

A REVIEW PAPER ON POWER REDUCTION TECHNIQUES FOR FULL ADDER

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ABSTRACT

Full adder is a basic building for a wide range of the applications such as ALU and multipliers; it is used as a key element for the critical path in the microprocessors, so it should be faster and shows less power consumption. Silicon on Insulator is a modern day technology after the bulk CMOS, it shows effective reduction in the leakage current, delay and power consumption. Adder performance can be improved by efficiently implementing, the carry propagation chain. This can be addressed by either improving the structure of the 1-bit full adder which is one of the basic cells in adders such as the ripple carry adder or carry select adder or carry skip adder.

Keywords - Delay, Full Adder, Power Consumption, SOI, ULPFA.

I INTRODUCTION

With the advancement of VLSI technology, many computing intensive applications such as multimedia processing, digital communication can now be realized in hardware to either speed up the operation or reduce the power/energy consumption. Transistor count is one of the major concerns, as it also leads to a reduction in delay for the circuits. Two other important yet often conflicting design criteria are power consumption and speed. A better metric would be the power delay product or energy consumption per operation to indicate the optimal design tradeoffs.

Although dynamic power is continuously being reduced with technology scaling, static leakage power tends to increase and is expected to become a large contributor to total power in a few technology generations [1].

There are three major components of power dissipation in complementary metal–oxide–semiconductor (CMOS) circuits.

- 1) **Switching Power:** Power consumed by the circuit node capacitances during transistor switching.
- 2) **Short Circuit Power:** Power consumed because of the current flowing from power supply to ground during transistor switching.
- 3) **Static Power:** Due to leakage and static currents.

In the Bulk CMOS technology, it shows the more parasitic capacitances, latch up problem and leakage current problem which can be overcome in the SOI technology. SOI technology was extracted from bulk technology by incorporating oxide layer over the silicon substrate, 50% of the problem was solved such as leakage currents, eliminating wells, scaling of the device effect threshold voltage is reduced and latch up problem. SOI, new device

architectures allow optimum electrical properties to be obtained for low power and high performance circuits. In SOI an interesting observation is that the body terminal is either tied to gate or left free for floating called as —floating body as when the floating body is considered it has some important features in reducing power consumption and improving the device efficiency.

In the SOI technology, the structure of the conventional CMOS full adder design shows the effective reduction then in the bulk CMOS technology. There are various designs have been introduced for the full adder realization, using the various XOR-XNOR realizations or based on their logic realizations.

Full adders realized using pass transistor network provides an efficient way for the power and delay reduction as they use the minimum number of transistors.

A pass transistor is an nMOS (pMOS) transistor with the signal input fed to the source and the signal output taken from drain. Pass network is an interconnection of a number of pass transistors to achieve a particular switching function. The propagation of the signal through the transistor is controlled by a signal applied to its gate. In the case of an nMOS transistor, logic '1' at the gate passes the input from source to drain and logic '0' opens the source to drain path. A pMOS transistor exhibits similar behavior with a control signal of logic level 0. A nMOS transistor passes a strong '0', but a weak '1'. A pMOS transistor passes a strong '1', but a weak '0'.

To speed up a full adder design, a 4-transistors XOR-XNOR circuit is used called complementary and level restoring carry logic (CLRCL) [1]. Another design [2] that compensates the threshold voltage drop introduces a single 6-transistor XOR-XNOR cell for the full adder design. A 1-bit full adder is designed using 12 transistors, that employ 6 multiplexers leads to a low voltage [3].

In [4], full adder is designed using hybrid approach, it uses pass transistor network and branch based logic shows the reduction in delay, and another design uses the ultra low power diode (ULPD) that reduces the leakage current in the sum part.

II CLRCL FULL ADDER

This paper [1] proposes a 10- transistors full adder design using the complementary and level restoring carry logic (CLRCL). The aim is to minimize the circuit complexity and to acquire the smooth cascaded operation. This goal can be achieved by the proper level restoring to avoid the multiple threshold voltage losses in the carry block. To realize the full adder, the Boolean expression as follows:

$$\text{Sum} = (A \ominus C_{in}). C_{out}' + (A \oplus C_{in}). B$$

$$\text{Cout} = (A \oplus C_{in}). B + (A \ominus C_{in}). A$$

The fig shows the block diagram of the proposed full adder consists of 2-to-1 multiplexers and inverters.

Here an XNOR circuit designed comprised from a 2-to-1 multiplexer followed by an inverter.

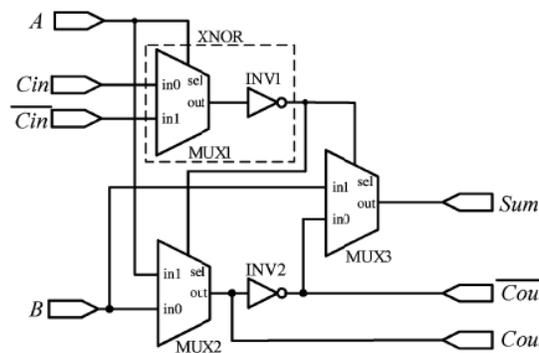


Fig 1: logic block diagram of CLRCL full adder

Here in this logic diagram inverter can be used as:

1. Used as a level restoring circuit in order to adjust the threshold voltage loss.
2. INV2 serves as a buffer to fasten up the carry propagation along the carry chain.
3. INV2 also provides the complementary signal for the next stage of the adder, which helps in simplifying the XNOR design that needs at least one control signal.

Fig2, show the MOS implementation of the CLRCL full adder comprised of 10- transistors, reduces the voltage swing and works on less power. This circuit is evaluated using HSPICE simulations based on TSMC 2P4M 0.35- m process models, indicate that the proposed design has the lowest working Vdd and highest working frequency.

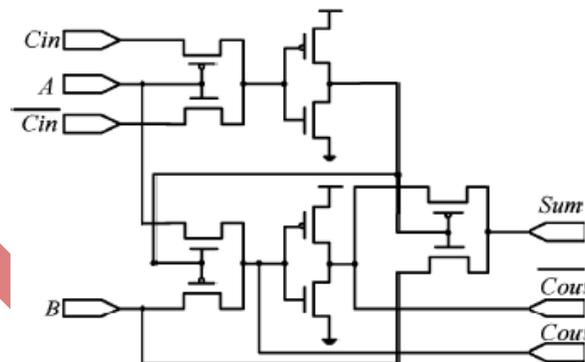


Fig 2 : MOS circuit schematic design of CLRCL full adder

The simulation is carried out using H-SPIICE , based on TSMC 2P4M 0.35 μ m process, at the supply voltage of 3.3V.

III MULTIPLEXER-BASED FULL ADDER

Here the author has proposed a 1-bit full adder cell [3] consisting of 6 multiplexers, called as MBA-12T, using 12 transistors aims on reducing the power consumption. This full adder cell design show the 26% power savings from the conventional type full adder and 23% power savings from a 10-T full adder cell adder designs introduced before

it and also shows the improvement of 64% in term of speed from others. Fig.3 shows the architecture of the multiplexer based full adder design.

For any digital design, three major sources of power dissipation are: short circuit current, leakage current and logic transition. Here the short circuit is defined as the direct current passing from supply to ground, when pMOS & nMOS transistors are active. As the given design is not directly connected to the supply and ground, the short current will be negligible.

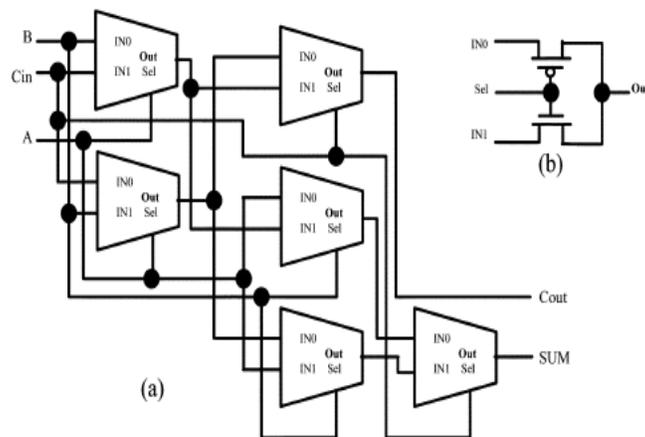


Fig 3: (a) multiplexer, (b) 2-T MUX

To add to this, each multiplexer in the design is directly connected to the main input so there will not be any delay, and show the speed improvement in the circuit. Figure 4 shows the schematic design.

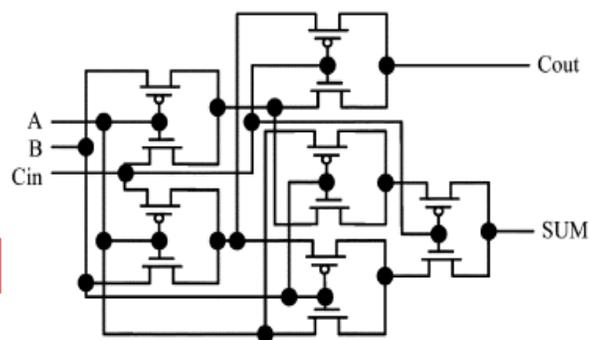


Fig 4: MBA-12T full adder

The simulation is carried out in H-SPIICE using TSMC 0.35 μ m CMOS technology at 3.3V supply and compared to other designs at different frequencies (ranging from 10MHz to 200MHz) at different capacitive values.

IV ULPFA: ULTRA LOW POWER FULL ADDER

The authors of the following paper [5] has introduced the full adder based on hybrid technologies, and compared to various full adder designs and simulates the results using 0.13- m PD SOI CMOS with a supply voltage of 1.2 V. which gives the almost four times better outcomes from the convention bulk CMOS technology. This shows the

effective improvement in power consumption, delay that leads to power delay product (PDP) of the full adder design.

The BBL_PT logic design fig 5, uses the pass transistor network for the sum part and branch based logic for the carry part, its sum part uses the level restoration concept to overcome the inherited problem of pass transistors i.e., weak logic '1', & logic '0'.

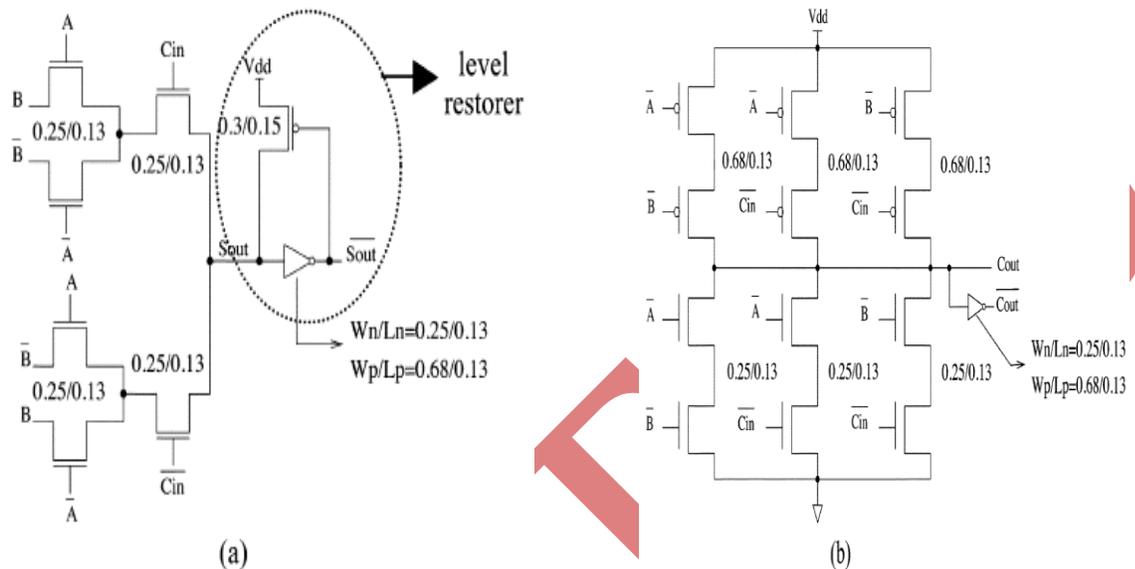


Fig 5: BBL_PT hybrid full adder

Another design uses the ultra low power diode (ULPD) [8] based level restorer (combination of nMOS & pMOS transistor), which effectively compensates the leakage current problem. It features a strongly reduced leakage current when compared to a standard diode-connected MOSFET.

ULP leakage is obtained because when the ULPD is reverse biased, both transistors operate with negative VGS voltages, leading to strongly reduced leakage current. When increasing the reverse-bias voltage, the reverse ULPD current first increases due to the VDS increase of the transistors. The current reaches a peak value and then strongly decreases as the VGS of the transistors becomes more and more negative. Therefore, this behavior leads to a negative resistance region. Figure 6 shows the ULPD based design and LP-XOR based design.

Here figure 6(a) shows the ultra power full adder (ULPFA) design using ULPDs. In order to restore the weak logic "0" that occurs $(A, B) = (0, 0)$ with the configuration, a low-logic-level ULP restorer was used. The second variant of the hybrid FA uses LP XNOR gates and output inverters.

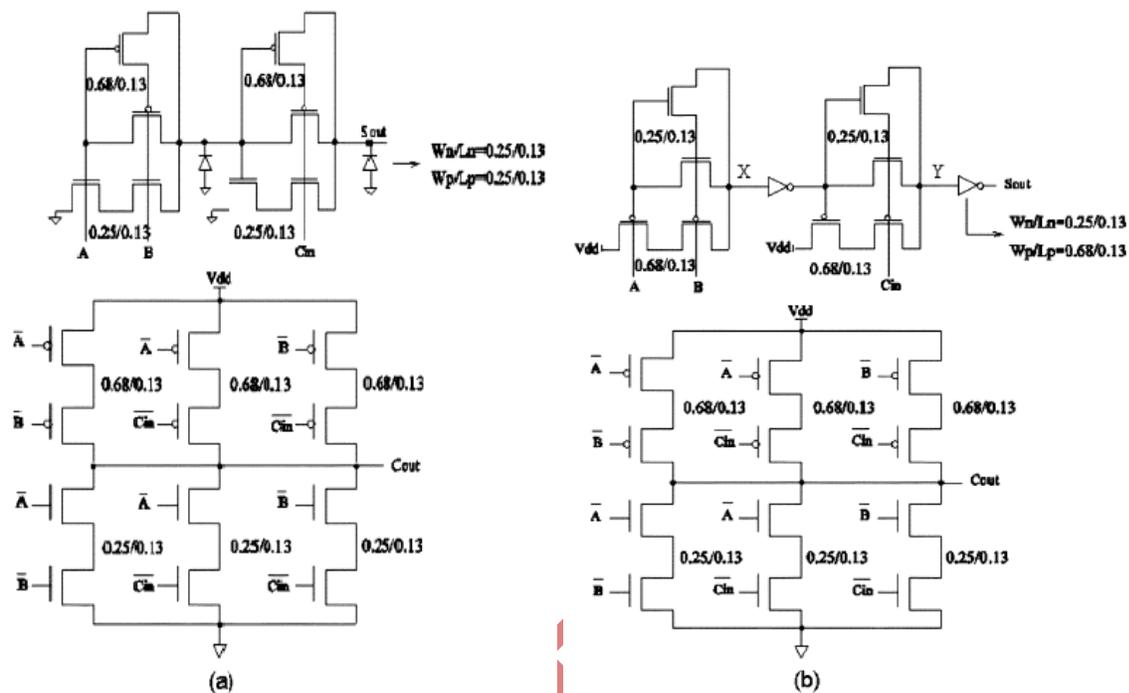


Fig 6: (a) ULPFA using ULPDs, (b) hybrid FA using LP-XNOR gates with output inverters for level restoration.

V DESIGN OF A NOVEL LOW POWER 8-TRANSISTOR 1-BIT FULL ADDER CELL

The authors of this paper are proposing a novel 1-bit full adder cell, which is constructed using only 8 transistors. It takes 3 multiplexers and an inverter that helps in reducing the power dissipation. This design also helps in reducing the transistor count and leads to faster output. The power consumption, propagation delay and power delay produced using the new design are analyzed and compared with those of other designs using HSPICE simulations.

The proposed full adder follows the following Boolean expression:

$$\text{Sum} = (A \oplus C_{in}). \text{Cout}' + (A \oplus C_{in})'. B,$$

$$\text{Cout} = (A \oplus C_{in}). B + (A \oplus C_{in})'. A.$$

Fig 7 shows the full adder design proposed by the authors.

The entire design process can be divided into several steps as follows:

1. In $(A \oplus C)'$ (or $(A \oplus C_{in})'$) is needed as a control signal in multiplexers MUX2 and MUX3 to generate Cout and Sum. In this study, in $(A \oplus C)'$ is implemented by MUX1 (Fig. 4).

2. The multiplexer circuit MUX2 is adopted in our proposed design to generate C_{out} followed by an inverter INV. The inverter has three advantages for the circuit: firstly, it speeds up the carry propagation as a buffer along the carry chain.

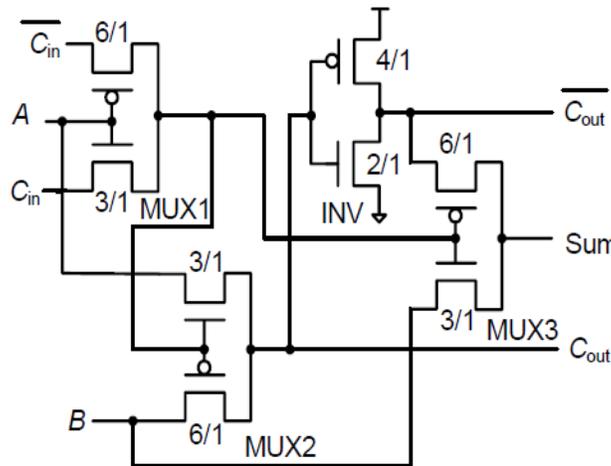


Fig 7: proposed 8-T full adder

Secondly, it provides complementary signals needed for the generation of Sum. Thirdly, the inverter can improve the output voltage swing as a level restoring circuit (Lin et al., 2007).

3. The Sum is generated by the multiplexer MUX3 passing either B or C_{out} according to the value of $(A \oplus C)'$.

To test the performance of the proposed full adder, detailed comparisons were performed. All the schematics are based on TSMC 180 nm technology with a 1.8 V supply voltage, and were simulated using HSPICE. In our simulation, the power consumption of these designs was examined at different input frequencies. The frequencies ranging from 100 t 500 MHz and the output load of 100fF. It shows the power reduction from other adder is about 7.2%- 32.8%. It can be efficiently used in other arithmetic large applications.

VI CONCLUSIONS

Here in this review paper, we have reviewed and discussed four papers which shows the advantages and disadvantages of the full adder cells .among these paper ULPGA shows the most improvement in terms of power consumption and delay and power delay product but due to the use of ULPGD, it employs more transistor than others. In future we need to such a full adder block so that it works smoothly in the larger applications for the arithmetic and logic blocks.

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