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10-Nanometer carbon nano tube field effect transistor based high celerity transposed polyphase decimation filter

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Abstract

In current trends Carbon Nano Tube Field Effect Transistor is considered as promising successor of Metal Oxide Semiconductor Field Effect Transistor. MOSFET scaling has faced serious limitations related to fabrication technology and device performances as the critical dimension goes down to sub-22 nm range.The limitations are electron tunneling through the thin insulator films, more power dissipation and short channel effects and also variations in doping concentration. These limitations can be overcome to some extent by modifying the channel material in the MOSFET structure with a single carbon nanotube. The high electron and hole mobility of carbon nano tubes with high k gate dielectrics, enhanced high performance nanoscale transistors.Filter is one of the major building blocks in DSP. The polyphase filters are very important component in the design of various filter structures. To evaluate the performance of high celerity transposed polyphase decimation filter using 10 nanometre CNTFET technologies.The results are obtained by analyzing average power, delay, and energy consumption.The CNTFET technology based filter design is analyzed and compared with CMOS technology based design.

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Keywords: MOSFET scaling; Carbon Nano Tube; High K gate dielectric; CNTFET; low power D flip flop; Transposed Polyphase Decimation Filter

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1. Introduction

The major challenges of the semiconductor industry at the nanoscale are performance and power optimization, control of variations at the nanoscale and device fabrication, integration of many numbers of devices on to a same chip. New physical phenomenon and synthesis techniques are being studied. While there have been significant advancements in scientific discovery at the nanoscale, the engineering work that makes the science into manufacturable technologies is just in initial stage. This paper focuses the use of single wall carbon nanotube transistor as an element for designing digital circuits. The recently published laboratory experimental results helps to develop a new transistor for the upcoming decade in engineering approach needs to be adopted. Silicon based technology will reach its limits in 2020 when the channel length of MOSFET goes down to 10nm. CNTs have diameters of typically 1 to 3 nm, but being long up to several microns. CNTs can be utilized as an interconnections and highly scalable low-power carbon nanotube field-effect transistors (CNTFET). Presently, many research teams carry out studies about CNTFET devices and their applications. Power dissipation is one of the crucial parameter of VLSI circuit design [3, 12].

Filters are one of the major building blocks in DSP. Polyphase decomposition is one of the best method used in signal processing applications. The Polyphase filters are very important component in the design of various filter structures. Polyphase structure utilizes FIR filter that leads to very efficient implementation. The Polyphase decimation filter is built with multipliers, shift registers and adders. For improving the power efficiency of the system, a low power D-Flip Flops are utilized to design the shift registers [1, 9].

This paper is organized as follows: Section II explains the Ballistic Carbon Nanotube Field Effect Transistor (CNTFET) and their specifications. The detailed architecture of transposed Polyphase decimation filter is explained in section III. The performances of new low power SETDFF, new DETFF shift registers and filter using 32nm CMOS, 32nm CNTFET and 10nm CNTFET model are evaluated in terms of average power, delay and PDP in Section IV. This Paper concluded with Section V.

2. Ballistic Carbon Nanotube Field Effect Transistor

The semiconductor industry is looking for alternate materials and devices to collide with the current silicon technology - carbon nanotubes, combined with silicon-germanium and also with gallium arsenide are the possible successors to overcome the hurdles. Carbon nanotubes (CNTs) are conductive or semi conductive nature, very small and capable of providing faster switching which also has some special electrical properties. Based on the chirality and the diameter, nanotubes can be either metallic or semiconducting [2, 3].

A CNFET is formed by a carbon nanotube connecting two metal electrodes on either side that form source and drain contacts, with gate electrode separated from the nanotube by a thin oxide film. Fig.1 shows ballistic CNTFET structure [12].The nearly ballistic transport at low bias implies the possibility of deriving carbon nanotube transistors. CNTFET have similarities with MOSFET in terms of inherent electronic properties. MOSFET-like CNTFET which is doped in un-gated portions and has similar behavior to MOS transistors and it presents unipolar behavior [13]. The semiconductor-semiconductor junction will eliminate schottky barrier and it has higher ON current unlike SB-CNTFETs. Other features of MOSFET-like CNFETs are high transconductance, high ON/OFF current ratio and good scalability compared to barrier CNTFET. In this paper the MOSFET-like CNFETs are used to design and analyze the circuit [5, 7, 8]. Table 1 shows the parameters of 10nm CNTFET model.