltage-controlled oscillator (VCO) is an electronic oscillator designed to be controlled in oscillation frequency by a voltage input. The most popular type of the VCO circuit is the current starved voltage

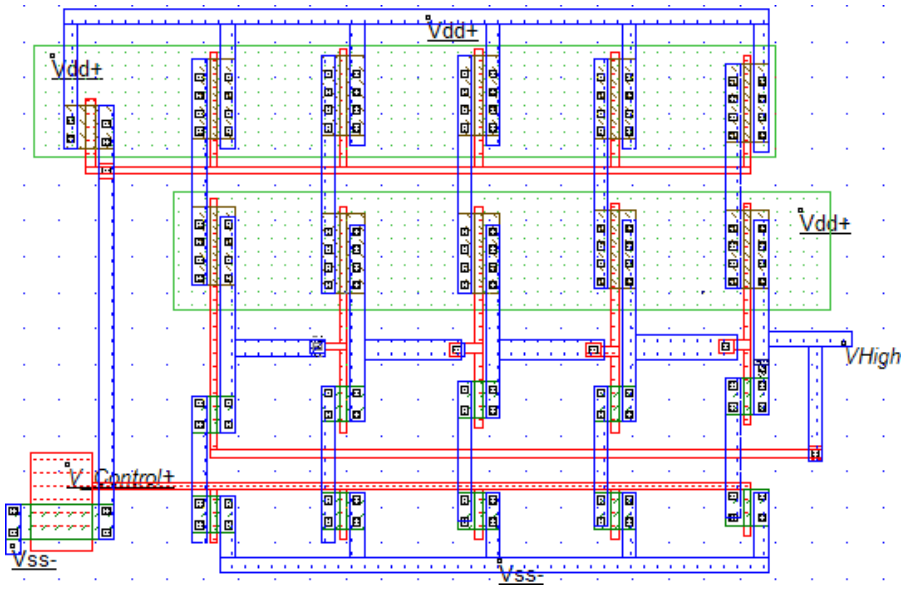

Figure 3:- Physical design of CMOS VCO.

The operating frequency for VCO is given by:

$$fosc = \frac{1}{2Nstage\ tD}$$

$$fosc = \frac{ID}{2Nstage\ CG\ Vth}$$

Where; Nstage = Number of delay stages in a ring oscillator, ID is Drain Current, Vth = Threshold Voltageand tD = Propagation Delay.

From the above question, it is clear that the oscillation frequency of ring oscillator can be changed by changing drain current.

For calculating Frequency of oscillations for designed VCO, N=5, Vth=0.240V, Cg=1.01fF, Id=0.028mA
Putting the values, F_osc= 2.24GHz GHz**(Calculated Frequency)**

Simulation Results:-

The physical design is simulated with Microwind EDA tool in build simulator. The AC transfer characteristics is for RO, LC and VCO is given below.

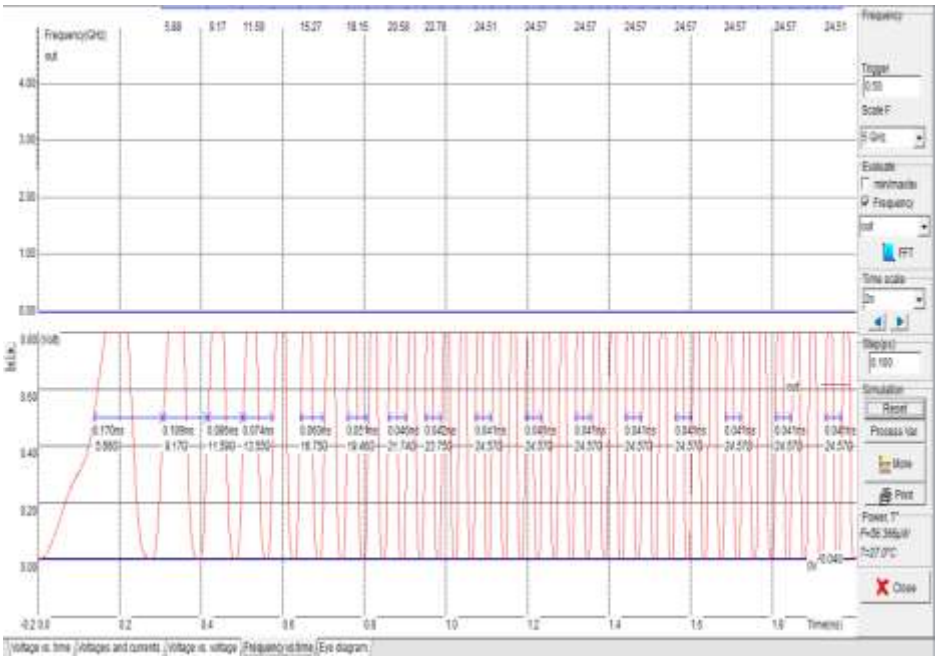

Figure 4:- Frequency analysis for RO 5 stages.

The simulated frequency of oscillations for 5 stages of RO is 24.51GHz.

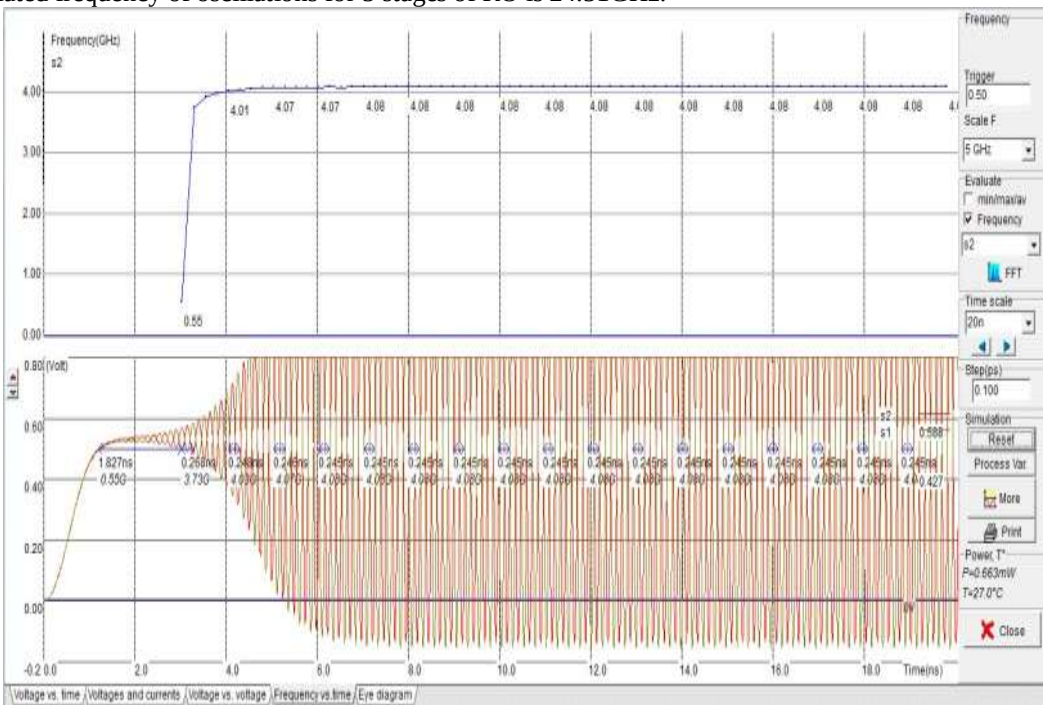

Figure 5:- Frequency analysis for Diff LC Oscillator.

The simulated frequency of oscillations for Differential LC oscillator 4.08 GHz.

When, V_control is a clock input with very slow change with little high rise time and same high fall time, the output frequency varies from 2.36 GHz to 3.23GHz with medium frequency of 1.55 GHz.

V_control is a input clock signal applied as DC supply with supply voltage as 0.5V;

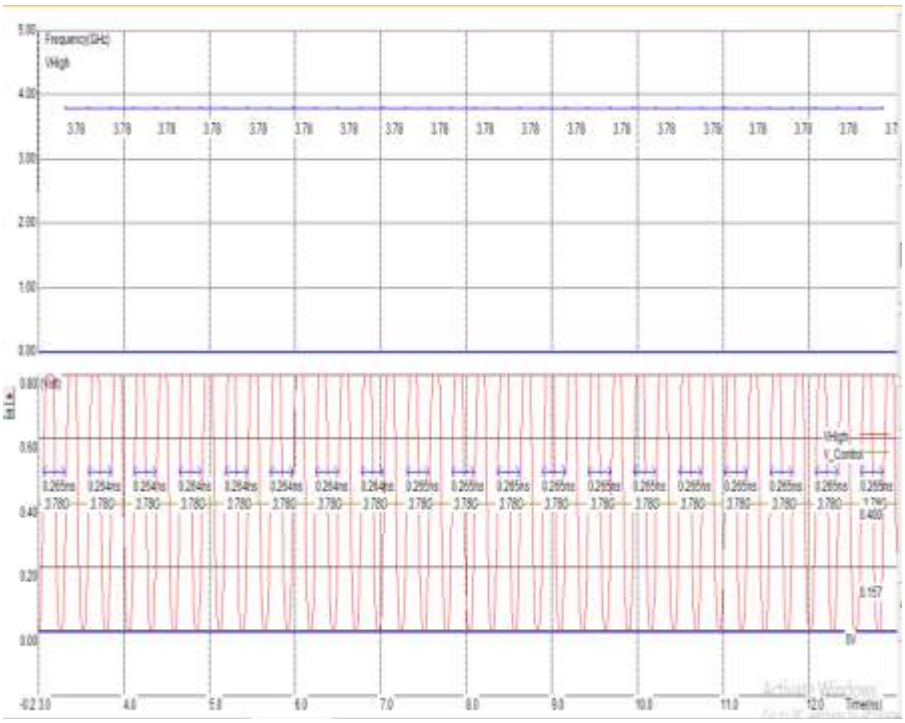

Figure 6:- Frequency analysis for VCO.

The simulated frequency of oscillations for CMOS VCO with 5 stages is 3.78 GHz.

Result and Observations:-

For Ring Oscillator:

Ring Oscillator		
Stages (N)	**Calculated F**	**Simulated F**
5	24.64GHz	24.75 GHz
9	14.24 GHz	13.78 GHz
11	11.65 GHz	11.35 GHz
13	9.86 GHz	9.51 GHz

For Differential LC Oscillator:

LC Oscillator		
Component	**Calculated F**	**Simulated F**
L= 3nH, C=1pF	4.11GHz	4.08 GHz
L= 3nH, C=1.2pF	4.02 GHz	4.04 GHz
L= 3nH, C=2.7pF	2.5 GHz	2.43 GHz

For Voltage Control Oscillators:

V_Control	**Calculated F**	**Simulated F**
0.5 V	5.30 GHz	5.60 GHz
0.6 V	7.37 GHz	7.13 GHz
0.8 V	9.24 GHz	9.44 GHz
1.0 V	10.59 GHz	10.78 GHz

Conclusion:-

There are plenty applications of a frequency, because it forms the basic function for most of the electrical and electronic systems. The proposed design of CMSO based RO, LC and a wide frequency range VCO was detailed in this work with CMOS 45nm tehnology. The detailed comparative analysis between physical design result and the

calculated results of frequency for Ring, Differential LC and VCO oscillators is presented. The maximum power consumption of the design for RO, LC and VCO is 56.366uW, 66.255uW and 25.151uW respectively which is very less as compared to the earlier design with good linearity over the tuning range.

References:-

1. “Implementation & Comparison of Different oscillators for ISM and WI -FI Band Applications”, Prof. Sandeep
2. K. Shelke, Prof. Priti J. Rajput, and Prof. Santosh Bari: IEEE – 2017 11th International Conference on Intelligent Systems and Control (ISCQ)
3. "Design and Analysis of Voltage Controlled Oscillators in 45nm CMOS Process", Kavyashree K, Chandana D S,Pruthvi Raj Anantharam Bhat, Sangeetha B G, Second International Conference on Innovative Mechanisms for Industry Applications (ICIMIA 2020) IEEE Xplore Part Number: CFP20K58-ART; ISBN: 978-1 7281-4167-1
4. "CMOS Current Starved Voltage Controlled Oscillator Circuit for a Fast Locking PLL", AbdulMajeed K.K,
5. Binsu J Kailath, IEEE INDICON 2015 1570186537
6. "A Wide Band CMOS Differential Voltage Controlled Ring Oscillator", Luciano Severino de Paula1, SergioBampi2, Eric Fabris1, Altamiro Amadeu Susin, 978-1-4244-2332-3/08/$25.00 © 2008 IEEE
7. "Design of Voltage Controlled Oscillator in 180 nm CMOS Technology", Sandhiya S., Revathi.S, Dr. B.Vinothkumar, International Research Journal of Engineering and Technology (IRJET)
8. "Design of Low Phase Noise Ring VCO in 45NM Technology"Pankaj A. Manekar , Prof. Rajesh H. Talwekar,
9. International Journal of Scientific & Engineering Research, Volume 4, Issue 6, June-2013
10. “A CMOS Voltage Controlled Ring Oscillator with Improved Frequency Stability”, G. Jovanovi´c, M. Stoj˘cev,
11. Z. Stamenkovic, SCIENTIFIC PUBLICATIONS OF THE STATE UNIVERSITY OF NOVI PAZAR
12. "A Voltage Controlled Oscillator using Ring Structure in CMOS Technology", Mrs. Devendra Rani, Prof.
13. Sanjeev M. Ranjan, International Journal of Electronics and Computer Science Engineering
14. “Design of CMOS based VCO for PLL with improved Frequency Range", Swati Gulhane, Sujata Kadam,INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY
15. “Design and Performance Analysis of LC Oscillator and VCO for ISM and WI-FI Band Applications”, Mr. Jayant P. Sakurikar, Asst. Prof. Divyanshu Rao, Prof. Ravi Mohan, International Journal Of Engineering And Computer Science ISSN:2319-7242 Volume 4 Issue 6 June 2015, Page No. 12624-12628
16. “Design of LC Oscillator and VCO for ISM and WI-FI Band Applications”, Prof. Seema Zanje, International Journal of Innovative Research in Engineering & Management (IJIREM) Volume-1, Issue-3, November-2014
17. “Ring CMOS NOT-based Oscillators: Analysis and Design”, F. Sandoval-Ibarra, E. S. Hernández Bernal,Microelectrónica; semiconductor devices; circuitos integrados de efecto de campo. PACS: 84.40.-e; 85.30.-z; 85.30.Tv.