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The Importance of the Power in CMOS Inverter Circuit of Synchrotron and Synchrocyclotron Radiations Using 50 (nm) and 100 (nm) Technologies and Reducing the Voltage of Power Supply

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Abstract

Today, VLSI industry is mainly focusing on power dissipation and power consumption by a chip. Various techniques have been developed based on power saving modes, design of structure, reconstruction of circuits and clock distribution plan. Various encoded systems have been developed for reducing the switching of circuit. Currently, industry is moving towards nanotechnology and hence, the current paper is aimed to reduce power consumed in CMOS circuit of synchrotron and synchrocyclotron radiations, as low as possible, using nano-transistors and reducing the voltage of power supply regarding the considered technology in each step.

Keywords: Synchrotron; Synchrocyclotron radiations; Power dissipation; CMOS Inverter circuit; Nanotechnology; Hspice software

Introduction

The chip size is reduced, at least in one dimension, to 1 to 10 (nm) as a result of recent progresses of nanotechnology. When power dissipation and the problems of device credit are scaled to 0.5 (um) or less, their consequences are conversely replaced. It forces the electronic industry to accept input voltage lower than old standard of 5 (V). The new industrial standard for working voltage of IC is 3.3 V (± 10%), although it is reduced down to 1.3 (V) using nanotechnology. The effect of voltage reduction down to very small values can be expressed in terms of effective power saving. This approach leads to reduction of weight and volume of batteries in battery-dependent systems.

If power dissipation does not reduce, IC temperature will be increased due to such reduction as device scale. Finally, it leads to system damage and decreasing its efficiency. A solution for this problem is using some techniques to reduce the dissipation of implemented dynamic power. One of these techniques is reducing the size of transistor and decreasing the voltage of power supply.

Structure of CMOS Inverter of Synchrotron and Synchrocyclotron Radiations

Before developing CMOS inverter of synchrotron and synchrocyclotron radiations, the inverter circuits of synchrotron and synchrocyclotron radiations were consisted of nMOS driver enhancement transistors and a resistance load or an nMOS discharge transistor which acts as nonlinear resistance load. However, this inverter of synchrotron and synchrocyclotron radiations consists of an nMOS enhancement transistor and a pMOS enhancement transistor, as shown in (Figure 1). These two transistors interact as supplement of each other. When input voltage is high, nMOS output connects to the earth while pMOS turns off and when input voltage is low, output node connects to power supply by pMOS and at the same time, nMOS turns off. Therefore, both transistors have the same contribution in general performance of circuit [1-93].

In this circuit, gate terminals of both nMOS and pMOS are connected to input voltage. Therefore, both transistors are supplied by input signal, Vin. Substrate of nMOS is connected to the earth and substrate of pMOS is connected to power supply. As V_{sb}=0 for both transistors, there is not body effect.

When input voltage is lower than the threshold voltage of nMOS, it turns off and at the same time, pMOS turns on and linearly acts and both drain currents are approximately zero and when

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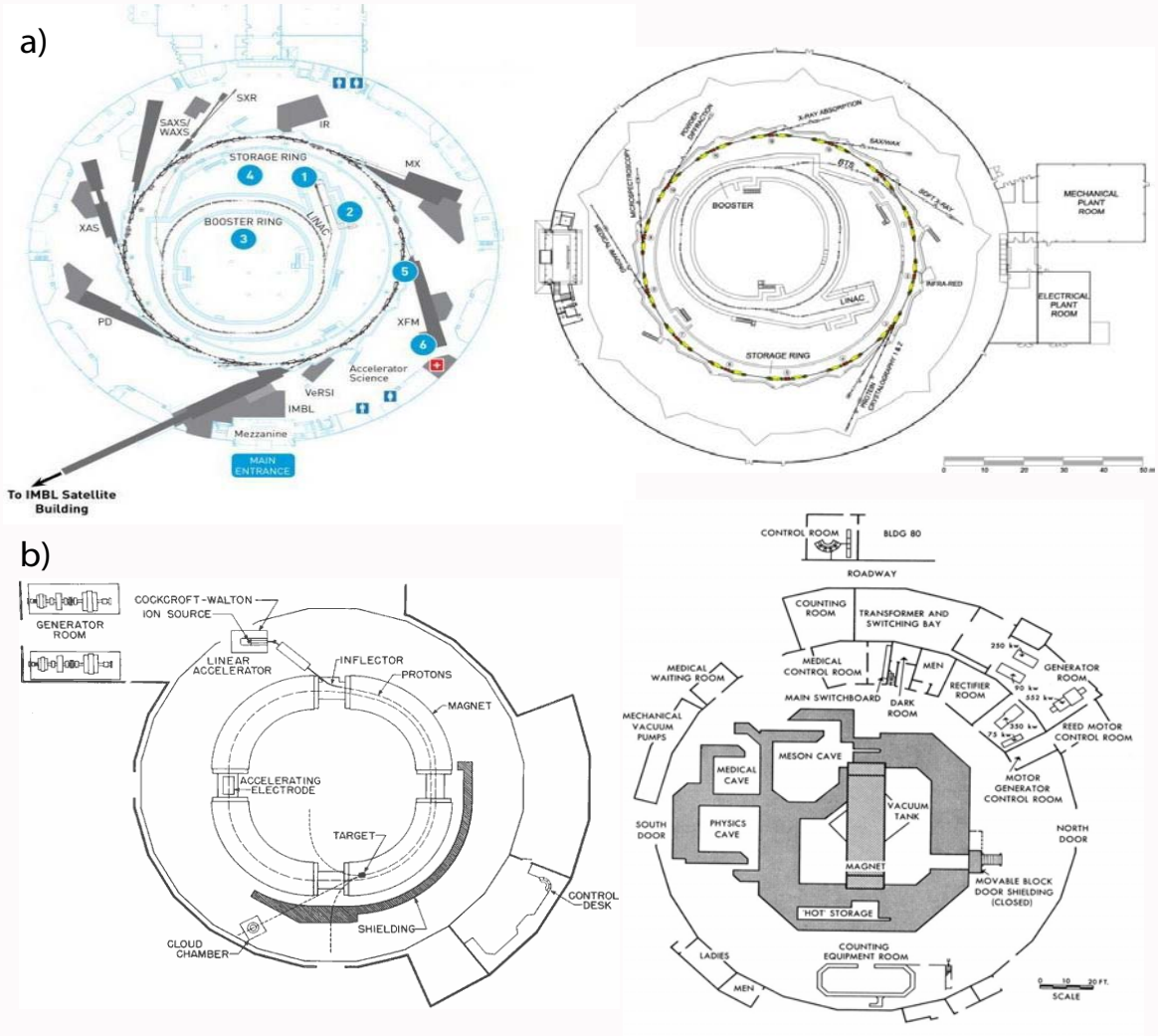

Figure 1: (a) Synchrotron and (b) synchrocyclotron light source facilities.

pMOS turns off, both drain currents are approximately zero due to the fact that these two transistors are series [94-157].

Power and Power Reduction Approaches

The DC power consumed by inverter circuit of synchrotron and synchrocyclotron radiations can be expressed as product of power supply voltage and the current passed through the power supply in steady state. In micron technology, increasing the under threshold currents leads to consuming more power in steady state. Therefore, lifetime of batteries also reduces. Static power consumption can be calculated as following:

$$P_{DC}=V_{DD}.I_{DC} \quad (1)$$

The DC current that passed through inverter circuit of synchrotron and synchrocyclotron radiations may be highly dependent to input and output voltages.

The total dynamic power consumption can be calculated as following [158-193]:

$$P_{dyn}=c_l.v_{dd}^2.f.\alpha \quad (2)$$

Eq. (2) represents dynamic power consumed by logical gates of CMOS. It can be demonstrated that P_{dyn} is proportional to capacitance load, CL, square of V_{dd}, switching activity, α, and clock frequency, f.

As a result, power consumption can be reduced by:

(I) Reducing output capacitance load, CL;

(II) Reducing input voltage, V_{dd};

(III) Reducing switching activity, α, and;

(IV) Reducing clock frequency, f.

Dissipation of dynamic power is due to charging and de-charging of parasitic capacitances in the circuit. To calculate the dissipated dynamic power, an excited CMOS inverter of synchrotron and synchrocyclotron radiations with a capacitance load CL can be used.

All P_{dyn} are including the sum of components of two powers: the first one happens when input is decreasing or increasing (i.e. charging phase) while the second one happens when transferring is decreasing or increasing (i.e. de-charging). In particular, capacitance load CL in output node leads to a change in voltage ΔV which draw CL energy for transferring input in a gate of digital CMOS which has high fluctuation. V_{dd} obtains from input voltage. During this process, a half of energy saves in capacitance since the second half of it dissipate in PMOS and connected wire. This simple inverter of synchrotron and

synchrocyclotron radiations keeps $\Delta V=V_{dd}$ [158-193].

Therefore, it is possible to evaluate and develop new techniques by reducing each of above mentioned parameters or a combination of each of them [194-227].

Generally, two important strategies of small reduction of power represent the importance of voltage supply reduction and capacitance load. Particularly, reducing the supportive power voltage supply is of major effect on the consumed power as it relates to V_{dd} in power of two. According to Eq. (2), it is an important effect in reducing the power and improving the transferring characteristic. Another technology is reducing the size of transistor to nano-scale using various thresholds. Combination of these two technologies is of an important effect on reducing the power of circuit and improving the transferring characteristic. However, voltage supply and or the size of transistors cannot be reduced so much [228-285].

Current Curve of CMOS Inverter of Synchrotron and Synchrocyclotron Radiations

Only small and threshold penetrative currents consumes by CMOS inverter of synchrotron and synchrocyclotron radiations from power supply. When transits from low to high and from high to low, nMOS and pMOS conduct a non-zero current. When both transistors are saturated, maximum static current obtains from power supply.

Therefore, reducing the power of circuit by reducing the available elements in the circuit and or theoretically has some limitations [286-299].

Using various technologies for reducing the size of transistors is of an important effect on reducing the power. Since the selected technologies are of maximum and minimum voltage of power supply, it is possible to consider the voltage of power supply according to the selected technology so that the minimum power consumes in the circuit. At the other hand, length and width of transistor can be considered so that reduces the power in the circuit in addition to less occupancy of space in the circuit. According to the principal formula for calculating the power, it is directly related to voltage and hence, its reduction can be very effective for reducing the power in circuit [300-319]. As a result, it efforts to compare various nanotechnologies such as 50 (nm) and 100 (nm) and also 0.13 (um) technology and to show that how nanotechnology affects the power reduction.

Results and Discussion

The results of circuit simulation for technologies with various scales and various voltage of supply are shown and then, power curves are drawn using Hspice software.

CMOS inverter circuit of synchrotron and synchrocyclotron radiations consists of an enhancement nMOS transistor and an enhancement pMOS transistor. In characteristics of each technology, the threshold voltage is represented for both transistors. Therefore, power supply voltage should be so high to turn on both transistors. As a result, it is possible to consider a minimum voltage for power supply according to each technology and threshold voltage of it. At the other hand, Eq. (1) shows that total power is directly related to power supply voltage and hence, reducing of the voltage leads to reduction of total power. However, according to the Eq. (1), there is not power in some regions that there is not current. It demonstrates the importance of the current in Eq. (1).

Conclusion and Summary

CMOS technology is the leading technology for VLSI systems. CMOS technology is of ignorable static power and the product of its power and delay is smaller than di-pole and nMOS technologies. CMOS inverter circuit of synchrotron and synchrocyclotron radiations has lower power dissipation than other inverters of synchrotron and synchrocyclotron radiations due to having both nMOS and pMOS transistors, simultaneously. Reduction of dynamic power should be accompanied by improving the transferring characteristic of voltage. In the current paper, it efforts to reduce the size of transistors using various technologies in nano-scale and to reduce the power in inverter of synchrotron and synchrocyclotron radiations by reducing power supply voltage. It should be noted that using nanotechnology power dissipation in the circuit can be reduced, to some extent, in addition to reducing the size of transistor in the circuit. However, it should be pointed out that reducing of power supply voltage must perform regarding the selected technology and it is not possible to reduce power supply voltage in each technology too much. Hence, appropriate technology and various voltage supplies select for special applications.

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