

# Comparative Analysis of Ladner-Fischer Adder and Han-Carlson Adder Parallel-Prefix Adder for Their Area, Delay and Power Consumption

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## ABSTRACT

Parallel Prefix adders have been one of the most notable among more than a few designs proposed in the past. Parallel Prefix adders (PPA) are family of adders derived from the generally known carry look ahead adders. The need for a Parallel Prefix adder is that it is mostly fast when compared with ripple carry adders. The classical parallel prefix adder structures presented in the literature over the years optimize for logic depth, area, and fan-out and interconnect count of logic circuits. In this paper, a comparison of two 8-bit parallel-Prefix adders (Ladner-Fischer adder and Han-Carlson adder) in their area, delay, power is proposed. In this proposed system Ladner-Fischer adder and Han-Carlson adder parallel prefix adder are used for comparison. The results reveal that the proposed Han-Carlson adder Parallel-Prefix Adder is more competent than Ladner-Fischer Parallel-Prefix adder in terms of area, delay & power. Simulation results are compared and verified using Xilinx 8.1i software.

**Keywords:** Parallel-Prefix Adder, Area, Power, Delay.

## I. INTRODUCTION

The arithmetic operations of binary numbers are one of the most stimulating problems in modern digital VLSI systems consuming a major design effort of digital signal processors and general purpose microprocessors. The design of high-speed, low-power and area efficient binary adders always receives a great deal of attention. Among the hundreds adder architectures known in the literature, when high performances are mandatory, parallel prefix trees are generally preferable [1].

Parallel Prefix Adders have been recognized as the most efficient circuits for binary addition in digital systems. Their regular structure and fast performance makes them mostly attractive for VLSI implementation. The delay of a parallel prefix adder is

directly relative to the number of levels in the carry propagation stage. The need for a Parallel Prefix adder is that it is primarily fast when compared with ripple carry adders. Parallel Prefix adders have been recognized as the most efficient circuits for binary addition [2]. These adders are best suited for adders with wider word lengths.

This paper investigates the performance of two different parallel prefix adders. The parallel prefix adders investigated in this paper are: Ladner-Fischer adder (LFA) and Han-Carlson adder (HCA). The performance metrics considered for the analysis of the adders are: area, delay and power. Using simulation studies area, delay and power performance of the various adder modules were obtained. It was observed that Han-Carlson adder has better circuit

characteristics in terms of delay compared to adders realized using other algorithms [3].

The rest of the paper is organized as follows: In Section 2, 3 and 4, a brief description of the two different parallel prefix adders are given, in Section 5, the methodology used for the research is explained. Section 6 gives results analysis and Section 7 gives conclusions.

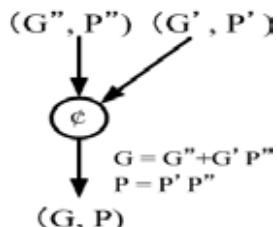
## II. PARALLEL-PREFIX ADDER

Parallel prefix adders are constructed out of fundamental carry operators denoted by  $\phi$  as follows:

$$(G'', P'') \phi (G', P') = (G'' + G' \cdot P'', P' \cdot P'')$$

where  $P''$  and  $P'$  indicate the propagations,  $G''$  and  $G'$  indicate the generations. The fundamental carry operator is represented as Figure 1.

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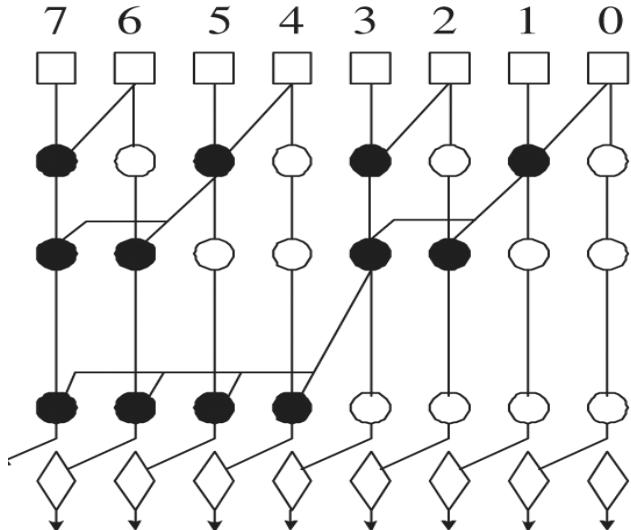


**Figure 1.** Carry operator

A parallel prefix adder can be represented as a parallel prefix graph consisting of carry operator nodes.

## III. LADNER-FISCHER ADDER

In 1980, R. Ladner and M. Fischer described this clever modification, Ladner-Fischer adder is a parallel prefix form carry look ahead adder. A parallel prefix adder can be represented as a parallel prefix graph consisting of carry operator nodes. The time required to generate carry signals in this prefix adder is  $O(\log n)$ .

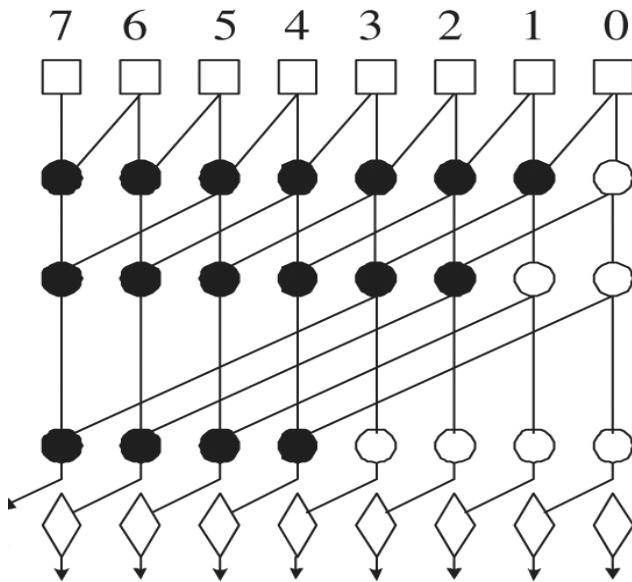


**Figure 2.** LFA adder tree diagram

The Ladner-Fischer adder tree diagram is shown in figure 2. It is a fastest adder design and mutual design for high performance adders. The large number of levels in Ladner-Fischer Adder (LFA) however reduces its operational speed. The better performances of Ladner-Fischer adder are minimum logic depth and bounded fan-out. But it has large area. LFA is also power efficient because of its lowest area delay with large number of input bits [4]. The parallel prefix adder of a LFA structure has minimum logic depth, but has large fan-out requirement up to  $n/2$ .

## IV. HAN-CARLSON ADDER

Han-Carlson adder contains a good trade-off between fan out, number of logic levels and number of black cells. Because of this, Han-Carlson adder can achieve equal to speed execution esteem to Kogge-Stone adder, at lower power utilization and area. In this manner it is fascinating to execute a speculative Han-Carlson adder. Moved by these reasons, have generated a Han-Carlson speculative prefix-processing stage by removing the final rows of the Kogge-Stone part of the adder.

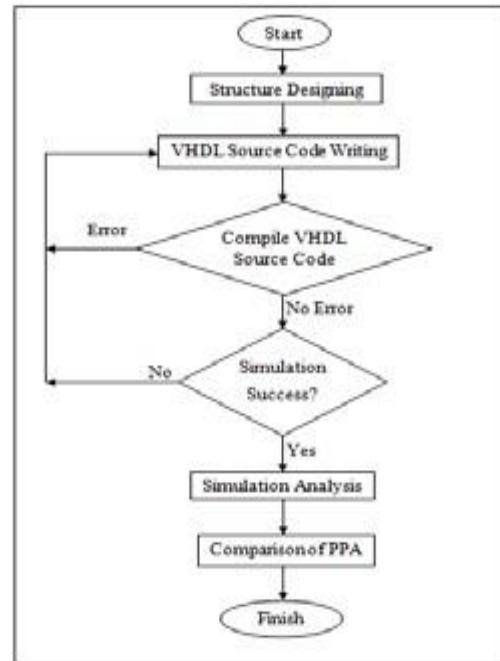


**Figure 3.** HCA adder tree diagram

Han-Carlson adder tree diagram is shown in figure 3 in which the two Brent-Kung rows at the initial and toward the end of the graph are unaltered, while the last Kogge-Stone row is pruned [5]. This yields a speculative stage with  $K=8=n/2$ . In general, one has  $K == n/2p$ . Where  $p$  is the quantity of pruned levels; the number of levels of the speculative Han-Carlson stage lessens from  $1+ \log( n )$  to  $1+ \log( k )$ .

## V. METHODOLOGY

The designs for the adders were produced by writing Very High Speed Integrated Circuit (VHSIC) Hardware Description Language (VHDL) source file. Figure 4 shows the system design flow chart. The VHDL source code writing is the most important part in this project. There are a total of two VHDL source codes for 8 bits Ladner-Fischer Adder and Han-Carlson adder. For this paper, the VHDL source codes contain elements such as entity, library, architecture, function and array. The design file has to be examined, synthesis and compile before it can be simulated. Simulation results in this project come in the form of Register Transfer Level (RTL) diagram and functional waveform. The synthesis report obtained in the form of gate count for the design (area), delay report and power consumption report. The RTL design can be obtained by using the RTL viewer based on the Net list viewer.



**Figure 4.** System design flow chart

Finally, the PPA comparison will be made once the two simulation results are analyzed. LFA and HCA will be compared at this stage. The comparisons will be based on the power consumption, propagation delay and area.

## VI. RESULTS ANALYSIS

The LFA and HCA are compared in three main aspects, area, delay and power. The comparison for area, delay and power consumed by the adder circuits are based on tree diagram of each adder. The results are shown in tabulation.

**Table 1.** Comparison of LFA and HCA

S.No	Specifications	LFA	HCA
1.	Gate count (Area)	951	656
2.	Delay	3.579ns	3.129ns
3.	Power Consumption	42mW	38mW

## VII. CONCLUSION

In terms of area between the two PPAs, the HCA proves to be a better. Even though the HCA's area rises as the bit size increases, it does not rise as radically as LFA. The higher the number of bits supported by the PPAs, the bigger is the adder in

terms of area. In terms of computational delay also HCA is better in time propagation delay (tpd) for the bit size of 8-bits, In terms of total power estimated also the HCA consumes less amount of power. Therefore the results reveal that the proposed Han-Carlson Parallel-Prefix adder is more competent than Ladner-Fischer Parallel-Prefix adder in terms of area, delay and power for the bit size of 8bits.

## VIII. REFERENCES

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