Design of a 4x4 Braun Array Multiplier with a 3-bit Kogge-Stone Adder

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***Abstract*—In this paper, a 4x4 Braun Array Multiplier has been designed and for the parallel prefix adder, a 3-bit Kogge-Stone Adder has been implemented. The multiplier designed is a type of a high-speed parallel array multiplier that comes with a relatively lesser area and delay, thus making it one of the ideal array multipliers to use. Braun Array Multipliers require a carry look-ahead adder in the design. In order to improve the speed and efficiency of the multiplier, a Kogge-Stone Adder has been implemented in the place of the carry look-ahead adder. It is a form of a parallel-prefix adder that comes with a lower fan-out at each of its stages, thus increasing the performance for typical CMOS processes. The implemented design is later verified for its functionality.**

I. Circuit Details

One of the most commonly used arithmetic operations in digital systems is binary multiplication. It is defined as the repeated process of addition. However, the process of multiplication in general is an extensive process when compared to the other binary arithmetic operations, and thus requires more computation time. Nevertheless, it is a very important operation that is primarily being done in digital signal processing applications. For example the Multiply and Accumulate (MAC) operation is used in implementing Finite Impulse Response (FIR) Filters, and other DSP algorithms. To increase performance and execution speed in DSP applications, parallel array multipliers are mostly used [1]. The Braun Array Multiplier is one such parallel array multiplier that is widely used. [1]. An n-bit Braun Array Multiplier is realised using $(n-1)^2$ full adders, n^2 AND gates and $(n-1)$ bit carry look-ahead adder. Thus, a 4-bit multiplier is required to have 9 full adders, 16 AND gates and a 3-bit adder circuit. The partial product generated at each stage, is added with the partial product of the previous stage. In order to further enhance the performance of the multiplier, a Kogge-Stone Adder is implemented instead of the conventional adder. It is a type of a parallel-prefix adder, whose name is indicative of the fact that the carry bits here, are obtained in parallel, thus increasing the speed of the addition process [1]. This adder is capable of producing the carry signal in $O(log\ n)$ time [1]. It also comes with a lower fan-out thus making it an ideal adder circuit that could be incorporated with the multiplier. Figure 1 shows the overall circuit of the 4-bit Braun Array Multiplier [2], while Figure 2 shows the waveform of two 4-bit operands and the resultant 8-bit product [3].

II. Reference Circuit

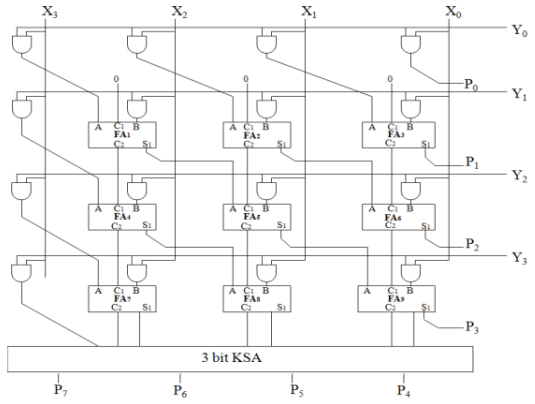

Figure 1. 4x4 Braun Array Multiplier with 3-bit Kogge-Stone Adder

III. Reference Waveform

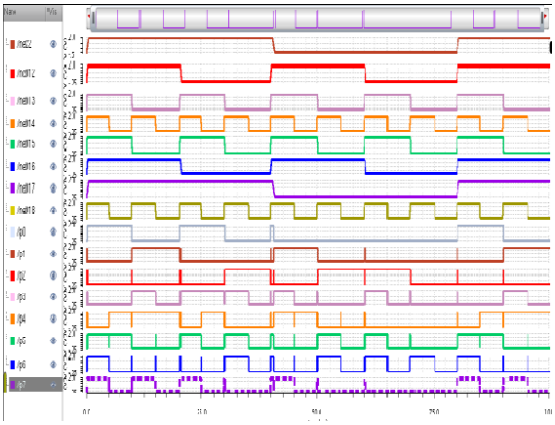

Figure 2. Resultant Waveform containing the input and output

References

[1] Shinde, et al. (2018). A Novel Approach to Design Braun Array Multiplier Using Parallel Prefix Adders for Parallel Processing Architectures: Second International Conference, ICSCS 2018, Kollam, India, April 19–20, 2018

[2] A. Raju and S. K. Sa, "Design and performance analysis of multipliers using Kogge Stone Adder," 2017 3rd International Conference on Applied and Theoretical Computing and Communication Technology (iCATccT), 2017, pp. 94-99

[3] B. Neeraja and R. S. P. Goud, "Design of an Area Efficient Braun Multiplier using High Speed Parallel Prefix Adder in Cadence," 2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT), 2019, pp. 1-5