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Literature Review on Ring Oscillator for Biomedical Application Using CMOS

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***Abstract:** In this paper we have been studies on various design techniques of oscillator for biomedical application. The major subject of this research study is oscillators, which are electronic circuits that generate periodic signals with a constant frequency. A comprehensive review of various oscillator topologies and their characteristics, including stability, frequency range, and phase noise, is provided in this article. The project's objective is to review contemporary oscillator design approaches and consider how they might be applied in a variety of sectors, such as instrumentation, control, and communication systems. Oscillators are electronic circuits that generate repeated waves at set frequency. It is the foundation of numerous electrical gadgets, such as radios, televisions, and computers. Oscillators are used in measurement, control, and communication systems. Science routinely examines the behavior and characteristics of oscillators, such as their stability, frequency range, and phase noise. Researchers may also look at novel oscillator topologies and design approaches to improve performance or enable new applications. Oscillator research is essential for the development of cutting-edge electrical technologies and systems.*
***Keywords:** Oscillator design ,Biomedical Application ,CMOS ,Ring Oscillator.*

I. INTRODUCTION

Since integrated circuit technology was introduced, the size of electronic devices has significantly decreased. There are a few characteristics that designers must consider when creating any integrated chip. They are delay, silicon area, speed, and power consumption. These integrated circuits are built using the commonly utilized CMOS (complementary metal oxide semiconductor) technology because CMOS circuits have a reduced space need and low power consumption. A complementary and symmetrical pair of p-type and n-type metal oxide semiconductor field effect transistors (MOSFET) is used to implement any digital circuit.[1]Comparatively speaking to other oscillators, the Ring oscillator is a very small apparatus. Ring oscillators provide various benefits, including the ability to operate at high speeds and low areas. The desire for low power and tiny size electronic gadgets is increasing quickly as we move further into the future. Integrated circuits made on complementary metal oxide semiconductors, or CMOS, are the digital technology that is thriving in the modern information age. An odd number of NOT gates make up a ring oscillator, which has an output that alternates between two voltage levels that correspond to logic 1 and logic 0.[2] An odd number of inverting amplifier stages with a feedback to its input make up a ring oscillator. The positive indication is added to the feedback signal.[2]A device known as an oscillator is one that runs independently of external signals and produces output that is continuous in nature, which refers to a repeated pattern like an alternating waveform.[3]High-performance CMOS circuits for on-chip integration are becoming more and more popular as a result of the high-speed wireless communication system's explosive growth. Due to dynamic power consumption that is inversely proportional to operation frequency, conventional CMOS circuits experienceexcessive power consumption at high speeds.[4]For low power consumption, various logic styles have been presented in the literature. For high-speed circuits, MOS current mode logic (MCML) is frequently utilized as an alternative to CMOS logic. High noise immunity and minimal power dissipation are features of MCML. Another issue with MCML logic is static power consumption brought on by the usage of constant current sources.[4]Electrical systems of all shapes and sizes exhibit oscillating. signals. A digital electronic system's processes can be synchronized by using an oscillating signal as a clock signal.[5]Oscillators can be classified as either linear/harmonic or nonlinear/relaxation. A ring oscillator is a kind of relaxation oscillator that generates a non- sinusoidal signal that alternates between high and low voltage by using an odd number of inverters. The first inverter receives the output of the last inverter, hence the term "ring" oscillator[5].

CMOS technology is frequently employed in commercial applications because to its many benefits. In this day and age, the majority of digital and electronic devices exhibit oscillatory behavior , hence reliability is another crucial factor that must be taken into consideration while developing low power circuits.

The most crucial element of all digital, optical, and communication systems are oscillators. In many biomedical applications, oscillators are essential. An oscillator is a circuit ordevice that generates an electrical signal that oscillates or alternates between two values at a particular frequency, frequently a high value and a low value. many biomedical applications, such as ,The high-frequency signals needed for ultrasonic imaging are provided by oscillators in the field of medical imaging. The frequency of the oscillator affects the resolution and depth of the ultrasonic waves' penetration. Signal recording for electrocardiograms (ECG) and electroencephalograms (EEG): ECG and EEG signals are recorded using oscillators. In these applications, the oscillator generates the signal, which is then used to measure the electrical activity of the heart or brain. In pulmonary function testing, oscillators are used to create a standardized airflow through the airways. The oscillator's frequency determines how frequently the lungs' pressures fluctuate, which can be measured to determine how well the lungs are functioning. Drug Delivery Systems: In drug delivery systems, oscillators can generate an electrical signal that prompts the release of a drug from a device at a specific frequency. Because they deliver the precise and controlled oscillations needed for a variety of diagnostic and therapeutic purposes, oscillators are generally essential in biomedical applications.

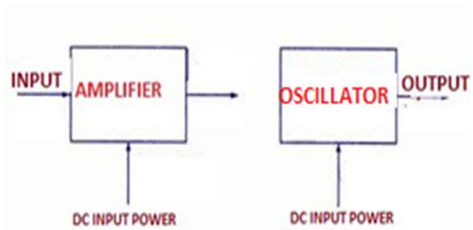

Fig -1: Basic diagram of Amplifier and Oscillator

A. Types of Oscillator Used in Biomedical Application

The specific requirements of the application determine the type of oscillator that is used in biomedical applications. A fewoscillator types are, nevertheless, frequently used in biological applications:

1) *Crystal oscillators:* Crystal Oscillator are the best choice for applications that require a high level of accuracy such as ECG and EEG recording, because of their great precision and stability.
2) *Relaxation oscillators:* These devices are widely employed in applications that call for a low-frequency signal, suchpulmonary Oscillators: function tests.
3) *Phase-Locked Loop (PLL):* PLL oscillators are often used in medical imaging applications like ultrasound imaging because of their capacity to produce precise and stable high-frequency signals.
4) *Voltage-Controlled Oscillators (VCOs):* VCOs are often used in implantable medical device like pacemakers and defibrillators due to their capacity to produce precise signals while consuming little power.

In general, the oscillator's frequency range, stability, precision, power consumption, and compactness are all important in biomedical applications.

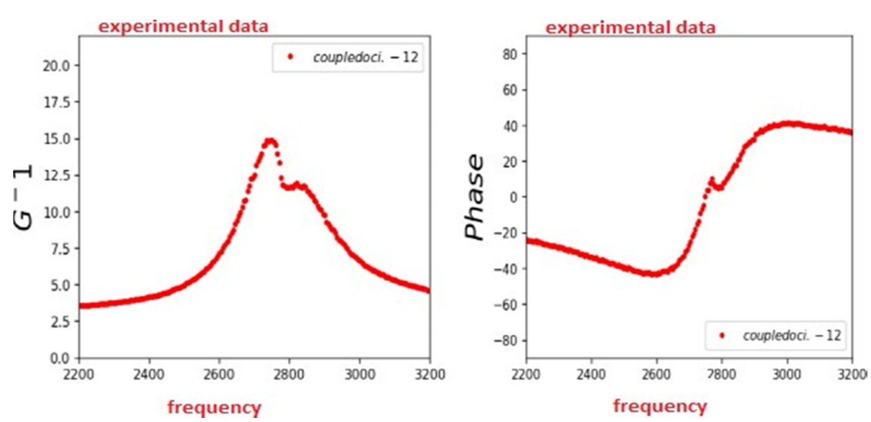

Fig-2: Amplitude and Phase response of Oscillator

B. Ring Oscillator

An electrical circuit that produces a steady oscillation signal is called a ring oscillator. It consists of an odd number of looped or ring-connected inverting amplifier stages. A closed loop is made when the output of the final amplifier is fed back into the input of the first amplifier. The delay through each step of the circuit, which is a function of the amplification and propagation delays of the used components, determines the oscillation frequency of a ring oscillator. digital circuits, the oscillation frequency of a ring oscillator is frequently employed as a clock signal or as a reference frequency. A ring oscillator normally produces a square wave as its output waveform, though alternative waveforms can be produced by altering the circuit. Ring oscillators are frequently used in integrated circuits because they are straightforward, simple to manufacture, and utilize a small amount of power. Additionally, they are utilized in phase- locked loops, clock recovery, and frequency synthesis applications, signal processing ,communication system such as, filters ,modulators and demodulators. A ring oscillator's design presents a number of trade-offs and difficulties, such as balancing the circuit's stability, frequency, and power consumption. For certain purposes, ring oscillators can be made using a variety of circuit topologies, amplifiers, and fabrication methods.

A ring oscillator's fundamental component is an inverter cell. The PMOS and NMOS in the cell are arranged in complimentary pairs. Additionally, the two cells are symmetric in thein such a way that factors like channel length and doping are the same for both devices. an inverting operation means that when the input is low, the output is high, and vice versa. Nowadays, practically all digital designs use inverters. Any complex circuit's behavior can be predicted by making an educated guess based on the inverters' results. All designs, both digital and analogue, can be produced utilizing CMOS technology.

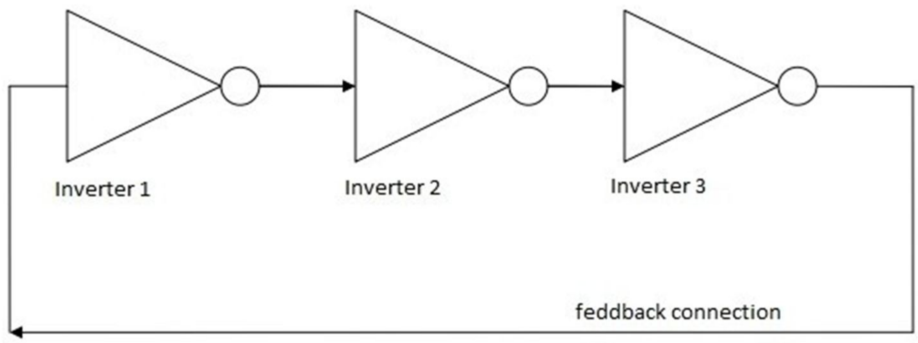

Fig-3: Basic Building Block of Ring Oscillator

II. CMOS INVERTER

CMOS, which is pronounced "see mos," stands for "complementary-symmetry metal-oxide-semiconductor." P-type and N-type MOSFET pairs with complementary and symmetrical architectures are used in the manufacture of CMOS devices to perform logic operations. Low static power consumption & good noise immunity are the two primary CMOS device properties. The most widely used flexible MOSFET inverters are CMOS inverters, which are used to construct integrated circuits such the CD4069UB CMOS hex inverter, CD4069UBE, CD40106BE, etc. They operate with relatively minimal power loss and at high speed. In small electrical circuits, these inverters are employed to generate data. The term "CMOS inverter" refers to a device used to produce logic functions, which is a crucial element in all integrated circuits. The field effect transistor (FET) that makes up a CMOS inverter has a metal gate that sits on top of an insulating layer of oxygen over a semiconductor. The majority of electrical devices that produce data in tiny circuits use these inverters. The CMOS inverter is made up of PMOS and NMOS MOS transistors, where PMOS is known as the pull-up network and NMOS is known as the pull-down network. When the input is low, the NMOS is off, the PMOS is on, and the transistor is pulled high. When the input is high, the NMOS is on, driving the network down and the output is low. In the CMOS inverter, both the PMOS and NMOS transistors can be connected in this way. A voltage supply (VDD) is connected to the source terminal of the PMOS transistor, a GND terminal is attached to the source terminal of the NMOS transistor, and the transistor is connected at its drain and gate terminals. The transistor's drain (D) terminals are connected to the output voltage (Vout), which is connected to both of the transistor's gate terminals (Vin). In a ring oscillator, the gain stages are connected in a loop such that the output from the last stage is fed into the input of the first stage. To produce persistent oscillation, the circuit must meet the Barkhausen requirements, which stipulates that it should have a phase shift of 2π and unity voltage gain.

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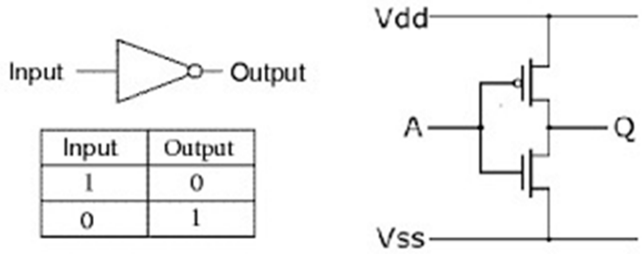

Fig- 4: CMOS Inverter

Comparison Table

Table -1: Different Types of Ring Oscillator are Compared in this table

Year	References	Technology	No of stage	Oscillator type	Power consumption
2016	[1]	45nm	5,7,9	Ring oscillator	Reduced by 79%
2019	[2]	65nm	n	Ring oscillator	25nm
2018	[3]	-	7	Ring	less
2021	[4]	TSMC 0.25µm	-	VCO	3.127mW
-	[5]	32nm	19	Ring	0.338µW to54.0mW -
2005	[6]	0.25µm	7	Ring	-
2012	[9]	45nm	9	Ring	Reduced by18.9%
2011	[10]	0.18µm	4	Ring	-
2013	[11]	180nm	3	VC Ring Oscillator	-
2017	[12]	90nm	3	Ring	0.295mW
2020	[13]	45nm	3,4	DRO	866µW
2017	[14]	65nm	4	Ring	328.6µW

III. CONCLUSION

Ring oscillators have been the subject of extensive research in recent years, including the development of novel materials, circuit topologies, and advanced simulation and optimization methods. Additionally, the study of fundamental physical phenomena including noise, nonlinearity, and synchronization has been conducted using ring oscillators. How an oscillator in research reaches a result will depend on the specific study question and goals being addressed. In general, oscillators are essential components of many electronic systems, from communication networks to consumer electronics. They generate signals at specific frequencies for timing, communication, and other functions. Enhancing particular elements, including frequency stability, power consumption, or other performance measures, may be the aim of oscillator research. Various oscillator topologies, including phase-locked loops, voltage-controlled oscillators, and quartz crystal oscillators, may also be researched. The main findings of oscillator research are typically summarized along with their importance for the design and operation of electronic systems. It may also highlight areas that require additional research or development, such as novel oscillator topologies or applications. Overall, the results of oscillator research are expected to emphasize the need of precise and reliable signal generation in a range of electronic systems and the ongoing requirement for innovation in this area.

Ring oscillators' design concepts, performance traits, and applications are all intended to be covered in this paper's overview. The literature on ring oscillators will be reviewed, and we'll focus on some recent advancement and potential future lines of inquiry.

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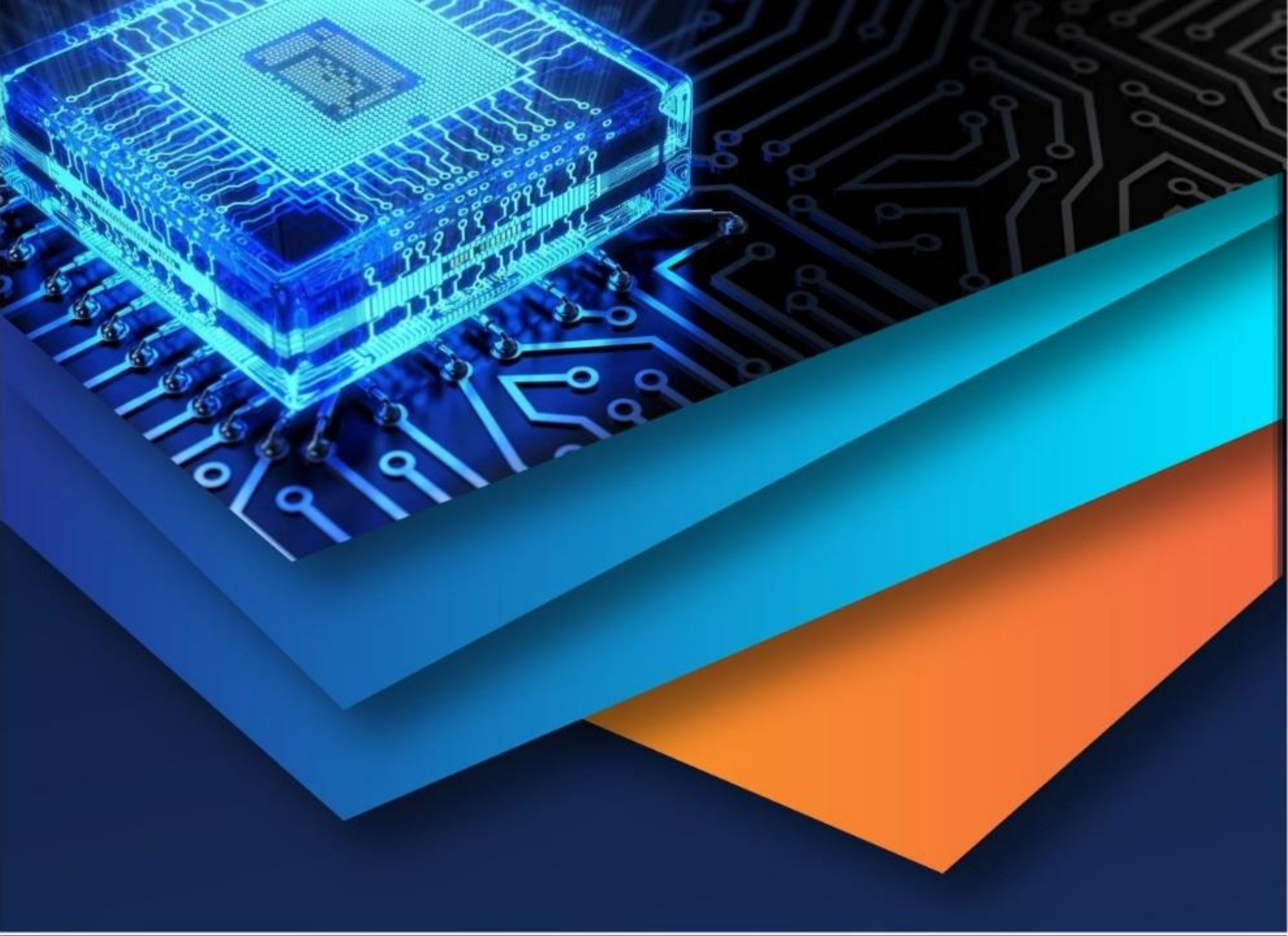

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