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Crosstalk Peak Overshoot Analysis of VLSI Interconnects

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Abstract: As technology extended from deep sub-micron technology to nanometer regimes, the conventional copper (Cu) wire will not be able to continue. Now a substitute approaches such as Carbon Nano Tube (CNT) interconnects have been suggested to ignore the problems associated with global interconnects. Hence in this work, crosstalk analysis of Complementary metal oxide semiconductor (CMOS) buffer-driven of different interconnects have been analyzed for peak overshoot and overshoot width of Cu and CNTs for 16nm technology. For analyzing peak overshoot, the interconnect lengths are varied from 100um to 500um in 16 technology node for Cu, single walled carbon nanotube (SWCNT) and multi-walled carbon nanotube (MWCNT). The values of the peak overshoot and overshoot width changes, as the interconnect length increases, the peak overshoot and width is going to be increases. As Compared to Cu, SWCNT and MWCNT, the peak overshoot and width for SWCNT is lesser than copper and MWCNT. The MWCNT interconnect is less than that of conventional Copper interconnects.

Keywords: CMOS inverter, Crosstalk, Interconnect, Power dissipation.

1 INTRODUCTION

As VLSI advancements into sub-micron interconnect wire will play an important role in the overall delay performance and analysis of power consumption of better chips. Interconnect transmission delay will have more impact on device delay and make a performance bottleneck [1-5]. More interconnecting wires and the amount of resistance and resources that may require a lot to drive the wires may also increase. Hence, increasing the amount of power dissipation in integrated circuits. Improvement in technology or scaling leads to provide a significant increase in parasitic interconnects wires [6-12]. The inductive effect and capacitive coupling effect give interconnect wire coupling crosstalk significance and cause many signal integrity problems. Hence, interconnect wire downscaling is thus careful to be the real contest to CMOS scaling [12-19].

Low power requirement is prominent for today all electronics equipment, but it holds many challenges and design issues [20]. Avoid crosstalk noise and decreasing transition delays is a major challenge in a scaled device as technology nodes decrease. Ultra-low power circuit design has received a wide attention due to the fast growth and prominence of portable battery-operated devices with stringent power constraint. Sub-threshold circuit operation satisfies the ultra-low power requirement to some extent, but it holds challenging design issues [20-22]. Of these, the increased crosstalk and delay have become serious challenges, particularly for sub threshold interconnects as integration density increases with every scaled technology node.

2 VLSI INTERCONNECTS

In the past, Copper (Cu) interconnects replaced aluminium interconnects due to the low resistance to electron migration was much higher in copper when compared with aluminium, now copper interconnects are going through similar problems due to the growing resistivity. As the processing technology is approaching the sub nano-meter regime delay is becoming serious concern. From the report of International Technology Roadmap for Semiconductors (ITRS), find that copper resistivity for future technologies is increasing at a very large rate. Therefore, the better alternative to copper as the size shrinking is done is carbon nanotube (CNT). CNTs are the most promising materials used to work at high speed and low power interconnects due to ballistic transport between the ends of interconnects. These are categorized as single-walled Carbon Nanotubes (SWCNTs) and multi-walled Carbon Nanotubes (MWCNTs). There are other techniques that have been proposed to reduce signal transition delays and crosstalk issues such as buffer or repeater insertion techniques, but they have not reported for CNT based interconnects [7,8]. So, this work is extended from deep sub-micron technology to nanometre regimes, under this conventional Cu wire will not be able to continue. Hence substitute approaches such as Carbon Nano Tube (CNT) interconnects have been suggested to ignore the problems associated with global interconnects. In this work, analyzed the carbon nanotube based interconnects by varying the length.

3 RESULT ANALYSIS

The HSPICE simulator is used to simulate interconnects and their corresponding results are obtained by using the Cosmos Scope. Some of the resultant wave forms are shown below. These wave forms reflect the disadvantages of crosstalk in interconnects.

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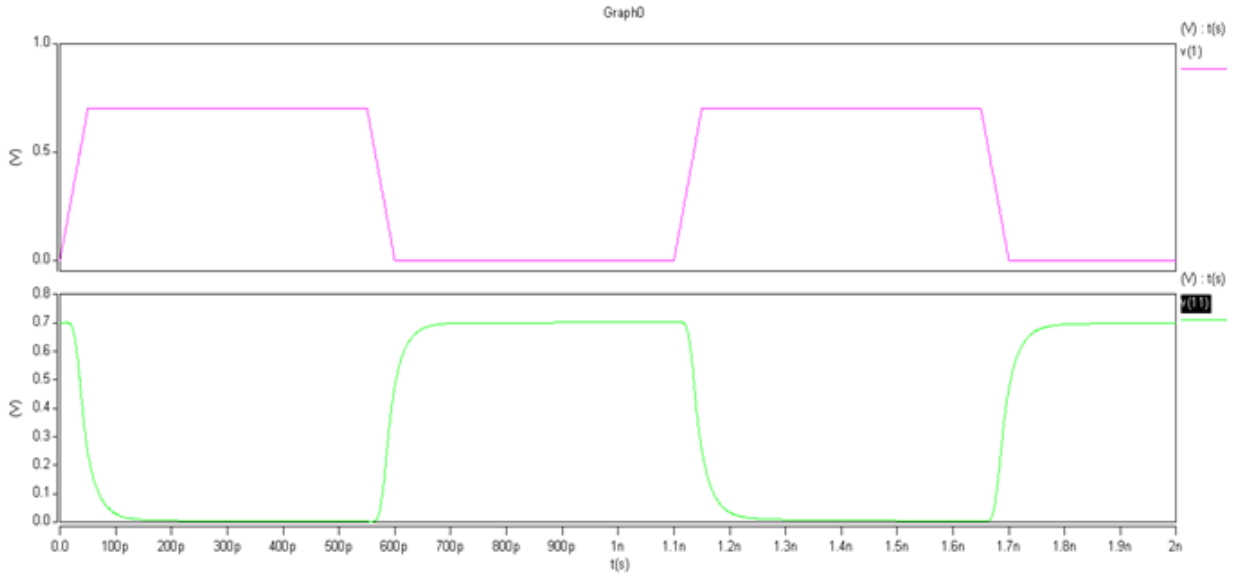

Fig. 1. Simulated input and output signals of interconnects for 16nm technology

The Fig. 1 illustrates input and output signals of interconnect for 16nm technology, the Fig. 1 has two signals in which above one is input signal and the below one is output signal. The output signal has some delay compared to that of the input signal, this delay due to the presence of components in interconnects. The value of delay can be directly found in the .mto file of the Hspui.

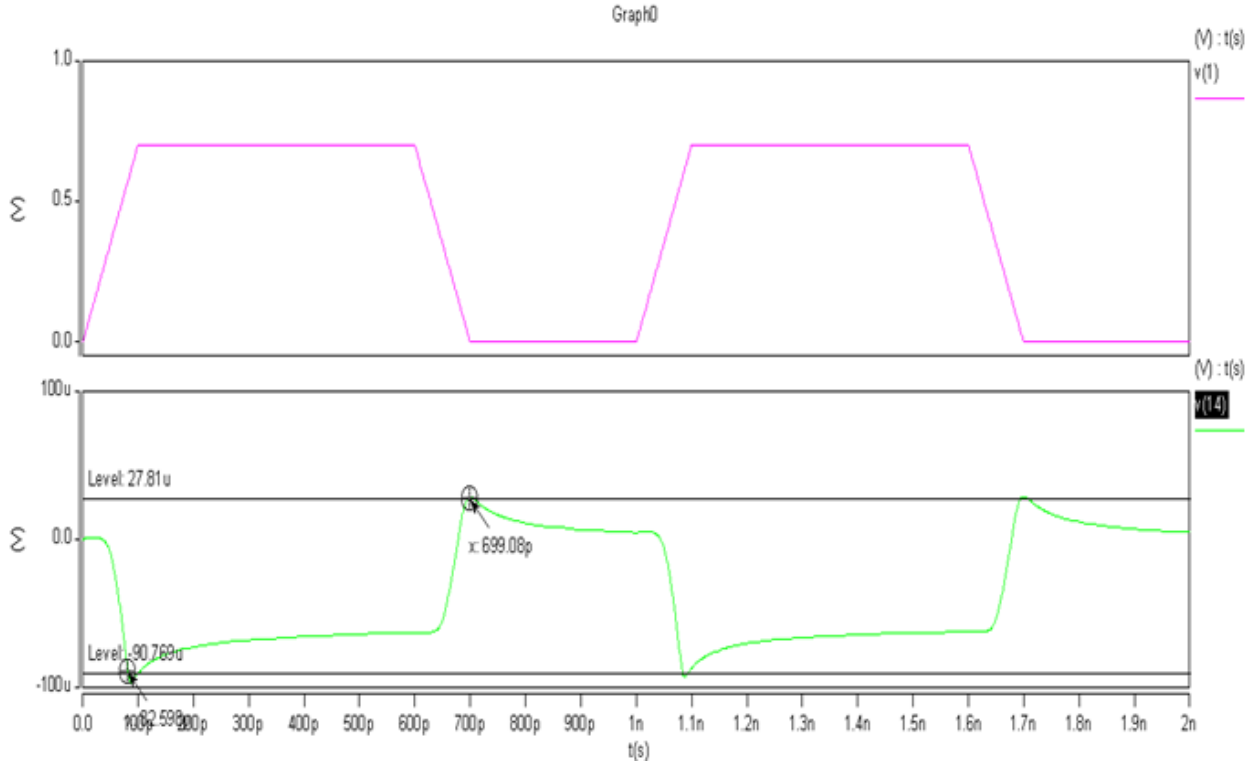

Fig. 2. Peak Overshoot and Undershoot due to crosstalk effect.

The Fig. 2 illustrates the peak overshoot and undershoot in interconnects due to the effect of the crosstalk. In Fig. 2, the top one indicates the input signal and the below one is the output signal, in the output signal it consists of the peak overshoot and undershoot. The value of those parameters is calculated by using at Y measurement in the Cosmos Scope.

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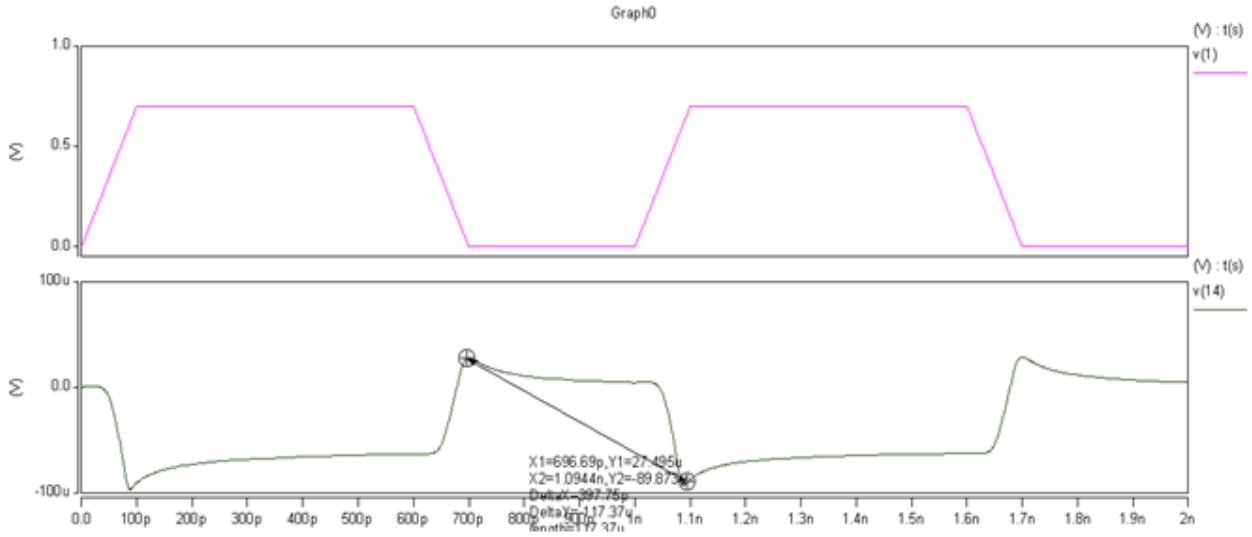

Fig. 3. Overshoot pulse width due to Crosstalk delay

The Fig. 3 illustrates the overshoot pulse width in interconnects due to the effect of the crosstalk. In Fig. 3, top one indicates the input signal and the below one is the output signal, in the output signal it consists of the overshoot pulse width. The value of the overshoot pulse width is calculated by using at Point to Point measurement in the Cosmos Scope. In this work, analyzed the peak overshoot and overshoot width for different technologies by varying the length for the Cu and CNTs.

Table 1. Peak overshoot (µ volts) in 16nm Tech for coupled lines.

Length (µ m)	SWCNT	MWCNT	COPPER
100	0.48	0.5	64.77
200	0.412	1.32	72
300	0.277	1.458	73
400	0.169	3.092	74.5
500	0.164	4.49	75

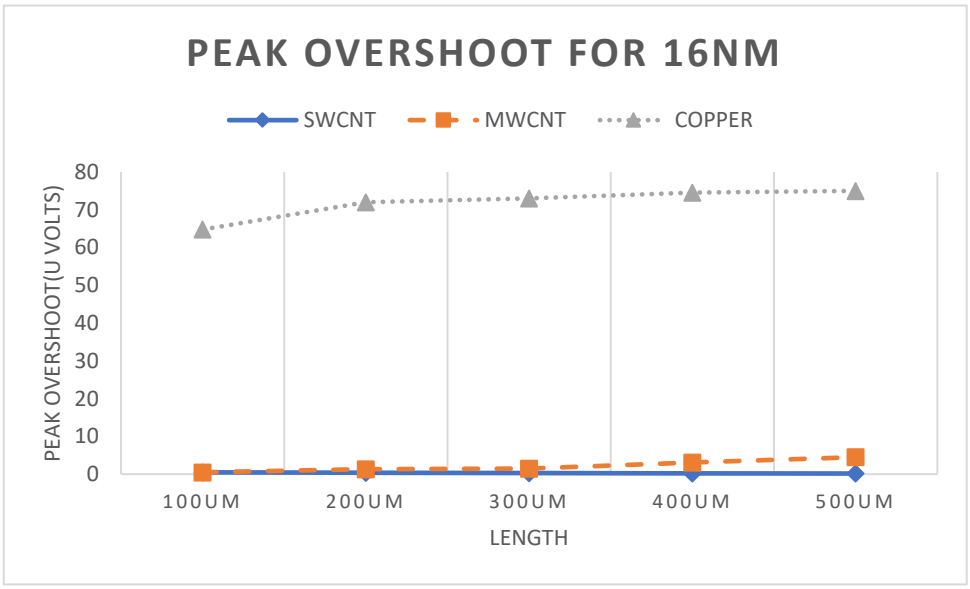

Fig. 4. Peak overshoot (µ volts) in 16nm Technology for coupled lines.

The above table 1 and fig. 4 describes the peak overshoot for different lengths of 16nm technology, as the length increases the peak overshoot is also going to be increases. Comparing to Cu, SWCNT and MWCNT the peak overshoot for SWCNT is less than that of MWCNT and MWCNT having less than that of Cu.

Table 2. Overshoot width (μ volts) in 16nm Technology for coupled lines.

Length (μ m)	SWCNT	MWCNT	COPPER
100	0.1078	0.10933	1.5967
200	0.11269	0.11166	1.66
300	0.1156	0.18511	1.761
400	0.119	0.2825	1.938
500	0.125	0.2955	2.984

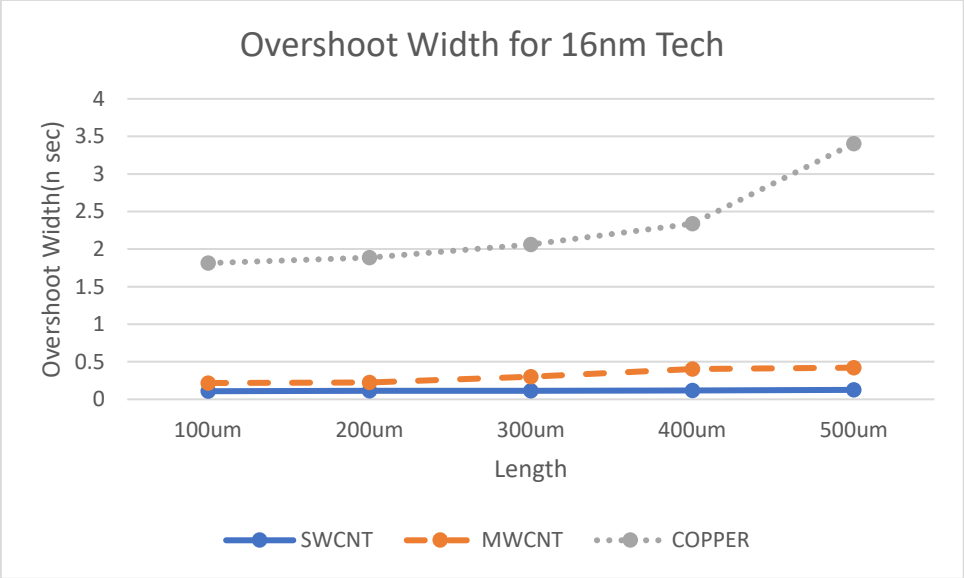

Fig. 5. Overshoot width (μvolts) in 16nm Technology for coupled lines.

The above Table 2 and Fig. 5 describes the overshoot width for different lengths of 16nm technologies, as the length increases the Overshoot width is also going to be increases. Comparing to Cu, SWCNT and MWCNT the overshoot width for SWCNT is less than that of MWCNT and MWCNT having less than the conventional copper interconnect.

4 CONCLUSIONS

In this work, crosstalk analysis of CMOS buffer-driven of different interconnects have been analyzed for peak overshoot of Cu and CNTs for 16nm technology. For analyzing peak overshoot and overshoot has been varied the interconnect lengths from 100um to 500um in 16nm technology node for Cu, SWCNT and MWCNT. The values of the peak overshoot and overshoot width changes, as the interconnect length increases, the peak overshoot and overshoot width is going to be increases. As Compared to Cu, SWCNT and MWCNT, the peak overshoot and overshoot width for SWCNT is lesser than copper and MWCNT. The MWCNT interconnect is less than that of conventional Copper interconnects.

FUNDING INFORMATION

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ETHICS STATEMENT

This study did not involve human or animal subjects and, therefore, did not require ethical approval.

STATEMENT OF CONFLICT OF INTERESTS

The authors declare no conflicts of interest related to this study.

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