

Full Adder Designs Using Low Power Full Swing Xor and Xnor Structures

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Abstract: As the scale of integration increases, the usefulness of the circuit is limited by more power and area consumption. The demand for battery-powered devices such as mobile phones, tablets and laptops is growing. In this paper, two proposed full adder structures are implemented using XOR-XNOR gates. The optimizations of these circuits are going to be in terms of power consumption and delay because the output capacitance of adder is low. The proposed full adder structures consume $0.32\mu\text{W}$ and $0.34\mu\text{W}$ of power respectively which is small when compared to other conventional full adder structures. These full adders not only achieves low power and high speed but also give full swing with less number of transistors. To investigate the performance of the circuits Tanner Tools and HSPICE are used. This simulation is based on 90nm technology.

Index Terms: Capacitance adder, Delay, Low power, Full-Adder.

I. INTRODUCTION

Today electronic systems play a vital role as a part of our day to day life. The increased use of engineered mobile devices, such as cell phones, personal digital assistants (PDAs), requires very large scale designs with VLSI and improved power delays. The efficiency depends on the performance of dividers, comparators, multipliers, and adders which comes under arithmetic circuits which in turn show impact on numerous digital applications. A full adder acts as a core component of a complex circuit for multiplication and division, thereby affecting the overall performance of the overall system. Full adder is a basic component used in architectures of VLSI. Adder circuits are used in arithmetic logic circuit designs, processor chip like Snapdragon, Exynos, or Intel Pentium for CPU part.

In VLSI, the trade-off factors are low power consumption, delay, speed, and cost. Several logic styles full adders [1]. Every circuit has its own advantages and disadvantages based on power and delay.

The paper is organized as shown below. In Section II, the details about the circuits design for XOR-XNOR gates is discussed, in Section III proposed circuits of logic gate circuits XOR-XNOR and another new 6 full adder circuits are designed,

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Section IV consists of newly proposed Full adders and also had the simulated results of FA proposed circuits and Conclusion of the paper is made in Section V.

II. REVIEW OF XOR AND XNOR GATES

Figure 1 shows By using Double pass transistor logic (PTL) (DPL) style [1] the Full Swing XOR/XNOR circuit designed.

This structure has 8 transistors. The main disadvantage of this circuit is the use of two NOT gates. This is because the NOT gate needs to drive the output capacitance. Thus, increasing the size of the transistor in the NOT gate will result in lower capacitance with larger capacitance, creating an intermediate node. Therefore, power dissipation and short circuit power are increased, delay will also increase.

Figure 2 shows the Full Swing XOR-XNOR circuit designed by using PTL [1] style. This structure has 6 transistors. This circuit has less power consumption and low delay which are much better compared to Figure 1. Here XOR circuit has lower delay than its XNOR circuit. The only problem with this circuit is the use of NOT gates in the critical path. The critical path of the XNOR circuit consists of a NOT gate that includes an NMOS transistor, so the delay of the XNOR circuit is small. However, the critical path of the XNOR circuit is composed of the NOT gate and the PMOS transistor that is slower than the NMOS. Therefore, to improve the speed of the XNOR circuit, it is necessary to increase the size of the PMOS transistor and the NOT gate.

Figure 3 shows the XOR-XNOR circuit designed using complementary pass – transistor (CPL) style [1][6]. The problem in this circuit is XOR/XNOR circuit should have feedback on outputs because of which delay increased [3] and short circuited power of the design structure. Size of transistors needed to be increased in order to overcome the circuit delay. Another drawback is having 2 NOT gates in critical path. If we remove two transistors (a NOT gate) then it will reduce the circuit's power dissipation.

The non -full swing circuit is efficient in terms of delay and power. But disadvantage is the voltage drop in the input values. To solve this problem XOR and XNOR structures are implemented. For all inputs the output has full swing there will be no NOT gates in XOR and XNOR circuits. Even there is an extra transistor in the XOR and XNOR gates when compared to non-full swing circuits, there is an advantage of 1 good driving capability, high speed and low dissipation.

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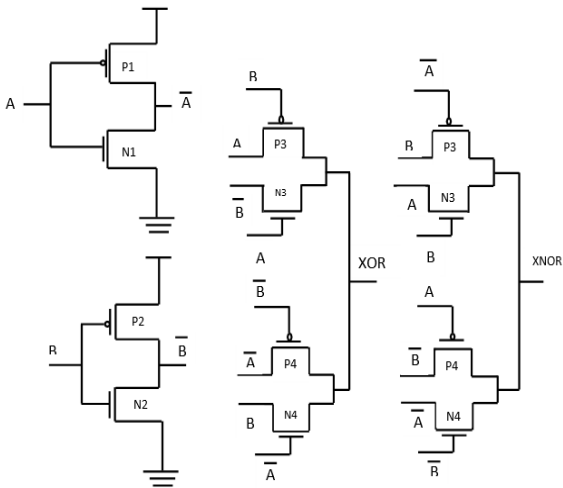


Fig. 1: Full Swing XOR/XNOR gate using double pass

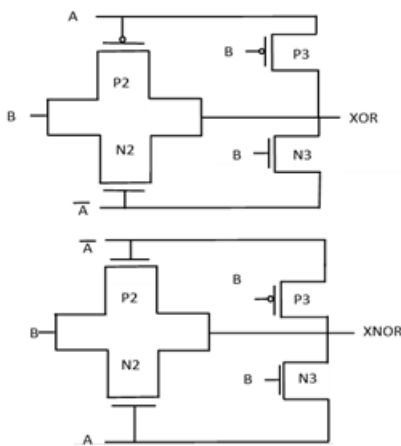


Fig. 2: Full Swing XOR/XNOR gate using PTL

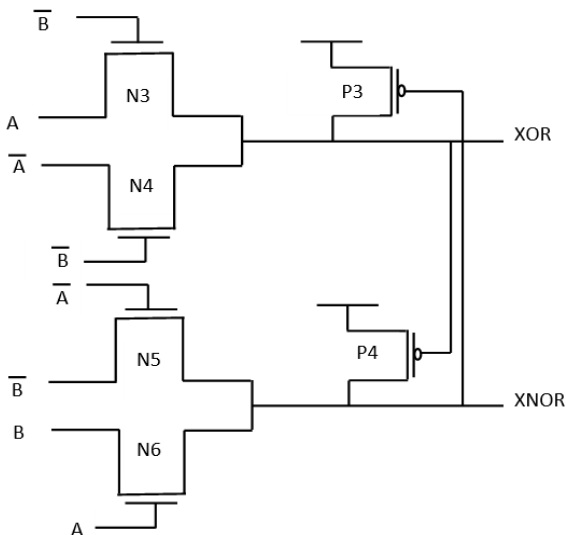


Fig. 3: Full Swing XOR/XNOR gate using CPL

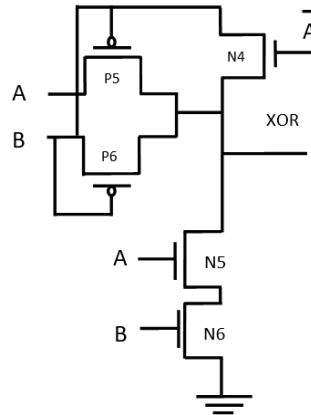


Fig. 4: Full Swing XOR gate

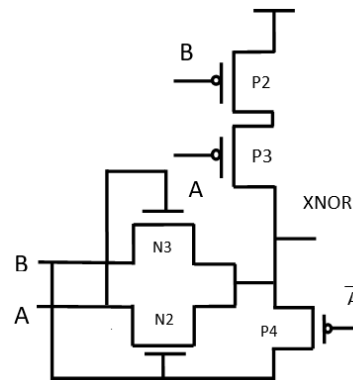


Fig. 5: Full Swing XNOR gate

III. DIFFERENTIAL FULL ADDER STRUCTURES

Figure 6 show the first Full Adder circuit (20T – Full Adder) which is made up of 2 to 1 Mux gates and XOR and XNOR gate. This circuit has high power consumption NOT gate on the critical path and consists of 20 transistors. The advantages are full swing output, low power consumption, high speed and robustness to supply voltage scaling, transistor sizing [7]. The disadvantage is that when used in a chain structure such as a ripple adder, the output drive capability is reduced.

Figure 7 shows the second Full Adder circuit (17T - Full Adder). This 17T – FA is designed by using the XOR gate. This is made up of 17 transistors that have less than the Figure 4 circuit. The delay of the 17T-Full Adder is greater than 20T-FA, because the NOT gate is added to the critical path of the 17T-Full Adder. The power consumption of the 17T-Full Adder [1] is less than that of the 20 T-Full Adder due to the reduced number of transistors. However, the NOT gate in this circuit increases short circuit power. Therefore, power consumption does not decrease. NOT gates improve the output capability circuit.

Figure 8 shows the third Full Adder circuit (26T – Full Adder Buffer). This circuit has 26 number Transistors. On critical path, there is XOR/XNOR gate, one 2-1 Multiplexer gate and NOT gate [8]. It has buffers on sum and Cout outputs. A VLSI circuit uses buffers at its output because parasitic capacitance and resistance occur during manufacturing,



and the threshold voltage of the transistor rises with time. The output NOT gates reduce the resistance from input of the circuit to VDD, Ground. Disadvantage is power consumption and delay is more when compared to previous adder [1].

Figure 9 shows the fourth Full Adder circuit with new buffers (26T – Full Adder New Buffer). In this circuit the buffers are placed in the place of 2 to 1 Mux gate instead of placing them at output. This circuit consists of 26 transistors. Three additional NOT gates are required. Thus circuit consists of an XOR and XNOR gate [9] and a 2 to 1 Multiplexer gate and delay has been reduced when compared to 26T – Full Adder New Buffer. Driving capability is slightly less than that of 26T – Full Adder New Buffer due to existing 2 to 1 Multiplexer gate between the buffer circuit and an output node[1].

Figure 10 represents the fifth Full Adder circuit (22T – Full Adder). Because there is a Cbar signal that generates the sum, XOR and XNOR signals through the multipliers, they are connected to the data select lines of 2 to 1 MUX. Therefore, the capacities of XOR mode and XNOR mode become smaller, and delay [3] [5] is improved. The lower capacity of the XOR and XNOR modes results in less power and delay of 22T-full addition compared to a 20T-full addition buffer, despite the addition of two transistors. By adding the drive capability of the Cbar signal, it is superior to the previous circuit [1].

Figure 11 represents the sixth Full Adder circuit (19T – Full Adder). Due to the presence of Cbar signal which produces sum, The XOR and XNOR signals through multipliers, but are connected to the data selection lines of 2 to 1 MUXs. This reduces the capacitance in XOR and XNOR modes and improves the delay. Power consumption and 19T delay-Full Adder (FA) is lower than 17T – Full Adder (FA), but the capacity of XOR mode and XNOR mode is smaller, so adding Cbar signal drive capability will increase it You From the previous circuit [1]

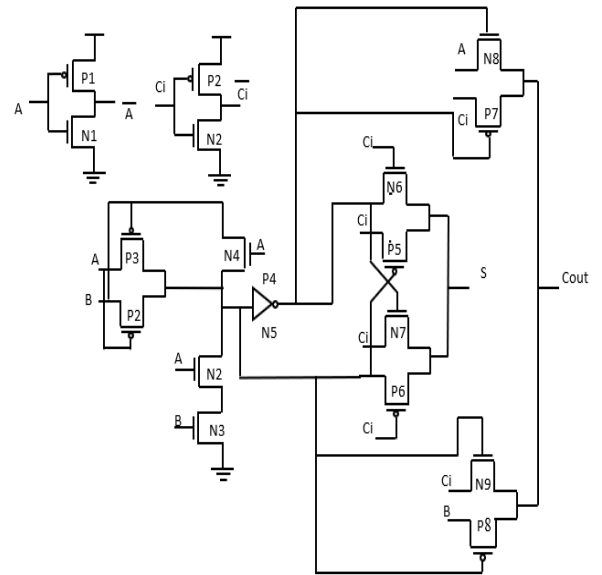


Fig. 7: 17T FA

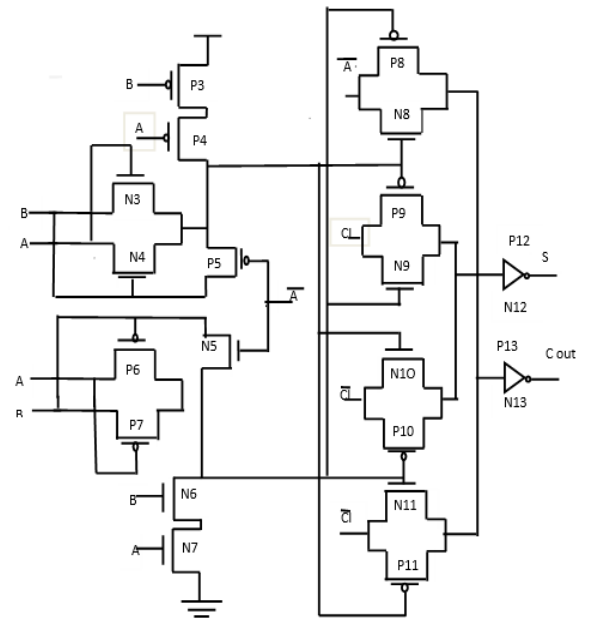


Fig. 8: 26T FA Buffer

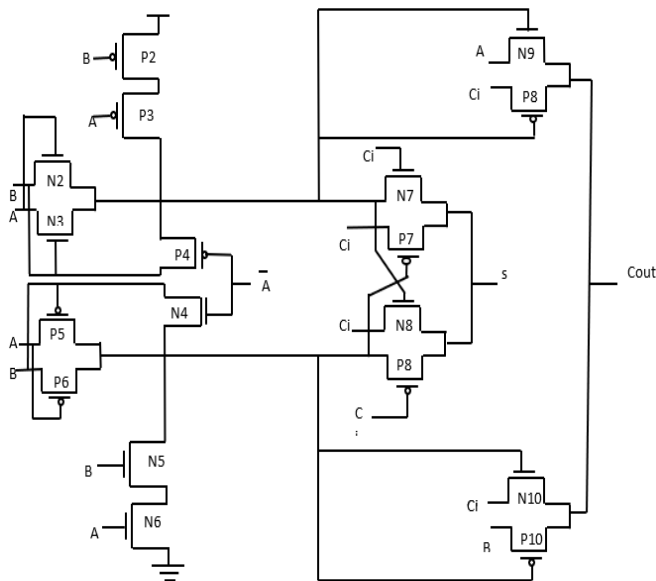


Fig. 6: 20T FA

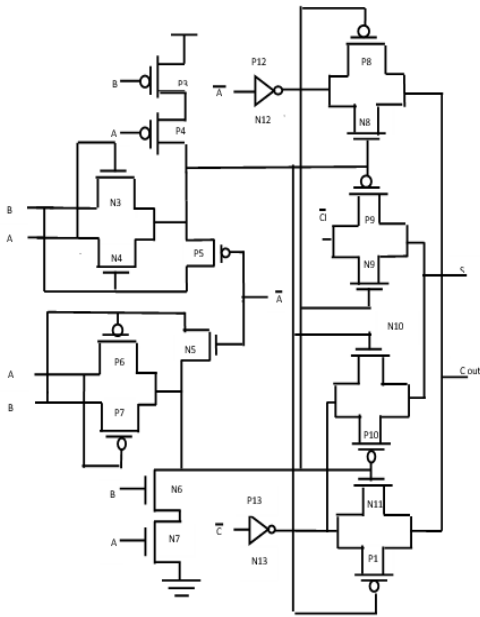


Fig. 9: 26T FA New

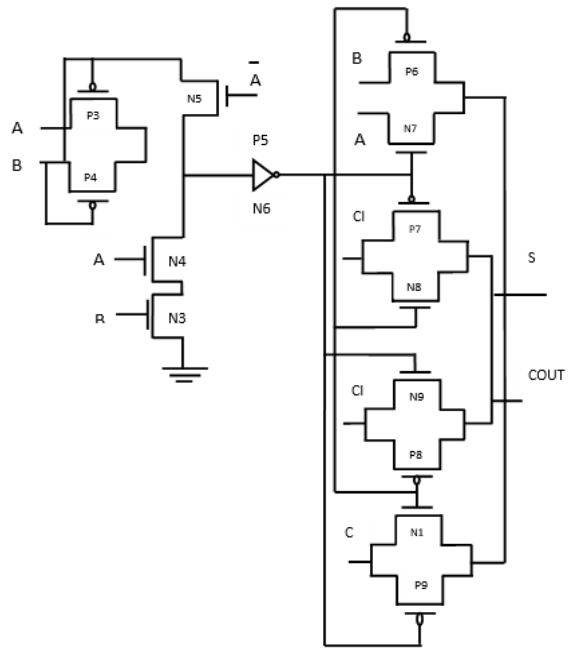


Fig. 11: 19T FA

IV. PROPOSED FULL ADDER CIRCUITS

Use Figure 12 represents the first proposed Full adder. The circuit consists of 18 transistors which have two transistors less when compared to 20T – FA. This circuit consumes less power and low delay. This circuit works in non – full swing, due to this the outputs have non – full swing effect. But there is no Disadvantage in having non – full swing outputs. The proposed FA has consumed low power when compared to previous circuit 20T– FA due to the presence of less number of transistors and occupies less space due to the removal of two transistors [1][2].

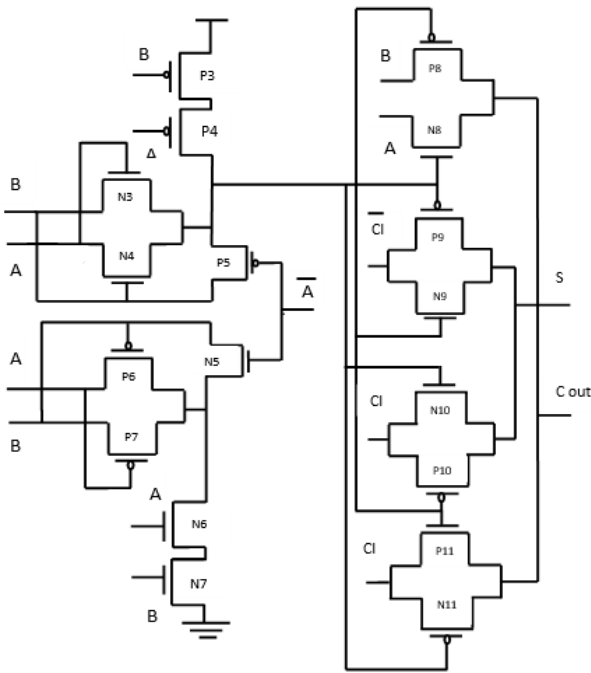


Fig. 10: 22T FA

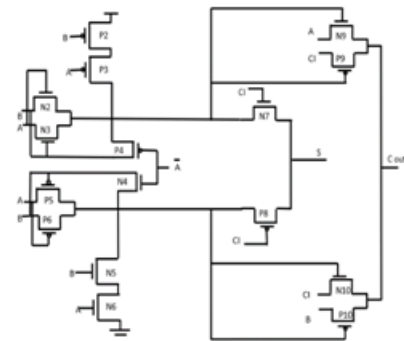


Fig. 12: Proposed FA

Figure 13 represents the second proposed Full adder. The circuit consists of 15 transistors which have two transistors less when compared to 17T– FA. This circuit has power consumption and delay in very low amount. This circuit works in non – full swing, due to this the outputs have non – full swing effect. But there is no Disadvantage in having non – full swing outputs. The proposed full adder has low power consumption when compared to the previous circuit 17T – FA and occupies less space due to

the removal of two transistors [1][2].

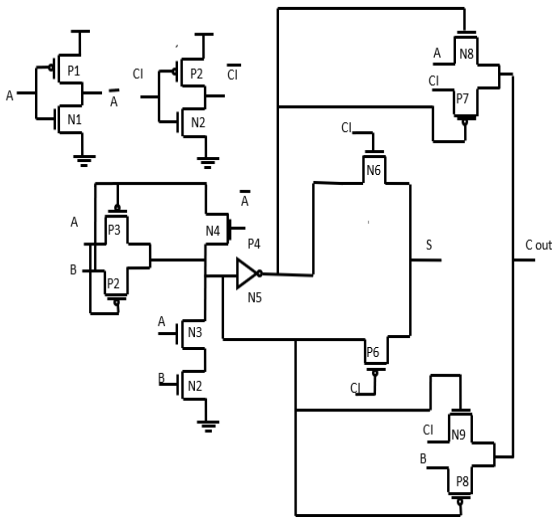


Fig. 13: Proposed FA 2

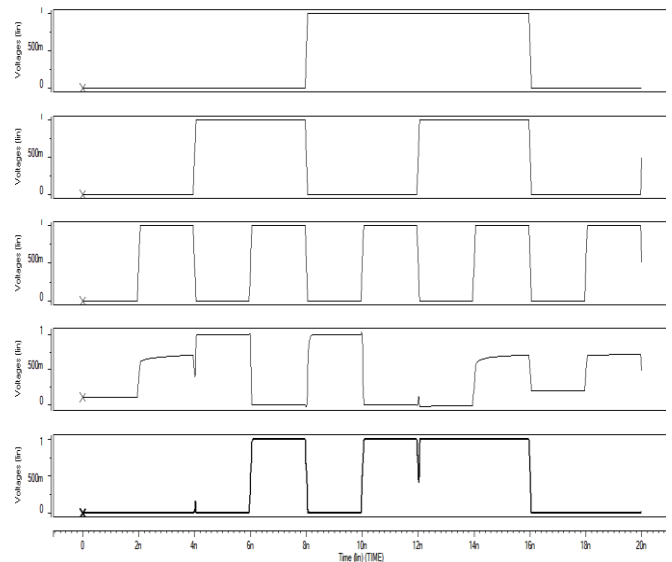


Fig. 15: Proposed FA 2

A. Simulated Results and Performance Comparison

Table 1: FA Comparison table

DESIGN	POWER	DELAY (SUM)	DELAY (CARRY)
20T – Full Adder	19.97 μ W	6ns	10ns
17T Full Adder	21.410 μ W	2ns	6ns
26T – Full Adder Buffer	1.8072 μ W	2ns	8ns
26T – Full Adder New Buffer	1.5994 μ W	6ns	6ns
22T – Full Adder	19.902 μ W	8ns	1ns
19T – Full Adder	12.580 μ W	8ns	8ns
Proposed Full Adder 1	0.3216 μ W	2ns	6ns
Proposed Full Adder 2	0.34928 μ W	2ns	6ns

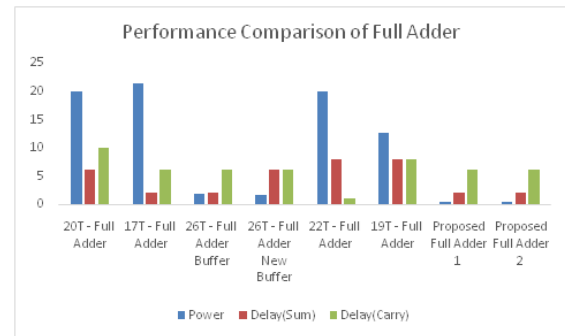


Fig. 16: Graphical Representation of Power and Delay

V. CONCLUSION

In this paper, the low power and fast FA circuits are designed by using XOR and XNOR gates. This work presents low power consumption of a 1-bit FA design in 90nm technology. The proposed FA circuits occupy less space due to number of transistors which consumes less power and which is operated at high speed when compared to the conventional FAs. The proposed FA1 circuit has been implemented by removing the P7 and N8 transistors which in turn reduces the circuit complexity. Similarly, in the proposed full adder 2 circuit is implemented by removing the P5 and N7 transistors which in turn reduces the circuit complexity. Similarly, in proposed FA 2 circuit is implemented by removing P5 and N7 transistors. As we are scaling down the transistors lengths to nano scale technologies we can reduce the power consumption from mW to μ W. The sizes of all the transistors of proposed full adders are optimized in such a way that it shows low power and high speed, which is suitable for high performance ALUs.

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