IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 5, May 2016

Comparison Of Architectures For The Numerically Controlled Oscillator

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Abstract: Numerically Controlled Oscillators are used in almost all stages of transmitters and receivers regardless of different wireless generations. This paper weighs pros and cons the two well known NCO architectures – the Look Up Table Approach and the CORDIC algorithm.

Keywords: NCO, CORDIC algorithm, Look Up Table.

I. INTRODUCTION

Enhancements in the fields of communication have been noticed since its inception. Few of the reasons for the same are need for good design, area and power efficiency [1], [2], [3], [4]. One of the important blocks in any communication device is a Numerically Controlled Oscillator (NCO).

A numerically controlled oscillator (NCO) is a computerized signal generator that generates a synchronous (i.e. timed), discrete-time, discrete esteemed representation of a waveform, ordinarily sinusoidal. NCOs are regularly utilized as a part of conjunction with an advanced to simple converter (DAC) at the yield side to make a direct computerized synthesizer (DDS). NCOs offer a few focal points over different sorts of oscillators regarding deftness, exactness, security and unwavering quality.

Numerically Controlled Oscillator are utilized as a part of correspondences frameworks including computerized up/down converters utilized as a part of 3G remote and programming radio frameworks, advanced PLLs, radar frameworks, drivers for optical or acoustic transmissions and multilevel FSK/PSK modulators or demodulators.

A NCO is an electronic framework for incorporating a scope of frequencies from an altered time base. Dissimilar to a stage bolted circle based simple recurrence synthesizer, NCO is fit for combining an extensive variety of exact recurrence proportions. NCOs are additionally called Direct Advanced Synthesizers (DDS), is an intense method utilized as a part of the era of radio recurrence signals for use in an assortment of utilizations from radio collectors to signs generators and some more.

An ordinary numerically controlled oscillator utilizes time space sufficiency tests to create a sinusoidal waveform whose recurrence is controlled by a computerized control word in the time of a solitary clock cycle. A NCO's yield recurrence will change right away without the procurement and lock time delays connected with traditional stage bolted circle (PLL) synthesizers. The NCO's yield recurrence is overseen by an info check/whole number quality. The engineering inside a NCO center fundamentally comprises of stage gatherer and a stage to-plentifulness converter (PAC). Two or more lookup tables, which store sine and cosine waveform samples, are utilized by a large portion of the PACs and stage to-sufficiency transformation is finished by some related rationale [5].

II. NCO DESIGN

In the easiest case, Utilizing ROM with tests of a sine wave put away in it (sine turn upward, LUT), a Numerically Controlled Oscillator is developed. Fig.1 demonstrates the square graph of a NCO framework. The sinusoidal signs at a given recurrence setting word (FSW) delivered by the NCO decides the stage step. When set, the sine wave recurrence to be delivered is controlled by this computerized word. The stage collector yield then ceaselessly delivers appropriate parallel words showing the momentary stage to the table gaze upward capacity.

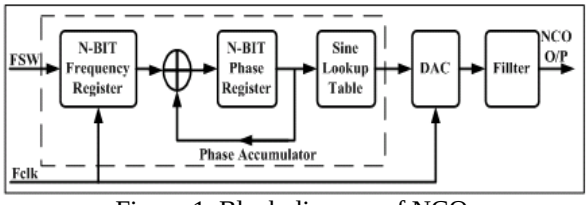

Figure 1. Block diagram of NCO

As such, the progressive location of the sine gaze upward table, which produces a computerized sine wave yield, is figured utilizing stage aggregator. Thusly, the examples are cleared in a controlled way i.e. with a stage contingent upon the Recurrence Setting Word. The interpretation of the subsequent stage to a sinusoidal waveform by means of the gaze upward table, and change of the computerized representation of the sine-wave to Simple structure utilizing an Advanced to-Simple converter took after by a

IJARCCE
ISSN (Online) 2278-1021
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low pass channel (LPF) is finished by NCO. The computerized part of the NCO comprises of the stage aggregator and the LUT. The recurrence of the yield signal for sign N-bit framework is controlled by taking after comparison [6].

III. EXISTING ARCHITECTURE OF NCO: LOOK UP TABLE

Sine and cosine are the fundamental capacities which can be gotten from any mind boggling capacities utilized as a part of an expansive scope of utilizations, for example, computerized signal handling, remote correspondence, biometrics, apply autonomy, and so on. 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 processed for each conceivable info contentions. This technique is moderately easy to be utilized subsequent to no particular estimations are required, depending just on the qualities put away on the table. Nonetheless, the quantity of table sections required will rise exponentially as the quantity of bits,which are utilized to speak to the yield contention, rise. This will bring about bigger zone required for equipment usage.

MacLaurin arrangement is utilized to speak to a capacity as unending whole of its subordinates got from Taylor arrangement that is assessed at zero. Practically speaking, the quantity of terms in the arrangement are resolved in view of the required exactness. For application that requires most extreme blunder to be 28 = 3.90625×103, the quantity of terms required is N = 9 which relates to greatest mistake of 1.1309 × 103. Thus, nine exponentiations, eight increases, and nine factorial operations should be done to deliver the capacity. For equipment usage, the qualities factorial operations can be put away on a lookup table following these are settled paying little respect to the information contention of the capacity. Notwithstanding, this will likewise devour bigger territory as the quantity of bits increments. Figure 2 shows the output of the LUT approach.

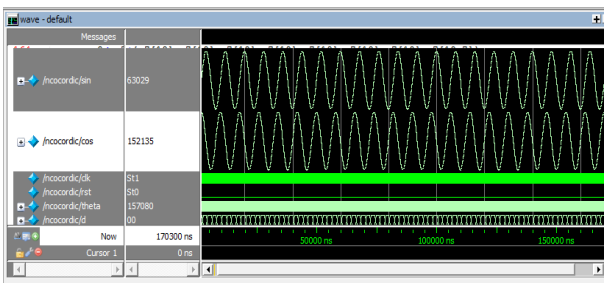

Figure 2: Sine wave obtained using LUT approach

Though LUT is efficient in terms of speed, it fails in an ASIC perspective since it requires huge memory to store corresponding sine and cosine values for a given set of frequencies. Also, if one desires to change the frequency of the wave to be generated, the sine and cosine samples stored have to be replaced. In order to eliminate this negative point, CORDIC approach can be implemented.

IV. CORDIC ALGORITHM

COordinate Revolution Computerized PC (CORDIC), concocted by J. E. Volder in 1959 [7],[8], is a calculation that can be utilized to perform trigonometric-related counts. By transforming a few parameters, CORDIC can likewise be utilized as a part of wide assortment of basic supernatural capacity including exponentials, logarithms, and square roots. CORDIC is basic and productive since this calculation requires just expansion, subtraction, bit moving, and table lookup.This prompts a proficient and minimal effort usage with by and large speedier pace than most equipment methodologies. A few models exist so as to keep the necessities and requirements of various applications. Iterative design furnishes equipment execution with least size with throughput as the tradeoff, while parallel and pipelined CORDIC offers fast and high-throughput calculation [9].

CORDIC computes the estimation of trigonometric capacities like sine, cosine, size and stage to any coveted exactness. It can likewise figure hyperbolic capacities, (for example, sinh, cosh and tanh). The CORDIC calculation does not utilize math based strategies, for example, polynomial or sane capacity estimation. It is utilized as estimate capacity values on all prominent realistic mini-computers, including HP-48G as the equipment limitation of adding machines require that the basic capacities ought to be processed utilizing just options, subtractions, digit movements, correlations and put away constants. CORDIC calculation spins around possibly "pivoting" the period of a mind boggling number, by increasing it by a progression of consistent qualities. Be that as it may, the "multipliers" would all be able to be forces of 2, so in parallel number juggling they should be possible utilizing just moves and includes. There is no real "multiplier" required, in this manner it is less difficult and does not require a mind boggling equipment structure as on account of multiplier. Prior strategies utilized for assessment of trigonometric capacities are table gaze upward technique, polynomial estimation strategy and so on.

CORDIC is valuable in planning registering gadgets. As it was initially intended for equipment applications, there are elements that settle on CORDIC a fantastic decision for little registering gadgets. Since it is an iterative strategy it has the point of preference over alternate strategies for having the capacity to show signs of improvement exactness by accomplishing more cycle, while the Taylor estimation and the Polynomial insertion techniques should be arrived at the midpoint of to show signs of improvement results [10].

Volder's calculation is got from the general mathematical statements for a vector revolution. On the off chance that a vector V with directions (x, y) is turned through an edge Ø then another vector V' with new facilitates (x', y') is shaped where x' and y' can be acquired utilizing x, y and Ø from the accompanying technique. For the simplicity of

IJARCCE

ISSN (Online) 2278-1021
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International Journal of Advanced Research in Computer and Communication Engineering
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computation here just revolution in anticlockwise bearing is watched first. So the individual comparisons for x' and y' can be modified as mentioned below.

$$x' = x\cos\emptyset - y\sin\emptyset \quad (1)$$
$$y' = x\sin\emptyset - y\cos\emptyset \quad (2)$$

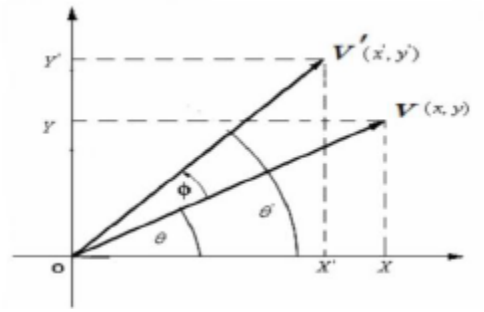

Figure 3: Rotation of vector V by an angle ϕ

Volder watched that by figuring out a {cos Ø} from both sides, coming about mathematical statement will be regarding the digression of the point Ø. Next in the event that it is expected that the edge φ is being a total of little points, and composite edges is picked such that their digressions are all converse forces of two, then this comparison can be revamped as an iterative recipe.

$$x' = \cos\emptyset\,(x - y\tan\emptyset) \quad (3)$$
$$y' = \cos\emptyset(x\tan\emptyset + y) \quad (4)$$
$$z' = z + \emptyset \quad (5)$$

When derived further, the final equations of CORDIC are obtained as follows.

$$x' = x - y*d*2^{-i} \quad (6)$$
$$y' = y + x*d*2^{-i} \quad (7)$$
$$z' = z - d*\tan^{-1}(2^{-i}) \quad (8)$$

The NCO is designed using these equations and the output of the same has been shown in Figure 4.

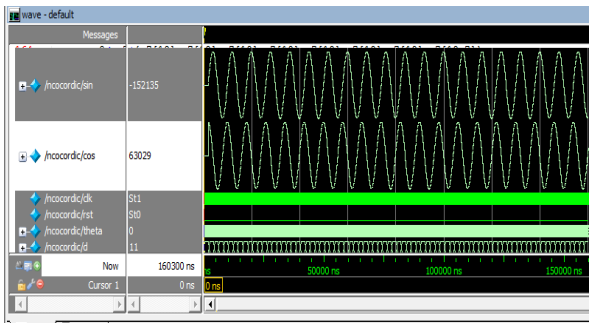

Figure 4: Sine wave obtained using CORDIC approach

V. RESULTS

Both the architectures are implemented on Spartan 6 FPGA. It was noticed that LUT consumes 58% of area, while CORDIC required 41%. The speeds of both were obtained as 268MHz and 155MHz respectively.

VI. CONCLUSION

Even though speed of LUT based NCO is much better, the problem with LUT is that when the frequencies change, the sine and the cosine values stored have to be changed manually. Thus, in order to avoid this, CORDIC approach can be utilized which can work for all frequencies.

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DOI 10.17148/IJARCCE.2016.55152