Design of Complementary Metal Oxide Semiconductor Based Three Stage Ring Oscillator On The Basis Of Frequency, Leakage Current and Leakage Power With and Without Memristor

Ravinesh Bhadoriya, Nikhil Saxena

Abstract- This paper is based on the results obtained from CMOS based three stage ring oscillator with and without using the memristor. After analyzing, the results obtained from memristor based oscillator are better in terms of frequency, leakage current and leakage power. Also a brief overview about the memristor is given, whose characteristics lies among resistance, inductance and capacitance.

Keywords: CMOS, Leakage current, Leakage Power, Frequency

I. INTRODUCTION

In past there were three basic constituents which used to complete any circuit. But an another element came in existence. This element is named as memristor. Memristor is basically a combination of resistor and memory which means it is essential to have resistor and memory for the memristor technology [3]. The value of resistor pivots on the rate of applied voltage and the value of time taken by it. In 1971, the abstraction of memristor came in light. Although, it was all depend until that scientists and researchers at HP lab who have the ability to create the first piece which may work properly. This was because of the size of memristor, as the variation in the resistance of memristor is unable to find if the range of the applied resistor of memristor is not under nanometer. In case if the size of memristor (thickness) is much as compare to nanometer in such case, it is unrecognizable from a slandered resistor. The major advantage of using the memristor in present computing is to it keeps on its resistance without even applying the voltage. This would allow a computer to retain its saved state while off and would require less power to run when it is on. The next advantage of memristors is of its analog nature. However there are two states of button which founds in computers usually known as on and off, the resistance of a memristor has the variable amount of values it can be.

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However the memristor can still be consider best for the storage of digital memory, the research on the progression of analog computers with memristors is growing on rapidly. Memristance is an attribute of an electronic constituent. If charge passes unidirectional in a circuit, the increment in value of flow of resistance is possible, however if charge is flowing in opposite direction in a circuit, the decrement in resistance is possible. In some cases where the flow of charge is stopped by turning off the supply of voltage, the component will 'consider' as its last rate of flow of resistance but if the charge starts passing afresh, the resistance of the circuit will be as same as it was last when the rate of resistance is at the time when the charge was flowing actively. It is stated that memristance is becoming the rapid growing technology because the feature sizes of circuits designed by memristor are decreasing which is the sign of bright future of memristor technology in field of electronics. At many point as memristor technology is heading towards the arena of nano-electronics, it is important to take account of memristance in any circuit in order to simulate and design electronic circuits properly [1].This technology is providing the advancement and a ray of hope to the researchers for a future technology. Memristor word is a combination of "memory and resistor". According to the name of the work and process is fully based on the name of memristor. There are two terminals which found in memristor, these two terminals are used for representing the properties of memristance. Let it suppose that the resistor as a pipe which has the water which flows under the pipe. The water is electric charge. The resistor's barrier of the passing of charge is then to differentiate the diameter of the pipe: the lesser diameter's pipe will contrary the huge amount of resistance, this means is that the broad diameter of pipe will carry the small amount of resistance. For the sample of circuit design, there is a fix parameter of diameter of pipe. However memristor is a shape of pipe which is able to change diameter as per the amount and the passing of direction of water which passes through the pipe. For an instant if water flows through this pipe unidirectional, it enlarges (becoming less resistive). In other case if the water passes in the opposite direction in such case the pipe gets shorten (becoming more resistive). Furthermore, the memristor keeps in mind about its diameter and hence water reaches on its end.

After the end of the water if the passing of water is turned off, the diameter of the pipe "becomes hold" until the water is turned back on [2].The memristor is generally described as a two-terminal constituent which has the magnetic flux (Φm) in the middle of these both the constituents which creates a function of the amount of electric charge q which goes through the device. All memristors are distinguished by a function which is known as memristance, this function describes the charge with rate of change of flux.

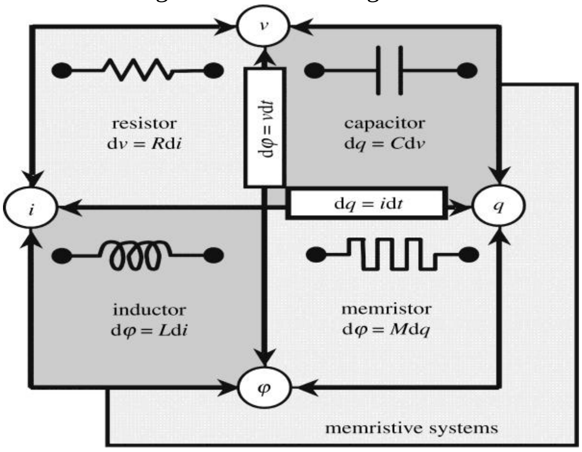

Fig I Full Component Layout Of A Memristor

From the fig.I it can be observe that in memristor technology the combination of resistor, capacitor and inductor is must for the operation of memristor technology properly.

II. TYPES OF MEMRISTOR

A. Molecular Ionic thin film memristor

These types of memristors primarily depend on various properties of thin film atomic grids which betray hysteresis under the application charge.

a. Titanium dioxide memristors

The titanium dioxide memristor first originated at HP Lab which is alike a two layer thin 'sandwich' of titanium dioxide films, constructed of symmetrical grids of titanium and oxygen atoms.(The resistance of titanium dioxide is changed under presence of oxygen, as it is used in sensors of oxygen). [3]The movement of atoms in the films is bind up to the motion of electrons in the material, which becomes the cause of major change in the atomic frame of the memristor. The down side last layer behaves as an insulator and the up side first film layer behaves like a conductor via oxygen vacancies in the up side first layer which moves to the down side last layer, which becomes the cause of changing the resistance and maintain the state. To access the memristive properties, it is necessary to do so, so that a charge can be passed through it.

b. Polymeric (ionic) memristors

Exploiting the characteristics of several solid-state ionic's, one element of the material body, either cationic or anionic, as it is free for motion all around the body just like a charge carrier. Polymeric memristors travel dynamically for the doping of polymer and inorganic dielectric-type substance to venture and excite hysteresis kind of behaviors. Normally, passive layer in middle of an electrode and an active thin film venture to overemphasize the removal of ions from the electrode. The words polymeric and ionic are simply used somehow like loosely and generically.

c. Magnetite memristive systems

In 2001, a substrate of double-layer oxide films based on magnetite, which averse to titanium dioxide, were betrayed as explaining memristive characteristics at the Houston University.

d. Resonant-tunneling diode memristors

Definite varieties of quantum-well diodes with special doping designs of the spacer layers in the middle of the source and drain regions exhibit memristive properties.

B. Spin and Magnetic memristor

In order to identify the participation of every spin torque to the domain wall motion in any trial, it is necessary to calculate the progression of the density of current. This current density is representing as Jth.

II. RING OSCILLATOR

An oscillator is an electronic system or device whose operations are based on oscillations i.e. a complete cycle from one extreme end to another extreme and back to it again. In other words it may be described as, an oscillator is a device which is used to convert direct current to alternative current of power supply. Some devices like computers watches, radios and televisions are few examples of among the several devices in which oscillators are used.

A. Simulation results of CMOS based three stage ring oscillator

Figure (II) shows the basic diagram of CMOS ring oscillator –

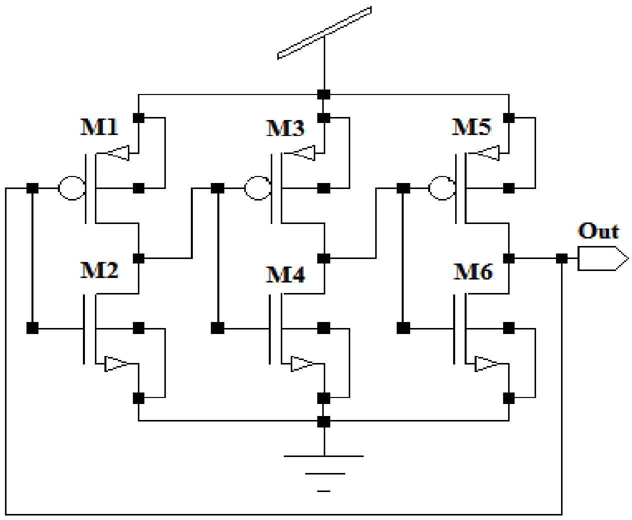

Fig (II) Cmos Based Three Stage Ring Oscillator Without Memristor

The simulation result of CMOS based three stage ring oscillator is showing below-

The oscillation obtained by using H-spice tool is showing below in figure (III).

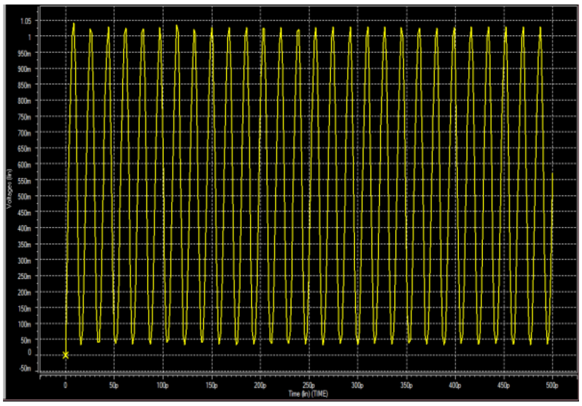

Fig III Simulation Result Of CMOS Oscillator Without Memristor

Based on the following simulation result of CMOS based three stage ring oscillator the various parameters such as frequency, leakage current and leakage power have been examined by applying 0.7V of power supply and the results obtained by using H-spice tool. The results obtained in this process are described in the table I below-

Table I Results

Parameters	Results
Frequency	1.449E+10
Leakage Current	5.8920E-06
Leakage Power	4.1241E-06

The one line graphical representation of the parameters like frequency, leakage current and leakage power of CMOS based three stage ring oscillator without memristor by changing the supply voltage from 0.5 to 1.5 V is showing respectively in the figure below-

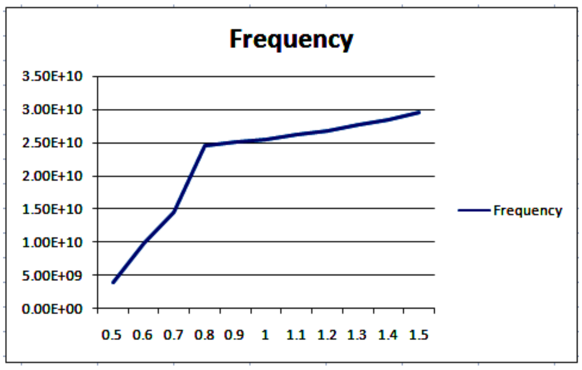

Fig (IV) Graphical Representation Of Frequency Of Cmos Oscillator Without Memristor

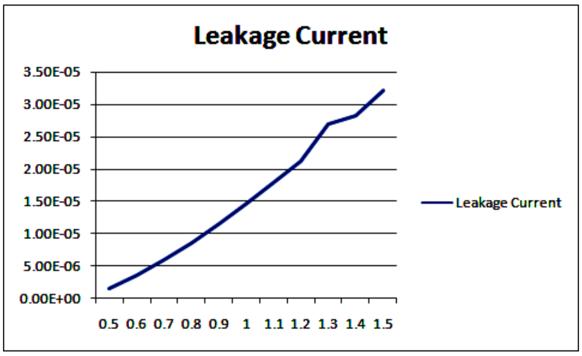

Fig (V) Graphical Representation Of Leakage Current Of CMOS Oscillator Without Memristor

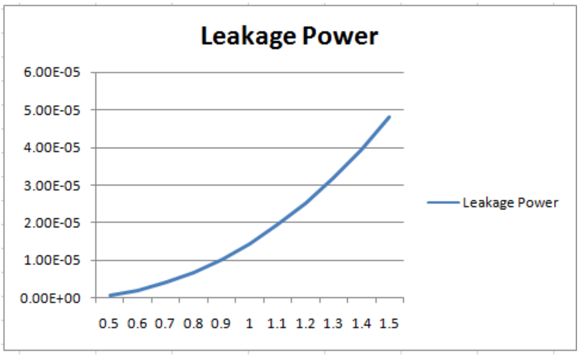

Fig (VI) Graphical Representation Of Leakage Power Of CMOS Oscillator Without Memristor

In this paper, for improving the results of CMOS based three stage ring oscillator, memristor technique has been applied. The simulation result of CMOS based three stage ring oscillator with memristor technique are better than the results obtained in CMOS based three stage ring oscillator without memristor technique.

B. Simulation results of CMOS based three stage ring oscillator with memristor

Figure (VII) shows the basic diagram of memristor based three stage ring oscillator below-

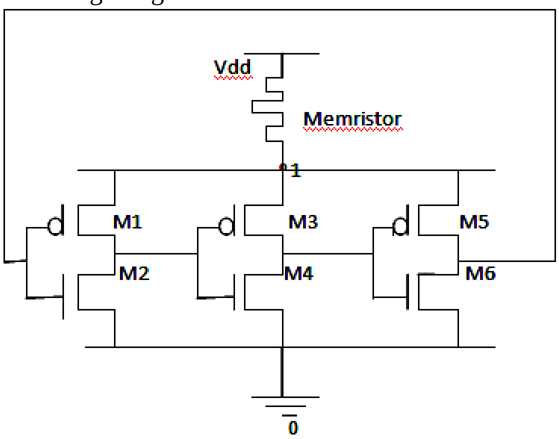

Fig (VII) CMOS Based Three Stage Ring Oscillator With Memristor

The simulation result of CMOS based three stage ring oscillator with memristor is showing in fig (VIII) below-

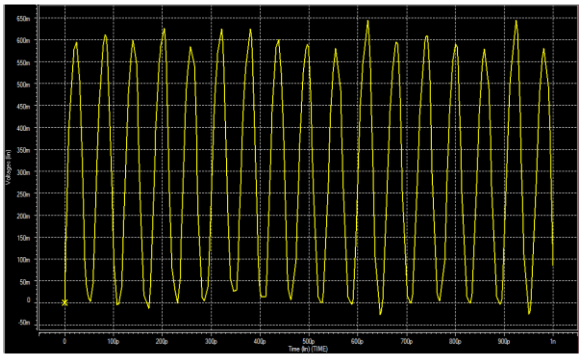

Fig (VIII) Simulation Result Of CMOS Oscillator With Memristor

The following simulation result is obtained by using H-spice tool. The power supply is applied of 0.7 V again in memristor technique. The results obtained by memristor technique are based on same parameters such as frequency, leakage current and leakage power are given in table II –

TableII Results

Parameters	Results
Frequency	0.1694E+11
Leakage Current	7.025E-07
Leakage Power	4.918E-07

The one line graphical representation of the parameters like frequency, leakage current and leakage power of CMOS based three stage ring oscillator with memristor by changing the supply voltage from 0.5 to 1.5 V is showing respectively in the figure below-

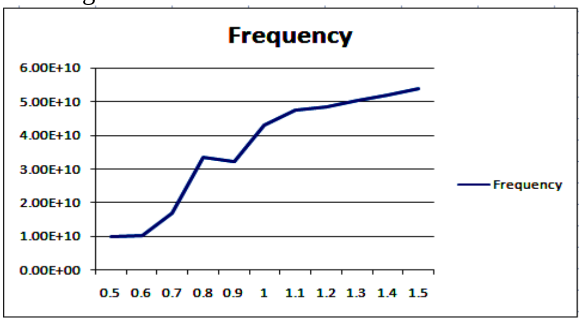

Fig (IX) Graphical Representation Of Frequency Of CMOS Oscillator With Memristor

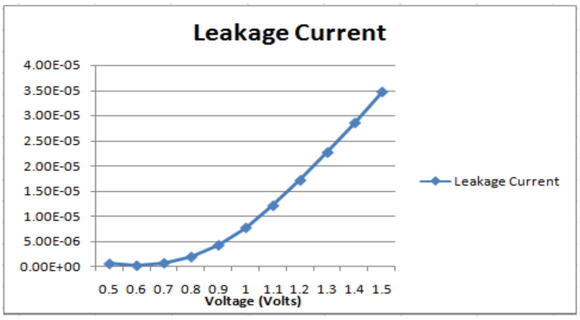

Fig (X) Graphical Representation Of Leakage Current Of CMOS Oscillator With Memristor

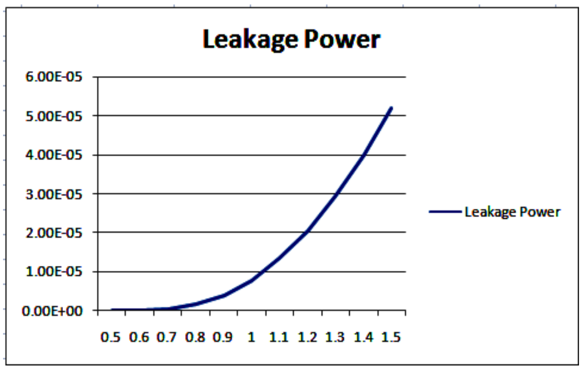

Fig (XI) Graphical Representation Of Leakage Power Of CMOS Oscillator With Memristor

From the table (I) and table (II) we can observe that the results are better in terms of frequency, leakage current and leakage power by using memristor.

IV. COMPARISON TABLE

A comparison is made with previous researches for comparing the results of this paper. The comparison is giving in table III below-

Table III Comparison Table

Parameters	CMOS Ring oscillator	CMOS Ring oscillator	CMOS Ring oscillator
Comparison with	Bhawika Kinger 2015 [4]	Rafiul Islam 2017 [3]	Proposed Work (with memristor)
Supply Voltage	1.0 V	1.0 V	0.7V
Channel Length	130 nm	90 nm	32 nm
Frequency	3.50E+09	6.02E+09	0.16E+11
Leakage current	-	-	7.02E-07
Leakage power	3.11E-05	0.29E-06	4.91E-07

V. CONCLUSION

In this paper in first stage the results are calculated of CMOS based three stage ring oscillator of the various parameters such as frequency, leakage power and leakage current. For improving the results of CMOS based three stage ring oscillator memristor technique is applied and the results which are obtained by memristor technique on CMOS based three stage ring oscillator are better in all the terms such as frequency, leakage current and leakage power. These results are performed under H-spice tool.

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AUTHORS PROFILE

Ravinesh Bhadoriya is the Research Scholar (VLSI Design) from ITM University (GOI), Gwalior. One paper has been published in an International Conference; the second paper is under review. This is third paper of author. The author has attempted the research in field of ring oscillator by using various techniques such as LECTOR, MTCMOS and Memristor for the improvement of frequency, and other parameters such as leakage current and leakage power.

Nikhil Saxena is working as assistant professor in ITM University (GOI) Gwalior in ECE department. The author has guided many students of M. Tech. (VLSI Design & CTM). Forty plus paper have published of the author in national and international journals.

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