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Carbon Nanotube Transistor Based Novel Ring Oscillator with Minimum Power Consumption at 32 nm Technology Node

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Abstract

In this article an analysis of carbon nanotube field effect transistor based ring oscillator is performed. After analysis it was found that carbon nanotube transistor consumes less power in comparison to silicon transistor. CNFET is one possible candidate to substitute silicon-based integrated circuit (IC) technology, as the performance increase of conventional transistors witnessed during the last decades will arrive at its ultimate limits in the near future. Its present progress is largely dominated by the materials science community due to many still existing materials-related obstacles for realizing practically competitive transistors. Compared to graphene, carbon nanotube provides better properties for building field-effect transistors, and thus, has higher chances for eventually becoming a production technology. So, in this work it is used carbon nanotube field effect transistor in place of silicon based transistor for making a ring oscillator.

Keywords: *Carbon nanotube, power consumption, leakage current, silicon*

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INTRODUCTION

The carbon-nanotube field-effect transistor (CNTFET) is the only possible transistor for future high performance nano electronic circuits. Further downscaling of digital electronics according to Moore's law may be done by CNTFET; on the other hand the conventional CMOS technology is approaching its fundamental physical limits. However, in the today's market, with the increasing importance of systems-on-chip (that means maximum number of transistors possible on a single chip); the digital performance should not be the only parameter to verify the performance of digital circuits. As shown in Figure 1, CNTFET works on a single carbon based transistor. First demonstrated [1] in 1998, there have been major developments in CNTFETs. According to Moore's law, the transistor count should be double after every two years.

This lowering of devices has been the propulsion in technological advances since late twentieth century. The bounds involve lepton tunneling through short channels and skinny material films, the associated outpouring currents, passive power dissipation, short channel effects, and variations in device structure and doping. These limits may be overcome to some extent. Associate in nursing facilitate any lowering of device dimensions by modifying the channel material within the ancient bulk MOSFET structure with one nanotube or an array of carbon nanotubes (Figure 2).

Proposed Oscillator Circuit

Oscillating signals area unit seen altogether differing types of electrical systems. Associate degree periodical signal will be used as a clock signal so as to synchronize the operations of a digital electronic system. These signals may be employed in radio and communication systems [1]. Electronic oscillator area unit designed so as to make these signals. There area unit 2 main sorts of oscillators,

linear/harmonic and nonlinear/relaxation. A hoop generator could be a kind of relaxation generator that contains associate degree odd range of inverters making a nonsinusoidal signal alternating between a high and low voltage [2]. The output of the last electrical converter is connected to the primary inverter; the name "ring" generator comes from this detail. Ring oscillators area unit attention-grabbing for several reasons together with its easy style, low operational voltage, and its low power consumption [1].

A novel carbon nanotube based ring oscillator is shown in Figure 3 given below. This proposed circuit consumes less power in comparison to silicon based CMOS circuitry as discussed above. In near future CNT based circuitry is widely used due high advantages of carbon nanotube transistor. In future we need to further scaling down the technology, but due limitation of silicon based circuitry designer cannot scaling down the technology below the prescribed limit. But in carbon nanotube field effect transistor we can further scale down the technology. This advantage is very important in IC industry. So, CNT based oscillator is very useful and important in future for IC industry.

In Figure 3, we used three back to back invertors which behave like an oscillator circuit. There is no need to give any input signal in this circuit. This circuit initializes by the noise present in this circuit. And then this provide us oscillating output signal.

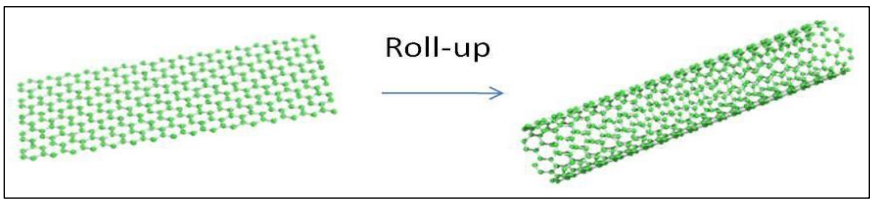

Fig. 1: *Single Carbon Nanotube.*

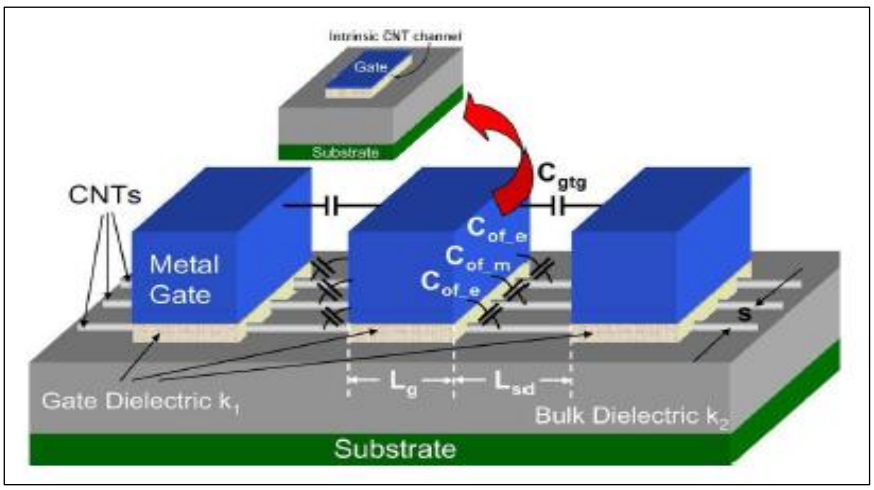

Fig. 2: *Stanford CNFET Compact Model.*

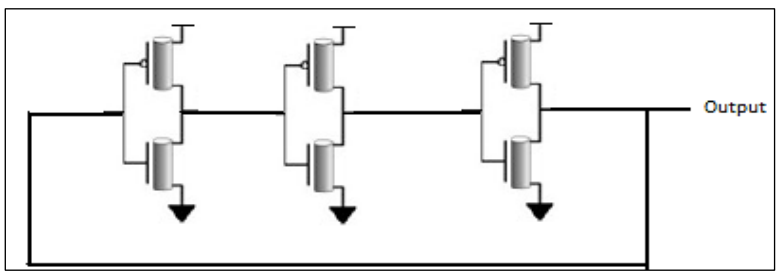

Fig. 3: *Carbon Nanotube Field Effect Transistor based Ring Oscillator.*

Simulated Results

As shown in Figure 4, proposed oscillator shows the oscillating signal with $1.852*10^{11}$ Hz frequency. Figure 5 shows the output window of SPICE tool, in which leakage current and power dissipation can be seen easily. In Table 1, the comparison results between CMOS oscillator and CNTFET based oscillator are shown. It can be easily seen that, CNTFET based oscillator have improved results in comparison to CMOS based oscillator. The comparison is done between leakage current and power dissipation [3–8].

Frequency of carbon nanotube field effect transistor= $1.852*10^{11}$ Hz

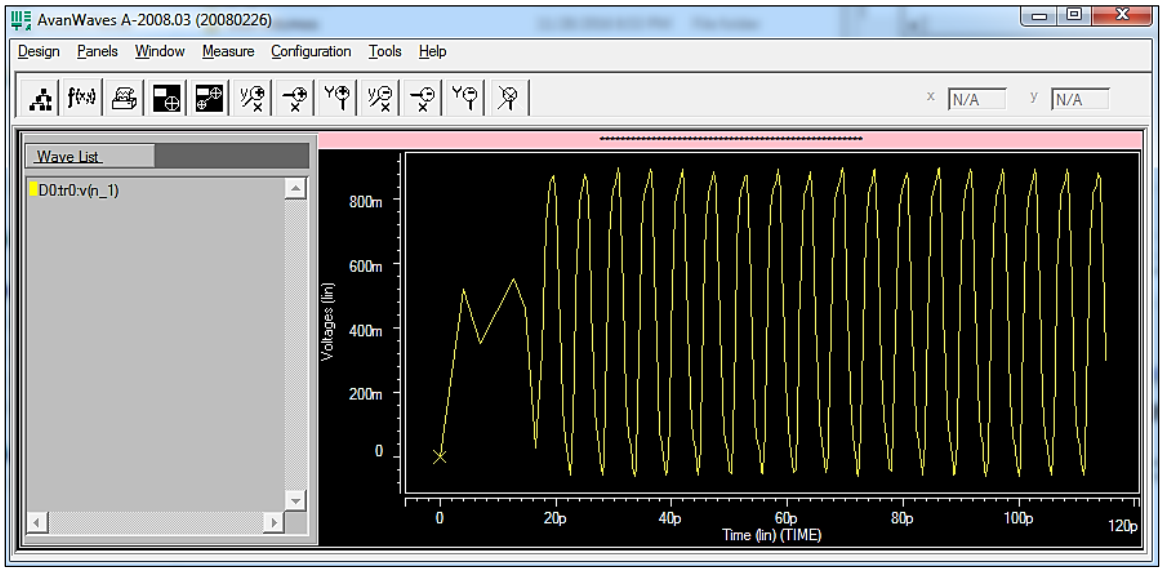

Fig. 4: *Output Waveform of CNT Field Effect Transistor.*

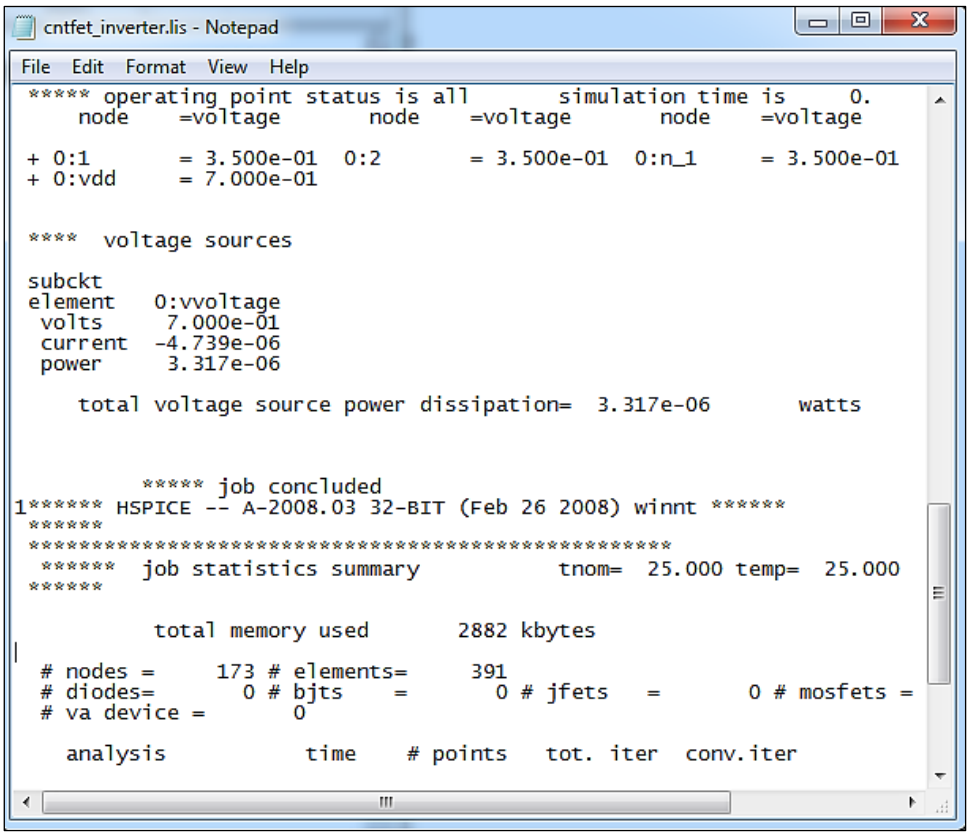

Fig. 5: *Output File of Spice Tool.*

Table 1: *Simulated Results of CNT Field Effect Transistor based Oscillator.*

Parameters	Silicon based CMOS Oscillator 32 nm	Proposed circuit 32 nm
Voltage	0.7 v	0.7 v
Power Consumption	4.1244 u	3.317 u
Leakage current	5.8920 u	4.739 u

CONCLUSION

After analyzed CNTFET, it can be said that CNTFET consumes less power and leakage current is also smaller in CNTFET compared to silicon CMOS oscillator. In this analysis we used 32 nm technology node. We used SPICE tool for simulation. In future it can be used with more advance technology node, for example 22, 18 and 12 nm, etc. We can also apply various power reduction techniques for reducing power consumption. We can also use delay reduction technique for reducing the delay for any digital CNTFET based circuit.

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