# Sine wave generation on FPGA and its FM

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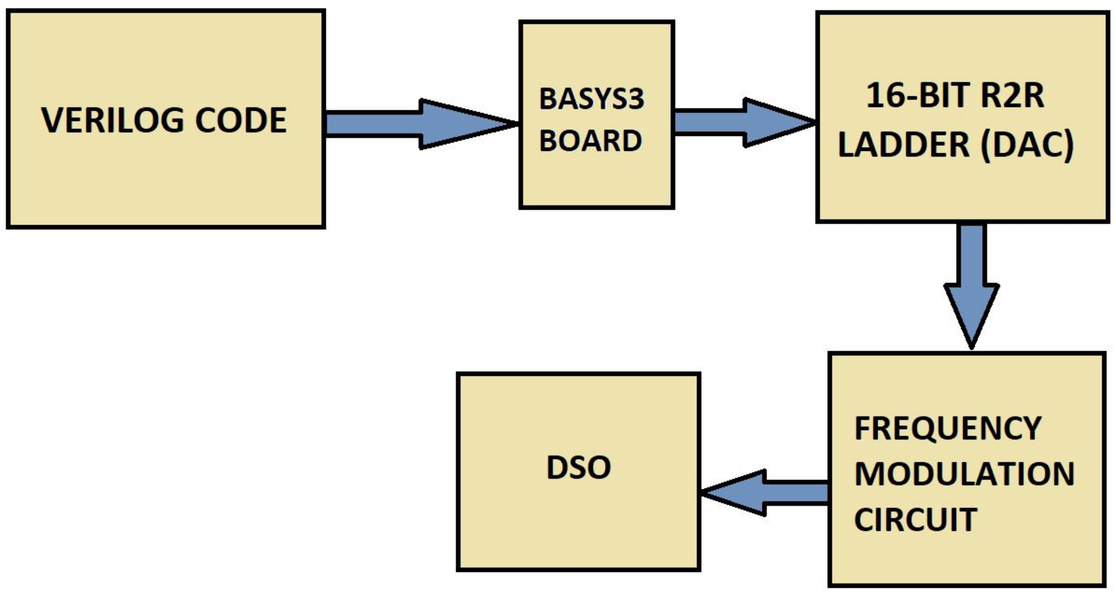
## ABSTRACT

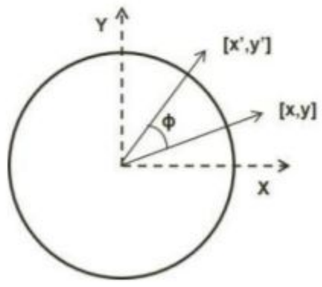
This project describes frequency modulation of a signal by hardware implementation of a sine wave generator using CORDIC algorithm. CORDIC is an algorithm that enables us to calculate the values of trigonometric functions such as sine and cosine using simple add, subtract and bit shift operations. The sine values of angles were continuously computed using CORDIC algorithm, incrementing the angles by 1 degree every clock cycle in the Verilog code written in Vivado's Xilinx. The stream of bits were fed into a Digital to Analog converter circuit and observed in DSO. This sine wave produced was fed into a VCO chip (ICL8038) as a frequency sweep. This chip then modulates this input sine wave using a carrier wave generated by itself. The Frequency Modulated output was observed in the DSO.

## OVERVIEW OF THE PROJECT




## CORDIC ALGORITHM

Consider with initial vector position (x, y) as shown in the figure. When this vector is rotated by an angle Φ, The new vector position is then given by x'= cos(Φ) [x – y tan(Φ)] and y'= cos(Φ) [y + x tan(Φ)]. Here, assume tan(Φ)=(2^i). This assumption results in the equations to be useful only for the discrete set of angles.Then the iterative equations are as follows:




$$X_{i+1} = K_i[X_i - Y_i * d_i * 2^{-i}] \qquad Y_{i+1} = K_i[Y_i + X_i * d_i * 2^{-i}]$$

$$Z_{i+1} = Z_i - tan^{-1}(2^{-i})$$

where, di = – 1, if Zi <0
1, if Zi >0

After completion of the desired number of iterations, the result obtained is given by $X_n = K[X_0cos(z_0) - Y_0sin(Z_0)]$ $Y_n = K[X_0sin(z_0) - Y_0cos(Z_0)]$ $Z_n = 0$
Here, K = 0.607. On starting the algorithm with the initial parameters X0 = 0.607(1/K) and Y0 = 0, the cosine and sine of the initial angles are made available in Xn and Yn variables after completion of n iterations.
Hence the sine of an angle is found by continuously rotating a vector by angles tan(Φ)=(2^i) in the clockwise and anticlockwise direction alternately unless he angle becomes 0. The ordinate at this point would give the value of sine of that angle. This algorithm can only be used for angles between -90 to 90 degrees.

*References:* www.allaboutcircuits.com, http://www.ee.iitm.ac.in/vlsi/_media/iep2010/cordic.pdf, www.researchgate.net, reference.digilentinc.com, www.ti.com, www.intersil.com

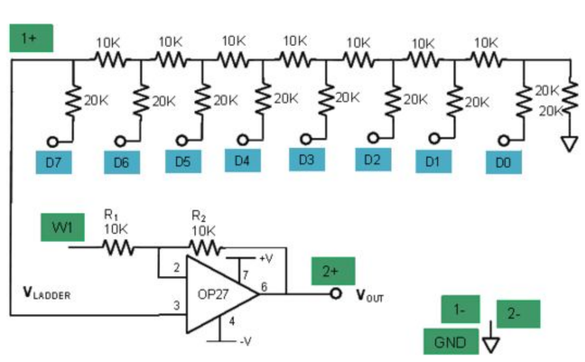
## SINE WAVE GENERATION

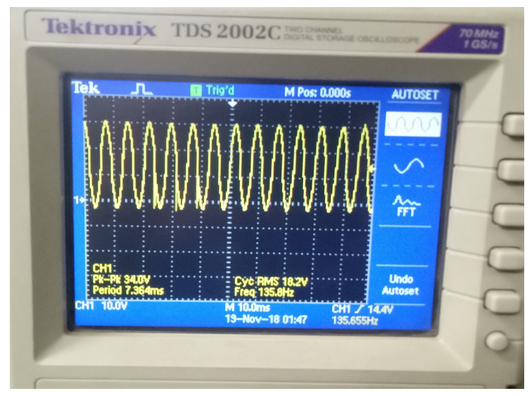
The angle is initialised to 0 degree & incremented by 1 degree every clock cycle. The simulation obtained in Vivado in Analog format is as shown:


The verilog code is then burned onto the Basy3 board and the outputs can be observed in the LED's. The output is taken out from the board through the Pmod headers.

## DIGITAL TO ANALOG CONVERTER

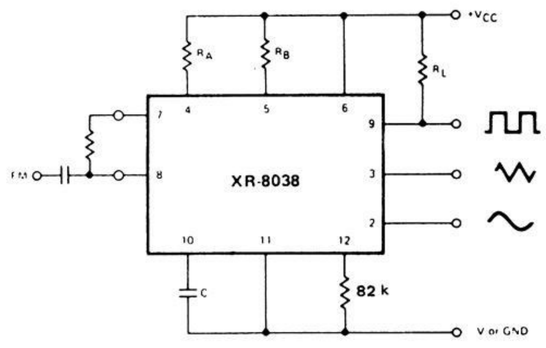
Output from the FPGA is passed through a 16 bit Digital to Analog Converter made using R/2R ladder concept

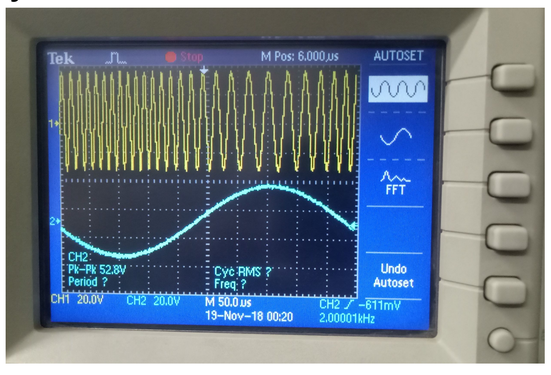



## FREQUENCY MODULATION

The analog output is fed into the VCO chip (ICL-8038) which treats it as a message signal and outputs the frequency modulated wave.




## CONCLUSION

In this project, analog sine wave has been generated from digital inputs by using a DAC circuit and is implemented on the Hardware. This is a very fast method to obtain sine values which further has numerous applications in different fields. One such application in the field of communication systems has been illustrated. The circuit constructed is as shown below: