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Design of Rectangular to Polar Reconfigurable Cordic

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ABSTRACT

CORDIC is an acronym for Coordinate Rotation Digital Computer. The CORDIC algorithm is a repetitive calculation approach ability of emerging different basic functions with a proper shift-and-add method Used to evaluate a large amount of functions. It has been used for many years for efficient implementation of vector rotation operations in hardware. It is executed merely by table look-up, shift, and addition operations. Rotation of vectors through fixed and known angles has many applications in animations, robotics, games, computer graphics and digital signal processing. In this paper we present improved method of shifting by using an alternate scheme by increasing the no. of barrel shifters with increasing pre shifting method and Fault Tolerance in Bi Rotational CORDIC circuits higher rate of accuracy in fixed and known rotations. The improvement in the fixed angle Rotation reducing the area- and Complexity in the application. From the basic architecture of cordic an fixed angle rotation is implemented by vector rotation. the rotation of vectors uncontrolled by the circuit till all rotations are completed it will results large system gain and unpredictable angles for effective operation of known angles in this paper angle correction, Quadrant correction and gain correction is implemented, this paper also proposed the rectangular to polar cordic for reducing number of multiplication and addition, also mentioned the simulation results.

Keywords: *CORDIC, Quadrant amendment, vectoring and rotation modes.*

I. INTRODUCTION

CORDIC is an acronym for Coordinate Rotation Digital Computer. It is classes of shift add algorithms for rotating vectors in a plane, which is usually used for the calculation of trigonometric functions. The CORDIC algorithm has become a widely used approach to elementary function evaluation when the silicon area is a primary constraint. The CORDIC algorithm was developed by J. E. Volder in 1959 for the computation of trigonometric functions. This has been recognized as the best compromise between the table look up approach requiring large memory, and polynomial approximation method, which is slow to converge to the desired precision.

In 1971, Walther has generalized this algorithm to implement rotation in circular, linear and hyperbolic coordinate systems. Since then it has been used as an elegant method to realize elementary functions such as multiplication, division, logarithmic and exponential functions in addition to the computation of two dimensional vector rotations. These transcendental functions are the core for many applications such as digital signal processing, graphics, image processing and kinematic processing. The implementation of CORDIC algorithm requires less complex hardware than the conventional method.

Angle recoding schemes, mixed-grain rotation and higher radix CORDIC have been developed for reduced latency realization. Parallel and pipelined CORDIC have been suggested for high-throughput Computation.

I. METHODOLOGY

A CORDIC can be operated in two different modes, the vectoring and the rotation mode. In vectoring mode, coordinates (x,y) are rotated until y converges to zero. In rotation mode, initial vector (x,y) starts aligned with the x-axis and is rotated by an angle of θi every cycle, so sifter n iterations, θn is the obtained angle. All the trigonometric functions can be computed or derived from functions using vector rotations. The CORDIC algorithm provides an iterative method of performing vector rotations by arbitrary angles using only shift and add operations. The algorithm is derived using the general rotation transform. The CORDIC algorithm performs a planar rotation. Graphically, planar rotation means transforming a vector (x,y) into a new vector (x',y'). Vector V, came into image after anticlockwise rotation by an angle ϕ. From Fig.1 & 2, it can be observed that

$$x' = x\cos\varphi - y\sin\varphi \qquad (1a)$$

$$y' = y\cos\varphi + x\sin\varphi \qquad (1b)$$

Which rotates a vector in a Cartesian plane by the angle φ. These can be arranged so that:

$$x' = \cos\varphi.[\, x - y\tan\varphi \,] \ (1c) \quad y' = \cos\varphi.[\, y + x\tan\varphi \,] \ (1d)$$

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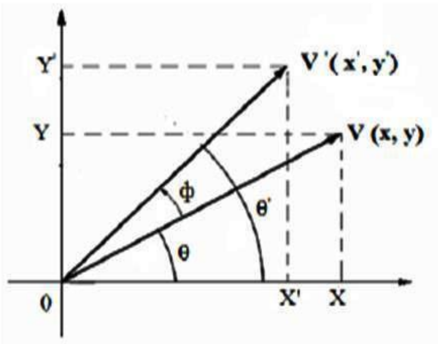

Fig.1 Rotation of vector V by an angle Ø

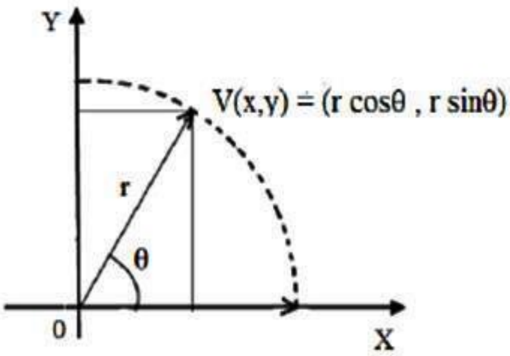

Fig.2 Vector v with magnitude r and phase θ

The computation of xi + 1 or yi + 1 requires an i bit right shift and add/subtract. If the function tan-1 (2-i) is pre computed and stored in table for different values of i, a single add/ subtract suffices to compute zi + 1. The tan-1 (2-i) values corresponding to 10 iterations are listed in Table 1. Each CORDIC iteration thus involves two shifts, a table lookup and three additions. If the rotation is done by the same set of angles (with + or – signs), then the expansion factor K, is a constant, and can be pre computed. For example to rotate by 30 degrees, the following sequence of angles be followed that add up to approximately 30 degree. 30.0 ≈ 45.0 –26.6 + 14.0 – 7.1 + 3.6 + 1.8 – 0.9 + 0.4
– 0.2 + 0.1 = 30.1

II. PROPOSED METHOD

The proposed CORDIC circuit is developed with optimization schemes for reducing the number of micro-rotations and for reducing the complexity of shifters for fixed angle vector rotation. A reference CORDIC circuit for fixed rotations is as shown in Fig.3. x_0 and y_0 are fed as set/reset input to the pair of input registers and the successive feedback values x_i and y_i at the ith iteration are fed in parallel to the input registers. Note that conventionally we feed the pair of input registers with the initial values x_0 and y_0 as well as the feedback values x_i and y_i through apair of multiplexers.

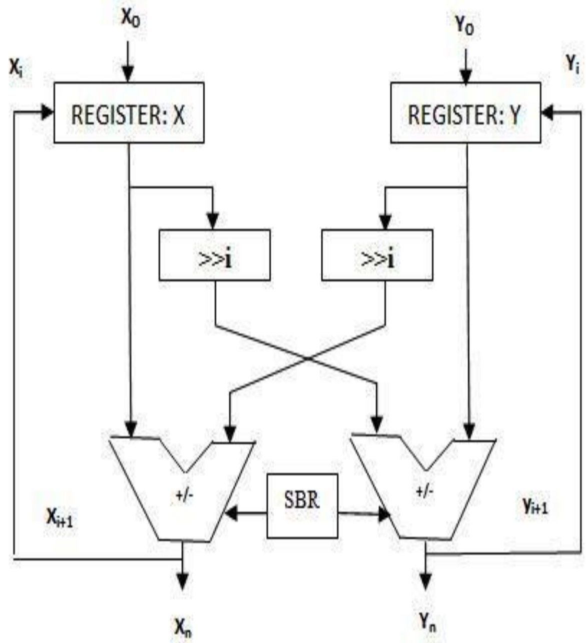

Fig.3 CORDIC circuit for fixed rotation

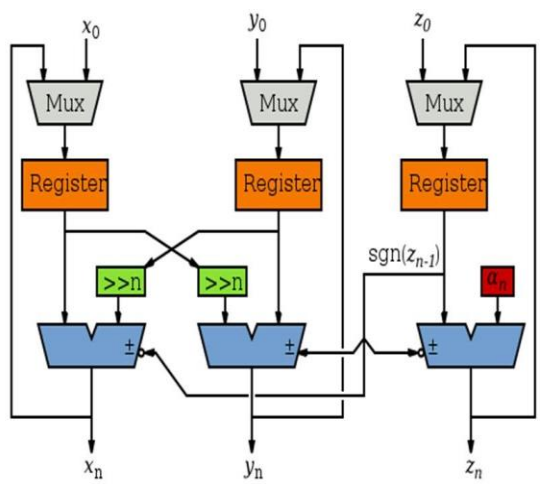

Fig.4 CORDIC hardware

A. *Superior Bi-rotational CORDIC:*

For reduction of adder complexity over the cascaded single-

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rotation CORDIC, the micro-rotations could be implemented by a cascaded bi-rotation CORDIC circuit. A two-stage cascaded superior bi-rotation CORDIC is shown in Fig.5. The first two of the micro-rotations out of the four-optimized micro rotations could be implemented by stage-1, while the rest two are performed by stage-2. The structure and function of the bi-rotation CORDIC is shown in Fig.5. For implementing six selected micro-rotations, we can use a three-stage-cascade of bi-rotation CORDIC cells. The three-stage superior bi-rotation cells could however be extended further when higher accuracy is required.

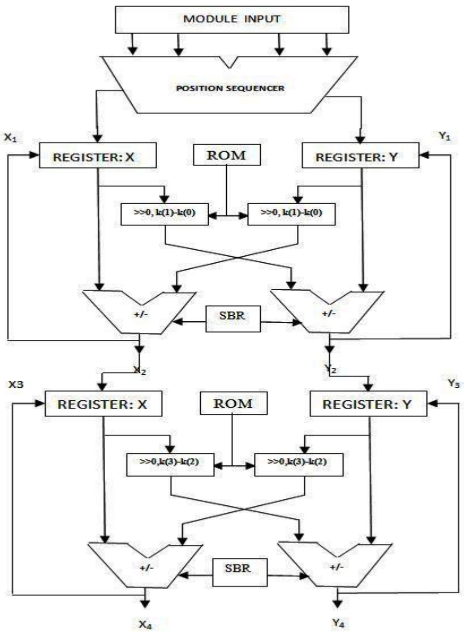

Fig.5 Two-stage superior Bi-rotational CORDIC cell

B. Rectangular To Polar CORDIC

This converter can be computationally used to implement the square-root function, the division Operation, and arctangent operation. Various algorithmic methods can be used to implement an RPC. These are classified by the manner in which their computations are performed. These classes are the polynomial approximation algorithms, rational approximation algorithms, linear convergence algorithms and quadratic convergence algorithms. The first method uses a degree – n polynomial to approximate a function over the interval of interest, where n depends upon the amount of error that can be allowed in the calculation. Polynomials of higher degrees generate less error, but they obtain this precision at the expense of long computation time. A rational approximation is the ratio of two polynomials of degree n and degree m respectively. This ratio is then used to approximate the function over the interval of interest. With the addition of the second polynomial, higher accuracy can be achieved with lower degree polynomials. This reduces the number of multiplications and additions required to obtain the answer, but it introduces a division operation, which is one of the most time consuming instructions in any computational hardware.

The rectangular to polar conversion has the following attributes:

- Xin and Yin are the input cartesian values
- Zinmust be zero
- mode = 0, to enforce vectoring mode
- Xut is the polar magnitude (scaled by processing gain)
- Zout is the polar phase

The rectangular to polar coordinate processor is built around the second CORDIC scheme which calculates:

$$[\, X\,j\,, Yj\,\overline{, Z\,j}\,] = [\, p1 + \propto \hat{}2\,,\, 0,\, \arctan(\propto)]$$

It takes two 16bit signed words as inputs (Xin, Yin), which are the rectangular coordinates of a point in a 2-dimensional space. The core returns the equivalent Polar coordinates where Rout is the radius and Aout the angle or θ.

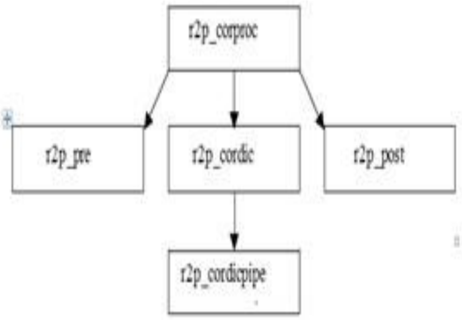

Fig.6 Structure

Port	Width	Direction	Description
CLK	1	Input	System Clock
ENA	1	Input	Clock enable signal
Xin	16	Input	X-coordinate input. Signed value
Yin	16	Input	Y-coordinate input. Signed value
Rout	20	Output	Radius output. Unsigned value.
Aout	20	Output	Angle(θ) output. Singed/Unsigned value.

Table:IO Ports

The outputs are in a fractional format. The upper 16bits represent the decimal value and the lower 4bits represent the fractional value. The angle output can be used signed and unsigned, because it represents a circle; a -180 degree angle equals a +180 degrees angle, and a –45 degrees angle equals a +315 degrees angle.

III. SIMULATION RESULTS

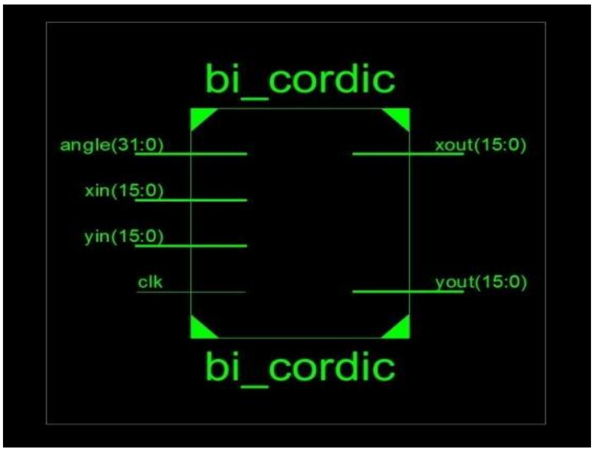

Fig.7 Block Diagram

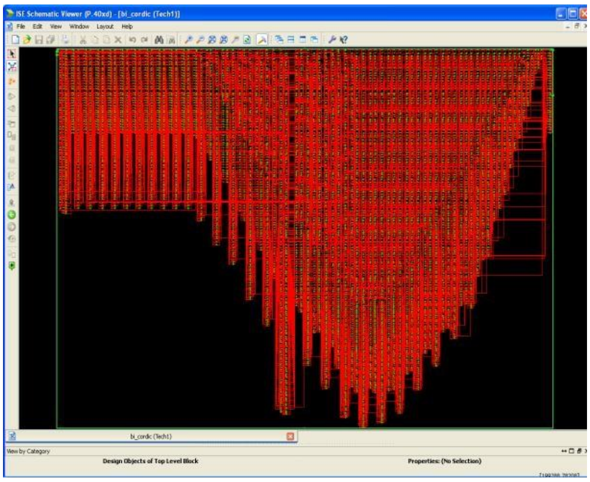

Fig.8 Technology Schematic (Full View)

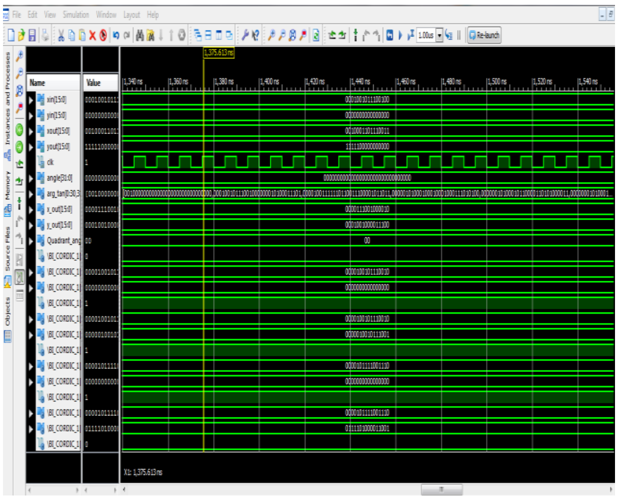

Fig.9 Simulation Results of CORDIC Algorithm

IV.CONCLUSION

The Superior Bi-rotational CORDIC is attractive for the calculation of fixed angle elementary functions because of its accuracy and parallel processing. The proposed CORDIC architecture requires more area over the reference design, but offer high throughput. The area-delay-accuracy trade-off for different advanced algorithms may be investigated in detail and compared with in future work.

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