VLSI Lab - Digital

Group - 20
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Contents

1 Project - Cartesian to Polar Conversion

1.1 Objectives

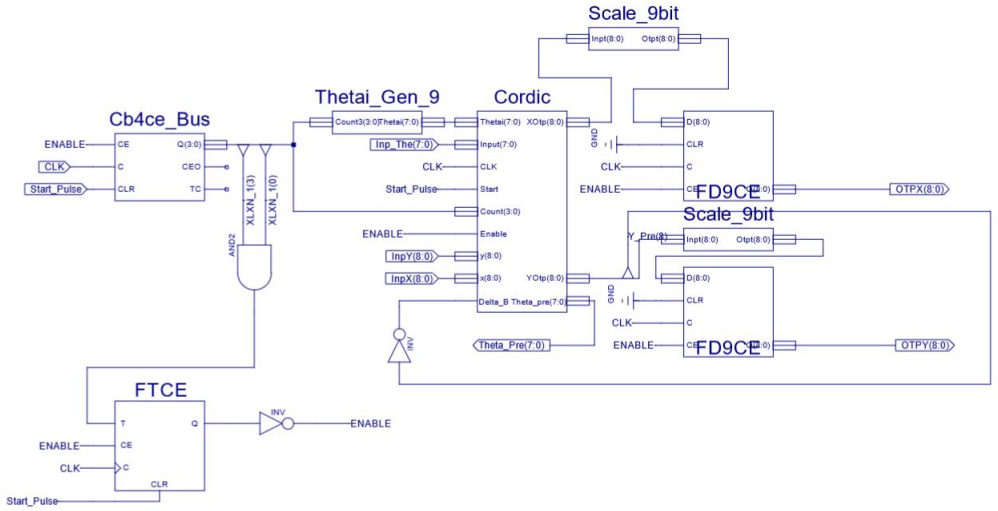
1.1.1 Inputs

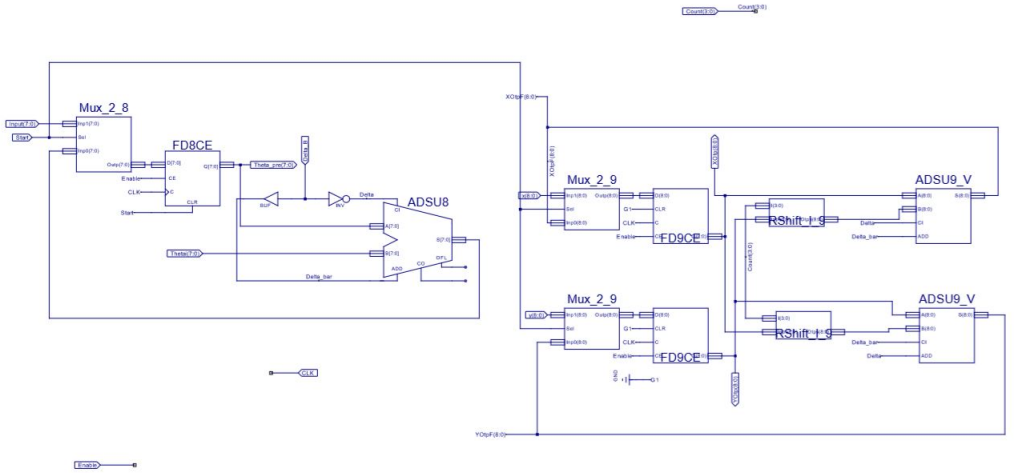
X and Y, Cartesian co-ordinate, 9 - bit in First or Second quadrant.

1.1.2 Inputs

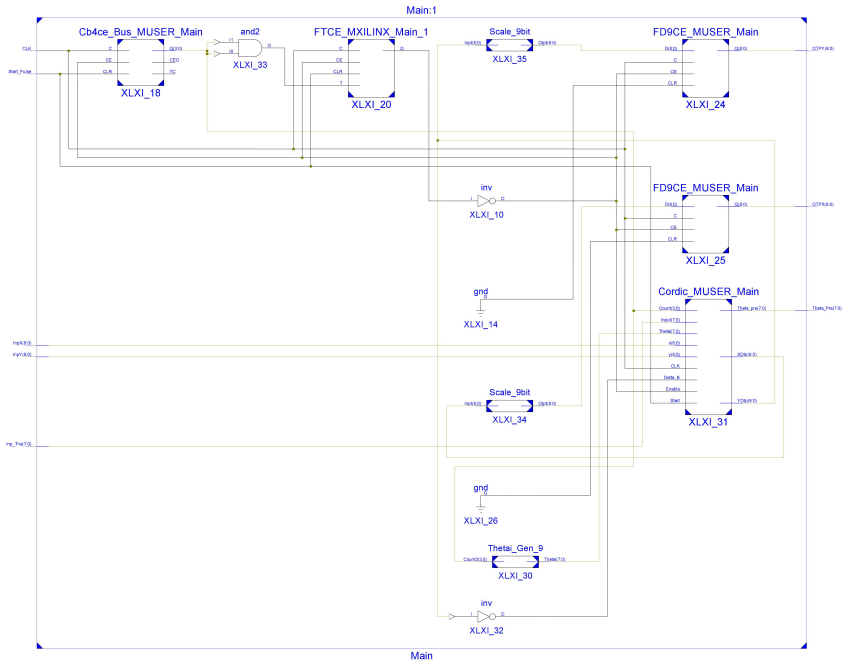
1)Theta = $tan^{-1}\frac{Y}{X}$ = ¿ 8 bit
2)Radius = $\sqrt{(X^2 + Y^2)}$

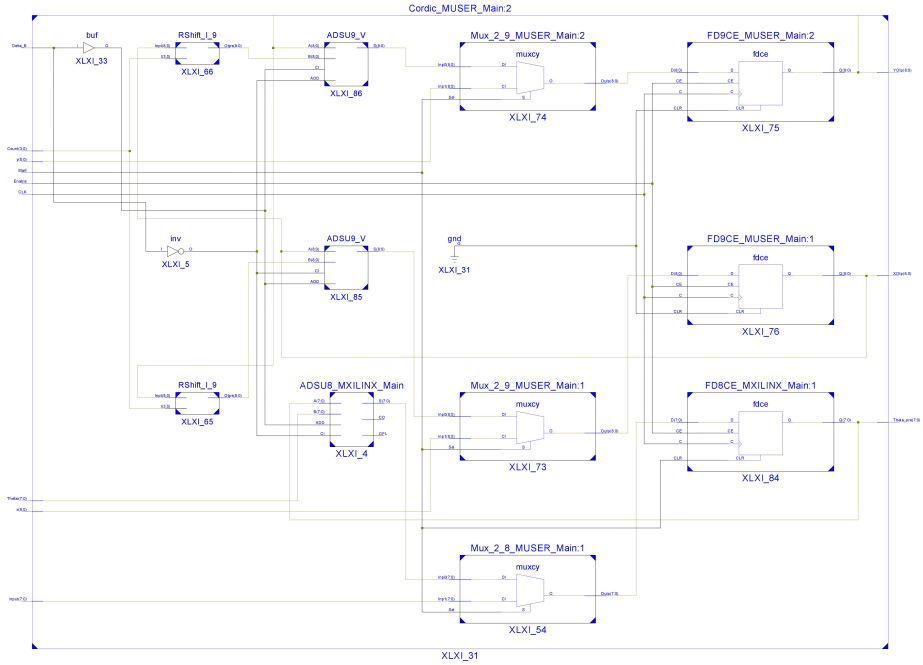
1.2 Block Diagram





1.3 RTL Schematic





1.4 Timing Summary

1) Minimum period: 14.397ns (Maximum Frequency: 69.460MHz)
2) Minimum input arrival time before clock: 3.854ns
3) Maximum output required time after clock: 4.063ns
4) Maximum combinational path delay: No path found

1.5 Post-Route Simulation

1.6 Results

Sr. No.	Co-ordinate		Expected Output		Observation	
	X	Y	R	Theta	R	Theta
1	-50	50	70.71	-45	70	-45.7(65)
2	70	30	76.15	23.2	75	24.6(35)
3	40	60	72.11	56.3	71	56.9(81)
4	60	40	72.11	33.7	70	33.05(47)
5	50	50	70.71	45	70	-44.3(63)

2 Project - Scan Conversion

2.1 Objectives

2.1.1 Inputs

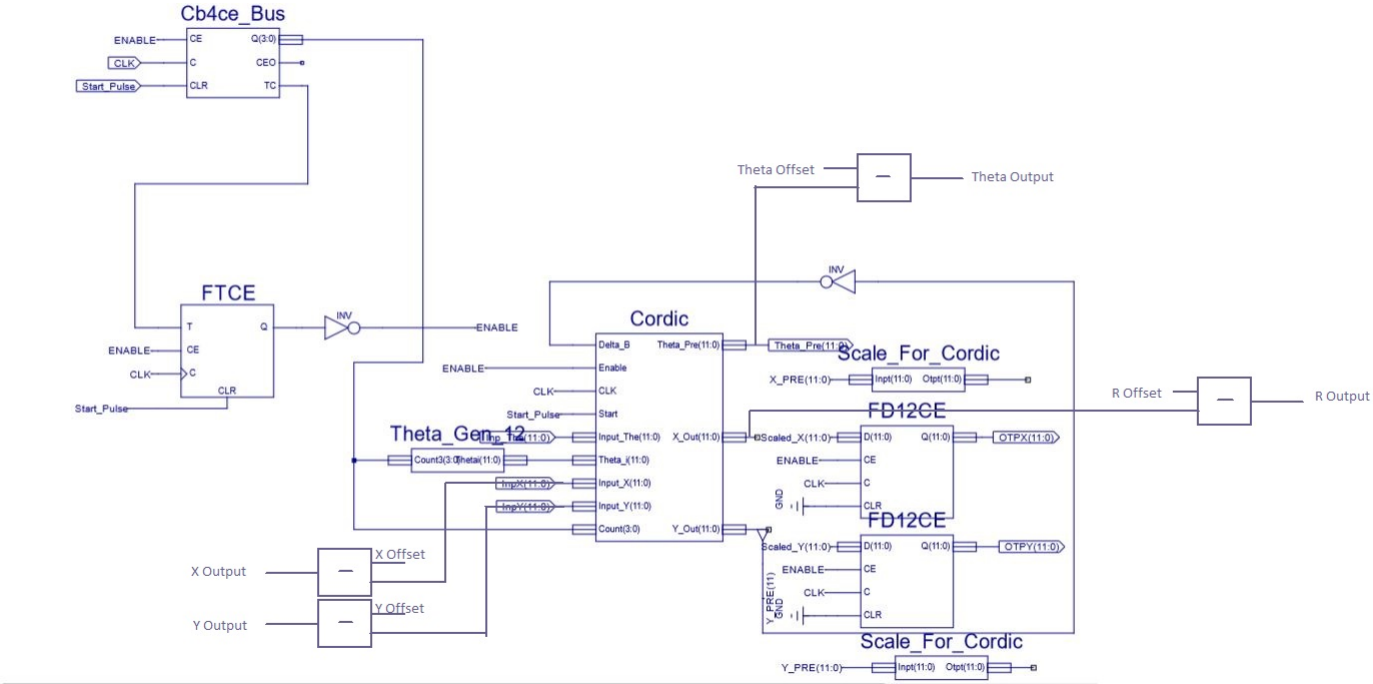
Image Size = 480*640
Scan angle = 58
1) X and Y which are the pixel coordinate in Cartesian image which is obtained from converting polar ultrasound image.
2) Offsets in X, Y , R and Theta which are pre-calculated.

2.1.2 Inputs

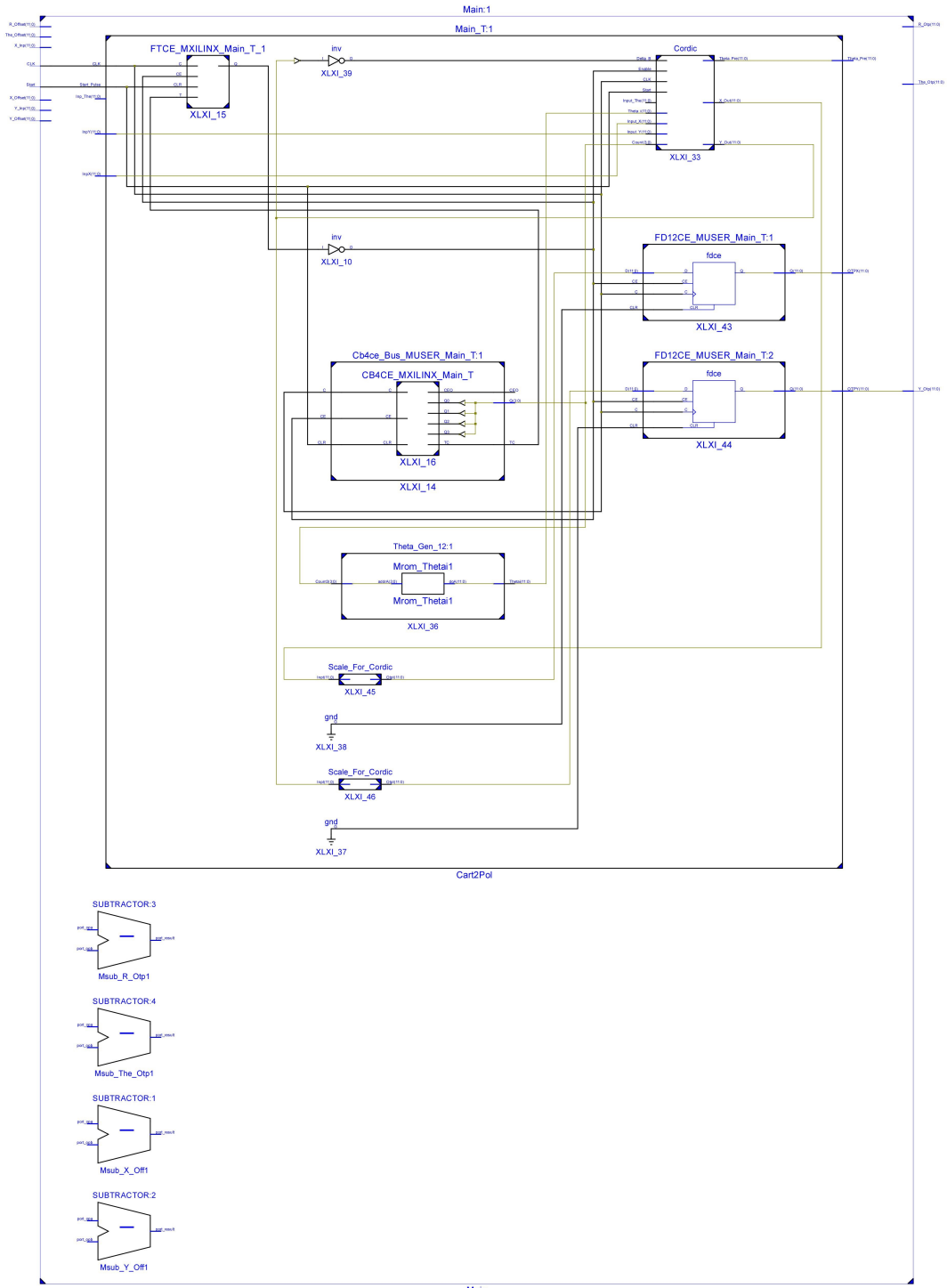
1)Theta = $tan^{-1}\frac{Y-YOffset}{X-XOffset} - ThetaOffset$ => 12 bit

2)Radius = $\sqrt{((X-XOffset)^2 + (Y-YOffset^2))} - ROffset$ => 12 Bit

2.2 Block Diagram



2.3 RTL Schematic



2.4 Timing Summary

1) Minimum period: 14.551ns (Maximum Frequency: 68.723MHz)
2) Minimum input arrival time before clock: 5.151ns
3) Maximum output required time after clock: 6.802ns
4) Maximum combinational path delay: 7.288ns

2.5 Post-Route Simulation

2.6 Results

X Offset = -109
Y Offset = 320
R Offset = 127
Theta Offset = -29

Sr. No.	Co-ordinate		Expected Output		Observation	
	X	Y	R	Theta	R	Theta
1	0	0	211.05	-42.19	209	-42.36(-964)
2	0	320	-18	29	-20	27.84(658)
3	0	340	-16.17	39.4	-17	39.7(904)
4	480	0	543	0.49	543	0.439(10)
5	480	620	543	57.51	543	57.65(1312)

3 Discussion

1) For making Cartesian to polar conversion, CORDIC is exploited by using sign of present Y coordinate of the current vector as the delta for next rotation. Hence if Y is positive the vector is rotated clock-wise and vice-versa. Hence after number of rotations the vector is rotated to align at positive X-axis.

2) At this moment the theta value at CORDIC output is the angle subtended by original vector on X-axis and value of X coordinate of the final vector is the length of the vector i.e. r.

3) This Cartesian to polar converter is modified to make the scan converter from Cartesian form of ultrasound image to polar form of the same. The offsets of the same are pre-calculated and fed as input in the module.

4) While deciding the optimum number of bits for the architecture, the maximum value of x = 480 + 109 = 589 and that of y = 320 . Now after rotation of the vector it is scaled by 1/0.609. So, maximum value of R can be $/sqrtX^2 + Y^2 = 680$. Hence maximum value of X can be, 680/0.609 = 1101. Again considering the negative side the minimum bit is 12.