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Computing Non-Restoring and Newton Raphson's Method for Division

*Lavanya B K[1], Savidhan Shetty[2], Akshatha D[2]
[1](Electronics & Communication Engineering, Sahyadri College of Engineering& Management, India
[2](Associate Professor Electronics & Communication Engineering, Sahyadri College of Engineering & Management, India)
[2](Associate Professor Electronics & Communication Engineering, Sahyadri College of Engineering & Management, India)
Corresponding Author: Lavanya B K

Abstract: *Division is one of the most time consuming and complex arithmetic operation. They are employed in various digital circuit designs and software applications. Many algorithms are suitable for implementing division in hardware. In this paper we implement the Newton Raphson's and Non-Restoring division algorithm, which is synthesized and simulated to check its accuracy. Newton Raphson's algorithm is one of the fastest division algorithms which is used to calculate the quotient. Non-Restoring algorithm is one of slow division algorithm which is used to calculate the quotient and remainder. The proposed method executes its operation by using shift, subtract and multiplex operations, in order to achieve a simpler implementation and faster calculation. In this paper the condition of add-shift schemes has been modified from existing algorithm. The modifications are to eliminate the integer multiplication and to round the unsigned result to the nearest integer. Newton Raphson's and Non-Restoring Division algorithm is implemented using Xilinx ISE 10.1 simulator. The power, area and delay of the algorithms are computed using cadence.*

Keywords: *CLA, Add-shift, non-restoring, Newton's method, multiplexer*

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I. Introduction

Division is the one of the four basic operations of arithmetic. Division of two numbers is the process of calculating number of time one number contained within one another. In digital processing division is one of the most time consuming operation and implementing it in hardware requires large area and high power consumption. Hence division is rarely performed but it is achieved in some other form of equations.Division can be implemented in various methods. So division algorithms are used to perform the division operation.A division algorithm is an algorithm in which, given two integers N and D, computes their quotient and/or remainder. Some are applied by hand, while others are employed by digital circuit designs and software. Division algorithms fall into two main categories: slow division and fast division.Slow division algorithms produce one digit of the final quotient per iterations. Slow divisions are restoring division,non restoring division and SRT. Even these methods are not efficient enough for operands consisting of large number of bits. Hence other methods called fast division algorithms.Fast division algorithms start with the close approximation to the final quotient and produce twice as many digits of the final quotient in each iterations. Newton Raphson's Division and is one of the fast division methods. Another division and Goldschmidt belong to this group. In this paper, we present the techniques we developed for proving correct rounding for division algorithms based on Newton-Raphson's iterations. Newton Raphson's uses Newton's method to find the reciprocal of D and multiply that reciprocal by N to find the final quotient. Newton-Raphson's iterations are usually performed in a higher precision than the precision of the operand and of the quotient. Another division that is Non-Resorting division method is computed using add-shift method. Because an implementation of division in hardware is expensive. One of the alternatives is by replacing it with cheaper adder and shifter. Integer division instructions are considerably slower than multiplication while multiplication instructions are several times slower than addition. It gives out a fixed number of quotient bits in iteration. This paper presents the development of algorithm round the division output to the nearest integer using add-shift scheme.

II. Algorithms

2.1 Newton Raphson's Algorithm

Newton Raphson's is one of the fast division algorithms. Newton Raphson's algorithm first find the reciprocal of Divisor D, then that reciprocal is multiply with Dividend to find the quotient. Here Newton's method is used to find the reciprocal of Divisor. It has three steps to compute quotient. They are:

1. Calculate an estimate X_0 for the reciprocal 1/D of the divisor D.
2. Compute successively more accurate estimates $X_1, X_2, \ldots, X_s$ of the reciprocal.
3. Compute the quotient by multiplying the dividend by the reciprocal of the divisor.

$$Q = Div*X_s$$

Where Q is the quotient

Div is the Dividend

Xs is the final approximate value

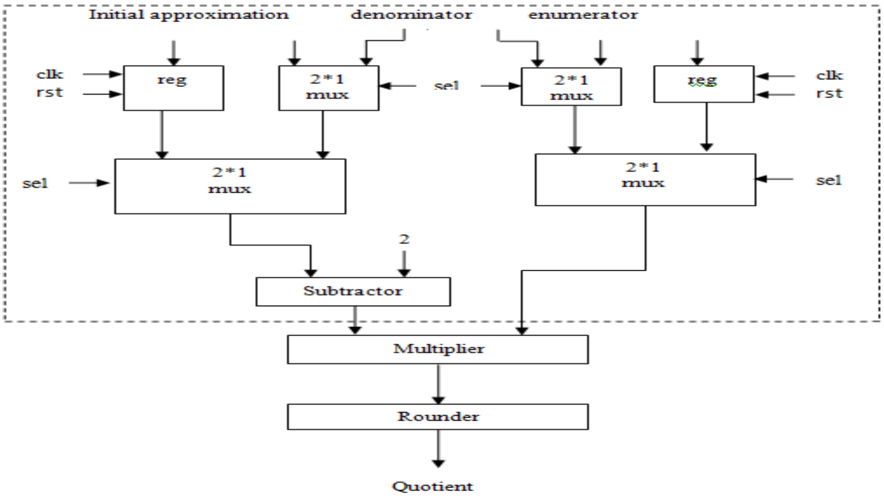

Fig.1 Flow for Newton Raphson's Method

2.2 Non-Restoring Algorithm

Non-Restoring division originally defined by Robstern in 1958. He described the non-restoring division method in recursive relationship that is shown below;

$$P_{j+1} = RP_j - Q_{j+1}*D \text{ with } j = 0, 1 \ldots\ldots m-1$$

Where P_j is jth partial remainder

P0 is the partial remainder

D is the Divisor

Q_j is the jth digit of the quotient

m is the number bits in Quotient

R is the radix

It is the operation of repetitive left-shifting and subtraction. At first initialize the divisor, dividend, partial Remainder (as 0), counter variable and carry out bit (as 1). If the carry out bit is 1 then left-shift the partial remainder and dividend's content and modify carry out bit and partial remainder subtracting divisor from it. Else left-shift partial remainder and dividend's content and modify carry out bit and partial remainder adding divisor. Then initialize the last bit of dividend as carry out bit. Then decrease the counter variable. If counter content is equal to zero then store the quotient and dividend and terminate. Else repeat from the step that is left-shift the partial remainder and dividend's content and modify carry out bit and accumulator subtracting divisor from it. If the divisor is B and the dividend is A then the result in non-restoring method is (2A-B). The process continues until all the bits of the dividend are exhausted.

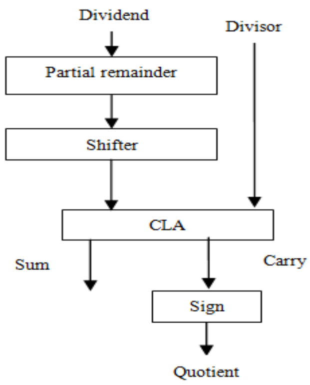

Fig.2 Flow for Non-Restoring Division algorithm

III. RTL, Simulation And Performance Result

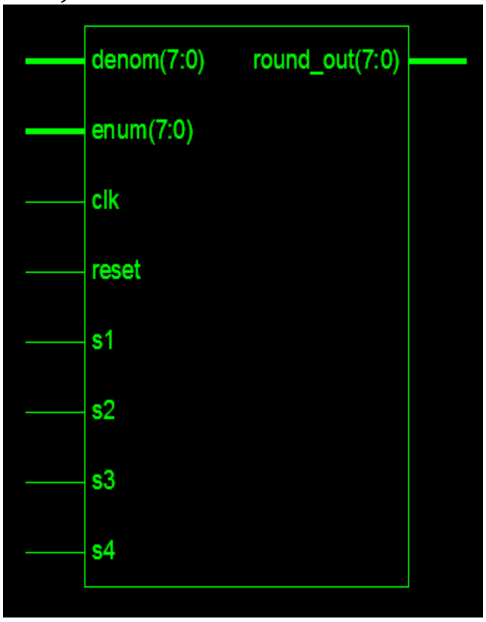

Fig.3 RTL for Newton Raphson's division algorithm

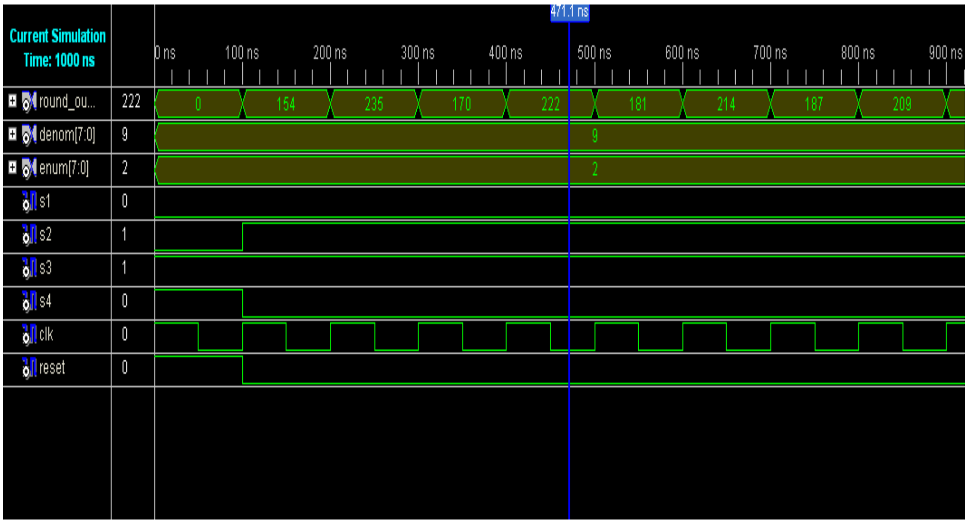

Fig.4 Simulation result of Newton's Raphson's method

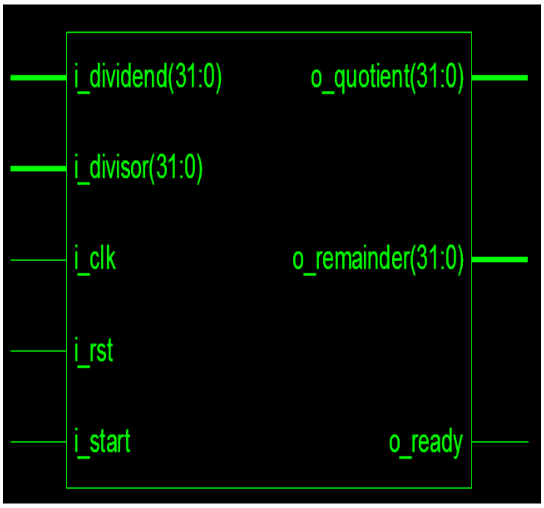

Fig.5 RTL for Non-Restoring division algorithm

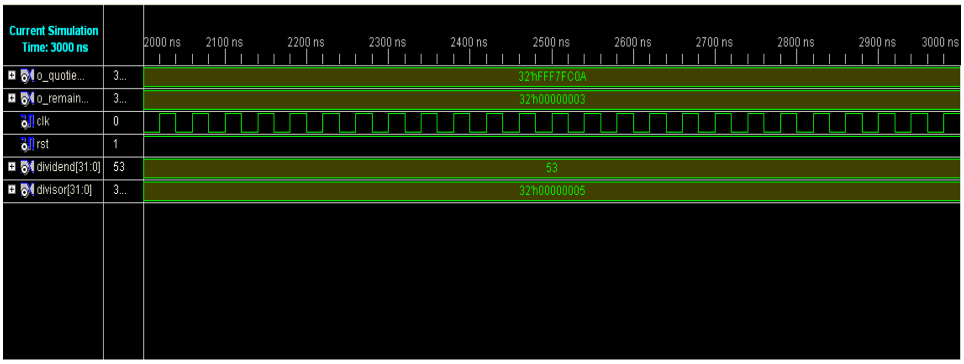

Fig 6. Simulation result of Non-Restoring division method

Division algorithms are implemented using Xilinx software and power, delay and area are computed using cadence tool

Table.1 cadence Results

Division Algorithms	**Area**	**Power(nW)**	**Gates**
Newton Raphson's	789	351090.5	789
Non-Restoring	2418	1697380.1	2418

IV. Conclusion

The proposed division methods proving the correct rounding for division algorithms based Newton Raphson's iterations. This method is one of the fast division algorithms the final output is in the decimal point format. Next algorithm is the no restoring algorithm where the partial remainder is calculated and then this value is shifted to obtained the quotient and remainder

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