Performance Comparison of Adder Topologies with Parallel Processing Adder Circuit

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Abstract - In today’s modern era IC architecture design adders are become obligatory block. The growth in digitalization scenario to produce compact design products parameters like power, delay and area should be minimized. In most of the complex design of digital circuits, adder is an elementary factor. If the performance of digital adders is enriched, it would lead to quickening the binary operations in involved in the complex circuits. The constraints in the operation delay of an adder are due to carry propagation in the circuit. The adder topologies involved in this work includes Carry Save Adder, Carry Select Adder, Ripple Carry Adder and Kogge Stone Adder.

Key Words - Carry Save Adder, Carry Select Adder, Ripple Carry Adder and Kogge Stone Adder.

1. Introduction
In a digital system adder is one of the indispensable circuits but the application differs from general ALU to multifaceted multiplication process. Consider the Kogge Stone adder circuit which is used to perform the Fast Fourier Transform algorithms in DSP applications [1]. Almost all the digital communication systems require FFT algorithms and many research works are towards the optimization of various parameters like power, delay and area. The transistors usage in the circuit is always proportionate to the count of adders in the circuit. The adders convoluted in the circuit plays a decisive part in the performance optimization of the digital systems. To enhancement of parameters like power, delay and area relay on the number of adders used in the design of any digital system [2]. To achieve high speed in complex structure, Kogge-Stone adders is introduced. In other hand Ripple carry adder is a low power consuming and area efficient circuit but the critical path delay is affected sternly. A single adder is not able to fulfill all the requirements so adders are chosen based on the application constraints. The usage of microprocessor and microcontrollers are increasing rapidly and key block in it is multiplier which is repeated addition process [3]. So, performance of any multiplier is depending on the performance of the adders utilized in the design and to be reflected in the complete performance of the digital system [4]. The selection of adders is based on the applications. For example, the adder which occupies additional area will not be considered for the design where size plays an important constraint. Likewise, if any design accepts tradeoff among power and area can be introduced in complex adder to achieve high speed operation [5]. The factors involve in the selection of the adder is area efficient, less power consumption and high speedy operation. Based on the parameters mentioned few adders are considered for the comparison of the performance.

Section I of this papers deals with introduction of adders. Section II involves the various types of adders used for the comparison of their respective performance along with circuit diagrams. Section III depicts the parameter comparison with its results. Section IV displays the conclusion.

2. Adders

Carry Save adder
In the carry save adder, simultaneously all 3 bits will be fed as input as shown in Figure 1.

Carry Select Adder
The carry select adder is similar to Ripple carry adder circuit in the way of performing addition operation. But the designing aspect is different each other [8]. The carry select adder performs parallel addition processing of two n-bit numbers and produces a cumulative result of both the n-bit numbers and a carry [9]. Compared to Ripple carry adder, Carry select adders does not generate full adders. For a 4bit Carry select adder, two parallel ripples carry adders and multiplexers is connected together to yield a sum and carry outputs [10]. The actual inputs are fed into the first block of ripple carry adder and set carry input as zero but in the second block of ripple carry adder inputs

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remains same but carry input is set to one and operation is performed in parallel [11]. Both the sum outputs are provided as inputs for the multiplexer and carry output determines the next stage of ripple carry adder to be connected. The carry select adder is shown in the Figure 2. The carry select adder is preferred over other adders when area and power are design constraints [12].

**Ripple Carry Adder**

The Ripple carry adder is designed by adding full adders in cascade manner. The Ripple carry adder is shown in Figure 3. The full adders are accountable for addition of two binary digits with the carry bit included initial stage and further rippled to further stages [13]. The output of the process will produce first bit of sum and carry-out. Then in further process the carry-out is given as carry-in of the earlier stages and it is continued till the last stage. The initial stage of full adder operations starts with input 1, input 2 and carry-in bit and the obtained sum and carry are further acts as the inputs for the succeeding stages of full adder blocks. The results of the last stage of the full adder block is the actual throughput of ripple carry adder. The delay in the ripple carry adder varies with respect to number of bits involved in the designing process [14].

**Kogge Stone Adder**

The Kogge stone adder shown in Figure 4 is most widely accepted as faster adder and engaged in the place of high-performance circuits in industries. One of the important features in the design is carry is generated faster through simultaneous process at the tradeoff of area. The time required to generate carry is \(O(\log n)\) time. The structure of Kogge stone adder is flexible to adopt with the present electronic technology.

Another salient feature of Kogge stone adder is minimized depth in logic and maximized fan-out which depicts it as faster adder consuming more area. The Kogge stone adder performance is done in three stages namely

- Pre-processing
- Carry generation
- Post-processing

The Pre-processing stage create signals and propagate signals are determined and vital in generating carry-in bit. In Carry-generation stage, a simultaneous process takes place to compute the carries with reference to individual bits [15]. Here two AND gates and One OR gate is comprised to perform the carry operation and later fragmented into miniature pieces. The Post-processing stage will determine the final sum bits and acts as a termination in processing stage.

3. **Simulation Results and Discussion**

The work was carried out for 32 bits adders among carry select adder, carry save adder, ripple carry adder and Kogge stone adder. These kinds of adders are involved in several applications made to choose for the comparison process [16]. The simulation results are obtained from the Xilinx ISE tool using Hardware Description Language. Mostly the adder and multiplier blocks are involved in signal processing applications [17]. The analysis was carried out for 10KHz signal rate and obtained values are tabulated for comparison process. The comparison of various parameters in the design of an adder is displayed in Table 1.

| S.No. | Adders              | Delay (ns) | Area (LUTs) | Power (mW) |
|-------|---------------------|------------|-------------|------------|
| 1     | Carry Save Adder    | 26.58      | 98          | 13.87      |
| 2     | Carry Select Adder  | 22.45      | 66          | 7.96       |
| 3     | Ripple Carry Adder  | 21.36      | 68          | 8.42       |
| 4     | Kogge Stone Adder   | 20.45      | 73          | 7.87       |

Overall, the delay of the Kogge Stone Adder provides better in comparison with remaining adders used here for comparison. The performance of the circuit is predominantly on the response of the execution of the inputs [18]. The next primary factor influencing the design...
is consumption of power which is almost level with Carry select adder and Kogge Stone Adder [19]. When it comes into area consumption carry select adder and ripple carry adder is much preferred than other two adders. Figure 5 shows the Parameters Comparison Chart.

![Parameters Comparison Chart](image)

**Fig. 5:** Parameters Comparison Chart

4. Conclusion

The works carried out and results reflects parameters like delay, area and power. The compact area is provided by Carry Select adder and Ripple Carry adder, which is one of the important constraints in the process of designing a digital system. The Kogge stone adder is widely used in the design of adder in the recent scenario since the performance of the system is calculated depends on the response time and consumption of power. The selection of adder is based on the requirement of the applications. The significance of the design may play a vital role depends on the tradeoff between the parameters area, delay and power.

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