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FPGA Based Cordic Algorithm

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ABSTRACT: DSP algorithms provide extraordinary performance in processing the real time data. Trigonometric functions play a vital role in real life applications. Especially Sine and Cosine waves are very useful in various fields of applications. Few to mention are signal processing, thermal analysis, electronic communication, medical science and many others. Algorithms play a vital role in the DSP applications. One such algorithm is the CORDIC (Co-ordinate Rotation Digital Computer) algorithm. Many real time applications require that the computation speed to be as high as possible. CORDIC is one such efficient algorithm. It was basically initiated by Volder in 1959. It is an iterative algorithm that uses shift, add/subtract and table look up operations. This paper presents implementation of CORDIC algorithm on FPGA for the generation of sine and cosine terms. The algorithm is implemented using VHDL language and simulation results are obtained from Xilinx ISE tool.

KEYWORDS: CORDIC, FPGA, VHDL, Xilinx, DSP.

I.INTRODUCTION

Sine and cosine are the essential capacities which can be gotten from any perplexing capacities utilized as a part of a wide scope of applications, for example, computerized signal handling, remote correspondence, biometrics, robotics, and so forth [1]. A few strategies exist to create equipment that performs sine and cosine counts, which are Lookup Table (LUT), Maclaurin arrangement, and CORDIC.

Table lookup technique uses pieces of memory which store estimations of the capacity to be figured for each conceivable info contentions. This strategy is generally easy to be employed since no particular estimations are required, depending just on the qualities put away on the table. Be that as it may, the quantity of table passages required will rise exponentially as the quantity of bits, which are utilized to speak to the yield contention, rise [2]. This will bring about bigger region required for equipment execution.

CORDIC is an acronym for COordinate Rotation DIgital Computer. CORDIC actualizes the figuring utilizing just adders, and shift registers evading the requirement for multiplier circuits. By utilizing this it spares and defeats the need of complex multiplier based equipment assets. CORDIC is utilized for estimations of trigonometric capacities. It is utilized for polar to rectangular and rectangular to polar change, likewise in a few changes like DFT, FFT. CORDIC Algorithm was for the most part created to discover an answer for constant route issues. CORDIC Algorithm discovered application in 8087 math coprocessor, radar signal processor, Hp-35 number cruncher and mechanical autonomy, and Wireless LAN at recipient side.

Computation of sine and cosine of given edge is a crucial prerequisite in numerous territories of genuine living. In therapeutic science, medicinal gear that measures normal repeating body capacities like pulse, breathing and so on use sine and cosine waves. In sign handling, advanced sound and superior quality recordings depend on entireties of sine and cosine. In topography, tremors are demonstrated with wave conditions which are comprehended utilizing aggregates of sine and cosine. Likewise, radio correspondence utilized as a part of hardware depends on utilization of blends of sine and cosine waves. Equipment gives most elevated pace because of its hardwired plan. This paper

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presents equipment outline for figuring sine and cosine estimation of given edge utilizing CORDIC calculation with restricted equipment use.

The CORDIC calculation has turned into a broadly utilized way to deal with rudimentary capacity assessment when the silicon zone is an essential imperative. The execution of CORDIC calculation requires less perplexing equipment than the ordinary technique [3]. The CORDIC calculation has discovered its way in different applications, for example, pocket number crunchers, numerical co-processors, to elite radar signal preparing, supersonic plane air ship with a computerized partner, calculation of the (Fast Fourier Transform) FFT, and at the consequences for the numerical exactness [4]. CORDIC calculation spins around "turning" the period of an intricate number, by duplicating it by a progression of consistent qualities. Notwithstanding, the "increases" would all be able to be forces of 2, so in double number juggling they should be possible utilizing just moves and includes; no genuine "multiplier" is required in this way it more straightforward and don't require complex equipment structure as on account of multiplier. Prior strategies utilized are Table gaze upward strategy, Polynomial estimate technique and so forth for assessment of trigonometric capacities.

II.LITERATURE SURVEY

Henry Briggs portrayed a portion of the digit-by-digit strategies for the calculation of the arithmetical rudimentary capacities. These are iterative pseudo division and pseudo augmentation forms, which take after rehashed expansion duplication and rehashed subtraction division. In 1959, Volder proposed an exceptional reason advanced processing unit known as COordinate Rotation DIgital Computer (CORDIC), while building an ongoing navigational PC for use in a flying machine.

This calculation was at first created for trigonometric capacities which were communicated as far as fundamental plane pivots. The equipment acknowledgment of the calculation conditions require augmentations, increases/subtractions and getting to the table put away in memory for trigonometric coefficients. The CORDIC calculation processes 2D turn utilizing iterative conditions utilizing move and include operations.

The flexibility of CORDIC was improved by creating calculations on the same premise for change between paired to Binary Coded Decimal (BCD) number representation by Daggett in 1959. These iterative strategies were depicted utilizing decimal radix for the configuration of effective little machines by Meggitt in 1962. In this manner, Walther in 1971 has proposed a bound together calculation to register pivot in round, straight, and hyperbolic direction frameworks utilizing the same CORDIC calculation, installing coordinate frameworks as a parameter.

Amid the most recent 50 years of the CORDIC calculation a wide assortment of uses has developed. The CORDIC calculation has gotten expanded consideration after a bound together approach was proposed for its usage. From that point, CORDIC based figuring has been the decision for experimental number cruncher applications, for example, HP-2152A co-processor, HP-9100 desktop adding machine, HP-35 mini-computer are a couple of such gadgets in light of the CORDIC calculation.

III. CORDIC ALGORITHM

The essential idea of the CORDIC calculation is to decay the required pivot point into the weighted aggregate of an arrangement of predefined rudimentary revolution edges such that the turn through each of them can be refined with straightforward shift and add operations.

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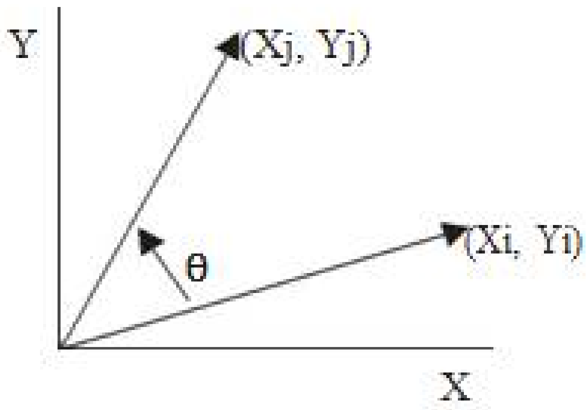

Figure.1: Graphical representation of cordic

The input angle whose sine and cosine is to be calculated is converted to radian first. Then this value is converted to binary and used in the code as input. Binary form of the output is obtained. It is then converted to decimal. The algorithm is successfully implemented on Spartan 3 FPGA board.

Utilizing a framework shape, a planar pivot for a vector of (Xi, Yi) is characterized as:

$$\begin{bmatrix} X_j \\ Y_j \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} X_i \\ Y_i \end{bmatrix}$$

The plot for every progression is given by:

$$\theta_n = \arctan\left(\frac{1}{2^n}\right)$$

$$\tan\theta_n = S_n 2^{-n}$$

Substituting in above conditions, we get:

$$\begin{bmatrix} X_{n+1} \\ Y_{n+1} \end{bmatrix} = \cos\theta_n \begin{bmatrix} 1 & -S_n 2^{-n} \\ S_n 2^{-n} & 1 \end{bmatrix} \begin{bmatrix} X_n \\ Y_n \end{bmatrix}$$

The cosθ n coefficient can be composed as:

Now another variable called "Z" is presented. Z speaks to the part of the point θ which has not been turned yet.

$$Z_{n+1} = \theta - \sum_{i=0}^{n} \theta_i$$

For each progression of the turn Sn is figured as an indication of Zn.

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$$S_n = \begin{cases} -1 & if\ Z_n < 0 \\ +1 & if\ Z_n \geq 0 \end{cases}$$

In a project like style:

For n=0 to infinity,
If (Z(n) >= 0) then
Z(n + 1) := Z(n) – atan (1/2^n);
Else
Z(n + 1) := Z(n) + atan (1/2^n);
End if;
End for;

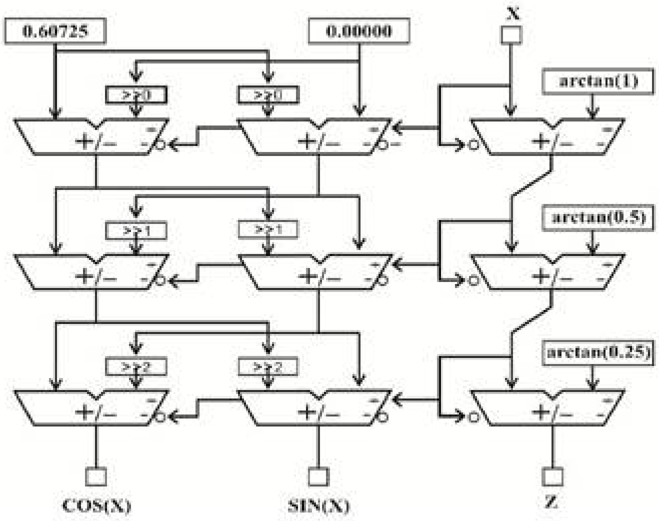

Figure.2: Flow chart for the CORDIC algorithm

The atan (1/2^i) is pre-computed and put away in a table. Interminability is supplanted with the required number of cycles, which is around 1 emphasis for each piece.

On the off chance that we include the calculation for X and Y we get the system like style for the CORDIC centre.

IV. EXPERIMENTAL RESULTS

Figure 1 demonstrates the graphical representation of CORDIC calculation. Figure 2 shows the flow chart of CORDIC algorithm which mainly uses shift, add/subtract. Figure 3 shows testbench waveforms of the implementation.

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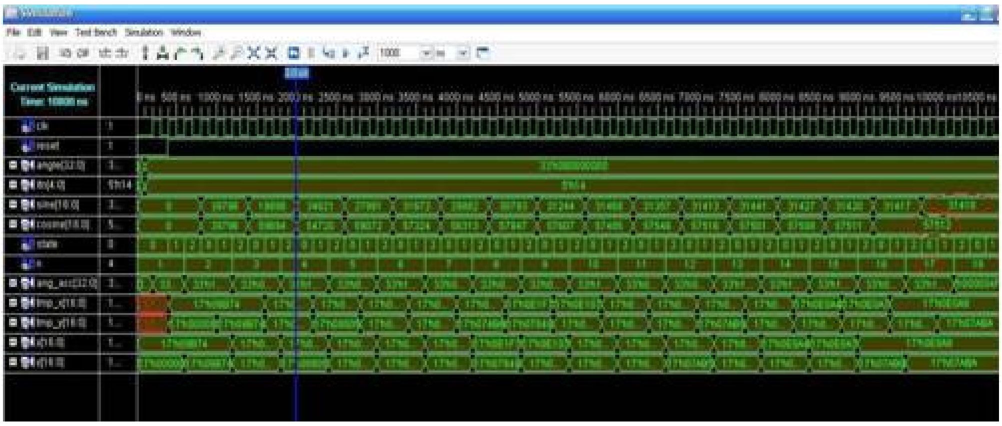

Figure.3: Test bench waveforms of cordic implementation.

Figure 4 shows sine and cosine values for a given input angle. For example 3 values of input angle z have been used as 30, 45 and 60 degrees. These angles are represented in fixed point notation as 00111100000, 01011010000 and 01111000000 respectively.

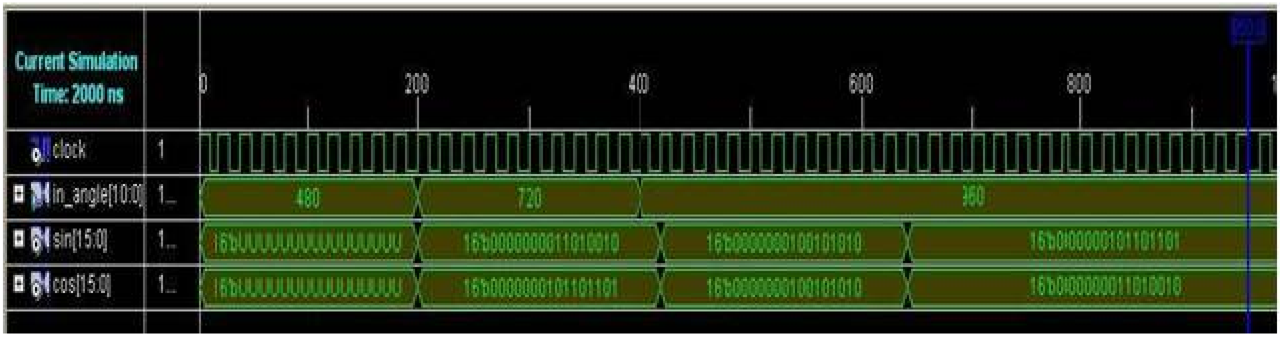

Figure.4: Sine and Cosine values for the required input angles.

As shown in figure 2, at each 200 ns, result for the value of input angle is being calculated. Results for the given input angles are as 0000000011010010, 0000000100101010 and 0000000101101101 respectively as shown for sine value. Dividing the output by 1.64676 we can get the sine value of an angle.

V.CONCLUSION

CORDIC is an intense calculation, and a mainstream calculation of decision with regards to different Digital Signal Processing applications. Usage of a CORDIC-construct processor in light of FPGA gives us an intense component of executing complex calculations on a stage that gives a ton of assets and adaptability at a moderately lesser expense. Further, subsequent to the calculation is straightforward and effective the outline and FPGA execution of a CORDIC based processor is effortlessly achievable. CORDIC Algorithm is a crucial device which is utilized as a part of Digital Signal Processing. The principle use of the CORDIC calculation in this paper is to plan and create sine and cosine values. This paper demonstrates that this calculation device is accessible for use in FPGA based processing machines.

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