ABSTRACT
2/5/2023

System Requirements
Define System Parameters/Goals
- Target Range
- Scanning Angle
- Power Requirements
- Frequency
- Bandwidth

System Model
Create System Model
- Components
- Parameters
- Modulation
- System Simulation

Parts List
- PCB/Substrate
- IC-chips
- Data Acquisition

Design
Component Design/Verification
- Design individual components
- Simulate components
- Verify parameter goals for each component
- Design Link

Fabricate

Data acquisition
- Signal Processing
- Create GUI

System Requirements

Target range – The system should be able to scan up 20 meters and down to 1 meter
Scanning Angle – The system should have a scanning angle of 45 degrees and a beamwidth of 5 degrees
VSWR – The system should not have a VSWR greater than 1.4
Power – The system should transmit at least 1W

Introduction
This project will be a continuous wave frequency modulated (FMCW) electronically scanning radar. This will be achieved using a superheterodyne transceiver architecture. On the transmit side of the system the components implemented will be a phased array antenna, a voltage-controlled oscillator, a 90 degree hybrid coupler, an transmit amplification stage and lowpass harmonic filters. On the receive side of the transceiver, the same phased array antenna will be used, a bandpass filter, an LNA, a mixer, an IF-gain stage an ADC and FPGA. The system will transmit 2.95GHz to 3.05GHz which is a 100MHz Bandwidth. A system level simulation will be performed in Keysight System Vue which will show a top level operation of the system. The system will be built on multi layer Rogers ro-3003 PCB board with an FR4 inner layer pre-impregnated. The board will consist of microstrip technology with microstrip stub matching and lumped elements for matching and DC-blocking. The system will have no components with an return loss greater than 15dB to limit standing waves (VSWR). The system will use the zybo-z7 FPGA for data sampling and signal processing. Research to conduct the implementation of the project will involve reading from Microwave Engineering by David Pozar and research from online scholarly articles using IEEE or other methods as sources

Methods

Components
90 degree hybrid coupler: this component will have its parameters calculated, will be simulated in Advanced Design System, and verified using momentum EM-simulator

Transmit Amplification
A driver amplifier, ad a power amplifier will be evaluated to provide a target output power of at least 30dBm (1W). I-V curves will be simulated for an optimal bias point which will result in a Q-point and load line calculation. Once that is found a proper matching network will be designed to provide the optimum load impedance for power delivery. An output matching network will also be designed to match the antenna to the power amplifier for optimum power delivery. The Amplification stage will be designed in Advanced Design System and verified in simulation.

Low-Pass Harmonic Filter
A microstrip lowpass filter will be designed to reject 2^{nd} and third harmonics due to possible non linearities the power amplifier will introduce. The filter will have no greater than -1dB insertion loss in the passband and will have minimum 30dB of harmonic rejection.

Phased Array Antenna
The phased array antenna will be designed using ANYSS HFSS and will have a 45 degree scanning angle and a 5 degree beamwidth. This will be done designing enough antennas in an array to tighten the transmit beam. Electronic steering will be done by using phase shifters either in parallel or series which will be modulated from the FPGA. The array will be of microstrip patch configuration.

Bandpass Filter
The Bandpass filter will be a parallel coupled line filter used to reduce Noise equivalent bandwidth. The filter will be designed using Advanced Design System and will not have an insertion loss greater than 1dB in the passband. the layout will be realized in Momentum EM-solver

LNA
The LNA will be simulated in Advanced Design System and should have a Noise Figure no greater than 2dB and a gain of 18dB. The input and output will be microstrip matched and the layout will be realized in Momentum EM-solver

Mixer
The mixer will be chosen to have a low baseband IF. The RF port and LO port will be matched using microstrip and lumped element matching. The matching will be done using advanced Design System and verified in simulation.

IF Amplification
Design IF amplifier, design enough gain to drive ADC and define ADC output protocol

System Simulation
All parts designed and simulated will be combined to do a system simulation

Signal Processing
Use Zybo z7 FPGA board and create VHDL code to process incoming signals. Create a user interface to realize data to distinguish target distance. This will be done using Vivado IDE suite

Parts

	Mouser #	**Mfr. #**	**Manufacturer**	**Description**	**RoHS**	**Order Qty.**	**Price (USD)**	**Ext.: (USD)**
1	772-CMD231C3	CMD231C3	Qorvo	RF Amplifier 2 - 6 GHz Driver Amplifier	RoHS Compliant	1	$49.31	$49.31
2	873-SKY13320-374LF	SKY13320-374LF	Skyworks	RF Switch ICs .1-6.0GHz SPDT GaAs IL .5dB @ 2.4GHz	RoHS Compliant	20	$2.09	$41.80
3	584-AD8138ARZ-R7	AD8138ARZ-R7	Analog Devices Inc.	Differential Amplifiers SOIC Lo-	RoHS Compliant	1	$12.24	$12.24

				Distort'n Diff I/O 500MHz Pb-Fr				
4	584-C2315ITS8-12TMPF	LTC2315ITS8-12#TRMPBF	Analog Devices Inc.	Analog to Digital Converters - ADC 12-B, 5Msps Serial Smpl ADC in TSOT	RoHS Compliant	1	$15.71	$15.71
5	139-TC16-161T	TC16-161T+	Mini-Circuits	Audio Transformers / Signal Transformers TC XFMR / SURF MOUNT / RoHS	RoHS Compliant	1	$3.86	$3.86
6	139-TC8-1	TC8-1+	Mini-Circuits	Audio Transformers / Signal Transformers TC XFMR / SURF MOUNT / RoHS	RoHS Compliant	1	$3.11	$3.11
7	841-AFT27S010NT1	AFT27S010NT1	NXP	RF MOSFET Transistors Airfast RF Pwr LDMOS Trx, .7-3.6GHz 1.26		1	$15.60	$15.60
8	549-CV55BE2865-3100	CVCO55BE-2865-3100	Crystek	VCO Oscillators 2865-3100MHz	RoHS Compliant	1	$34.85	$34.85
9	584-LT5527EUF#PBF	LT5527EUF#PBF	Analog Devices Inc.	RF Mixer 400MHz to 3.7GHz Hi	RoHS Compliant	1	$16.18	$16.18

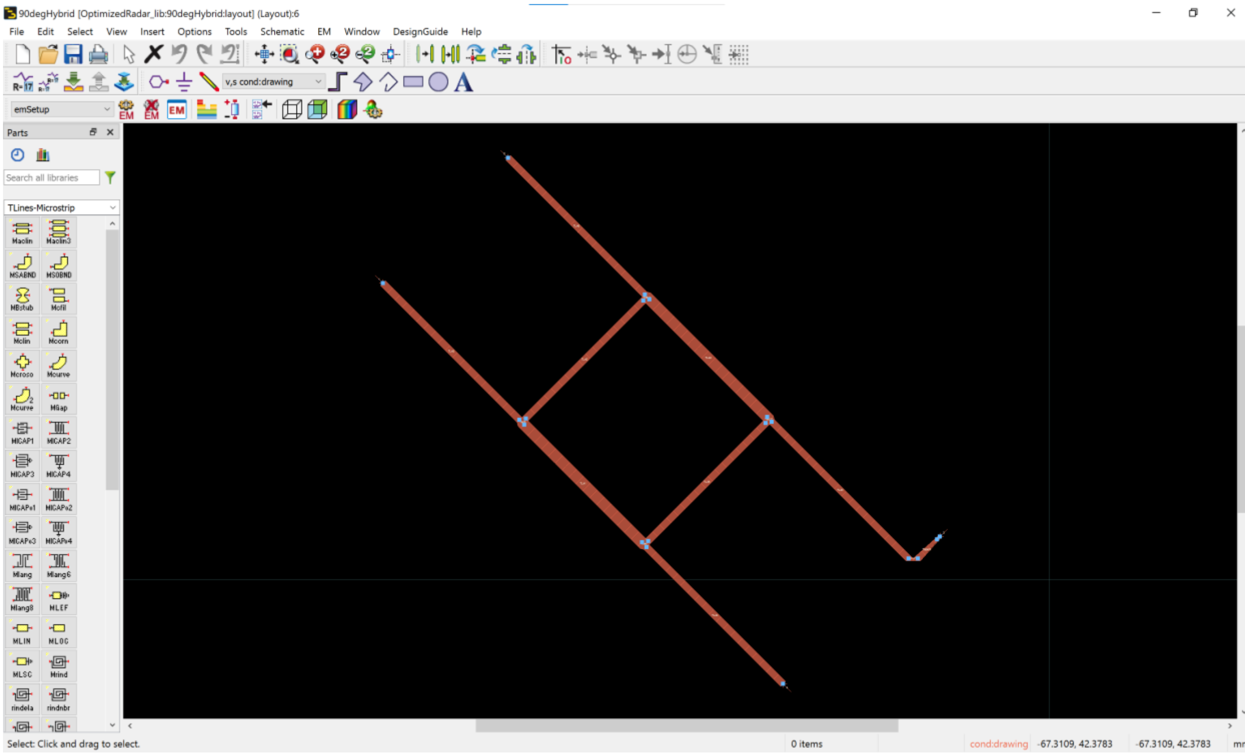
				Signal Level Downcon				
10	139-PMA3-83LN	PMA3-83LN+	Mini-Circuits	RF Amplifier LOW NOISE AMPL / SM / RoHS	RoHS Compliant	1	$14.67	$14.67

Results

The results from simulation will be recorded and tabulated in an IEEE formatted paper. Measurements will be taken on the fabricated board and will also be recorded and tabulated. Final results will be recorded of any signal processing and targets that are able to be resolved

Progress

90 Degree Hybrid S-Parameters


90degHybrid [OptimizedRadar_lib:90degHybrid:layout] (Layout):6
File Edit Select View Insert Options Tools Schematic EM Window DesignGuide Help
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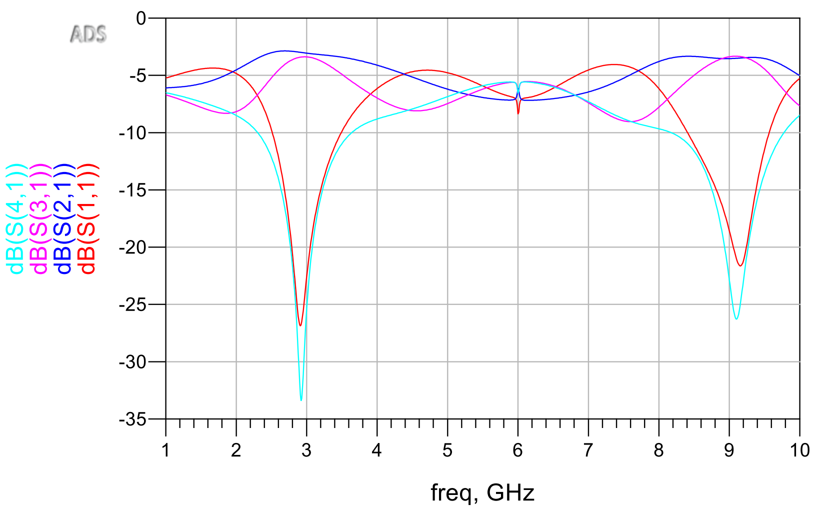
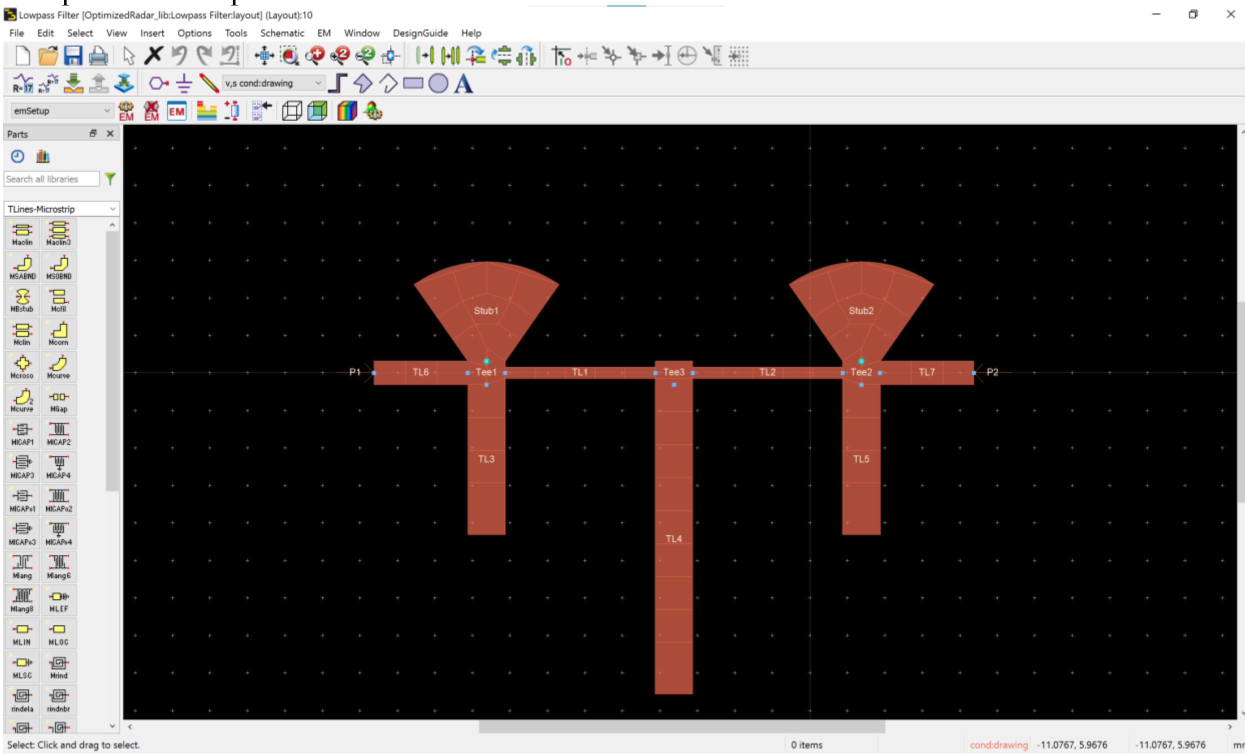
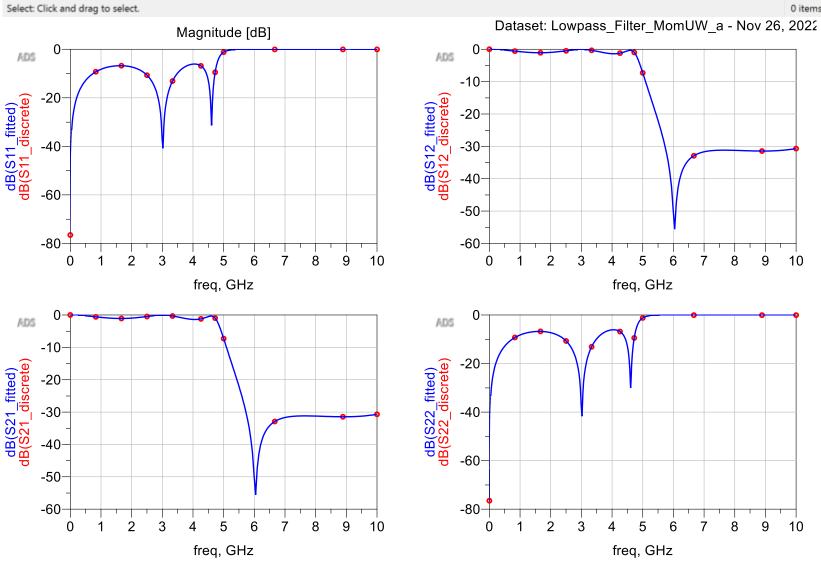
Parts
TLines-Microstrip
Select: Click and drag to select.
0 items
cond:drawing
-67.3109, 42.3783
-67.3109, 42.3783
mm

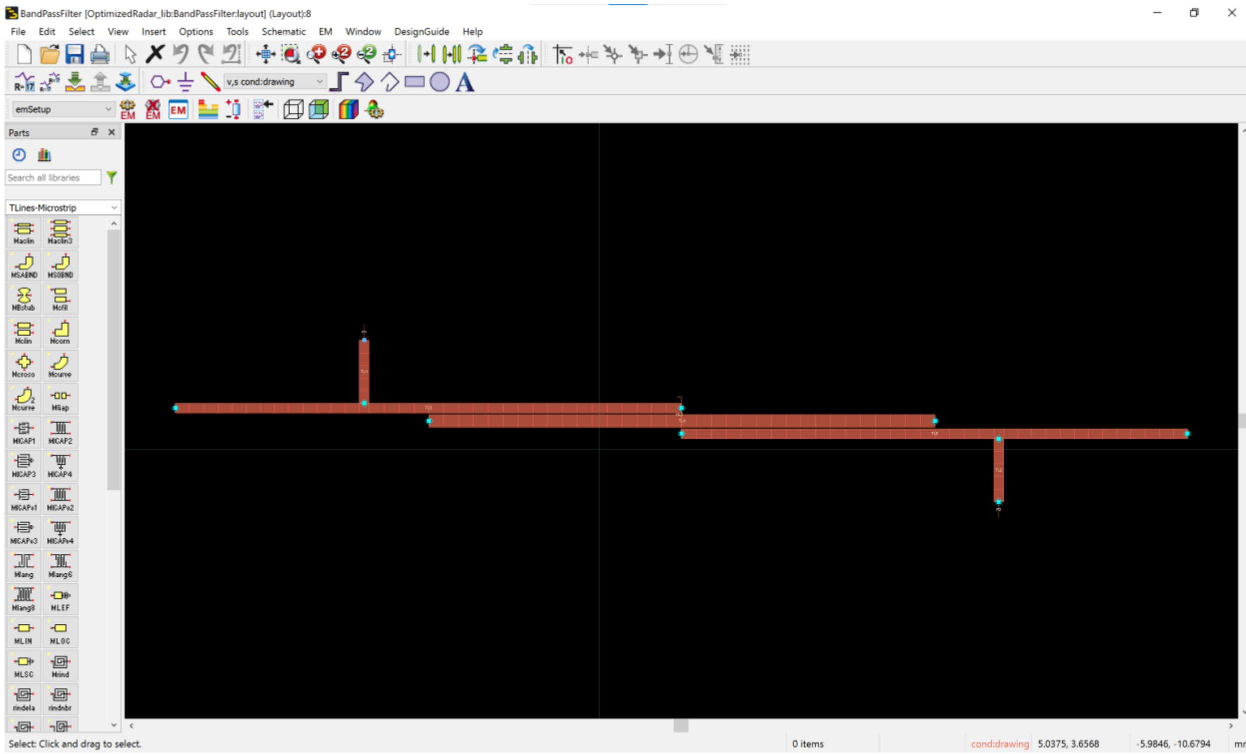

ADS
dB(S(4,1))
dB(S(3,1))
dB(S(2,1))
dB(S(1,1))
0
-5
-10
-15
-20
-25
-30
-35
1
2
3
4
5
6
7
8
9
10
freq, GHz

Lowpass Filter S-parameter





Bandpass Filter S-parameters



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File Edit Select View Insert Options Tools Schematic EM Window DesignGuide Help
emSetup
Parts
Search all libraries
TLines-Microstrip
Select: Click and drag to select.
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cond:drawing
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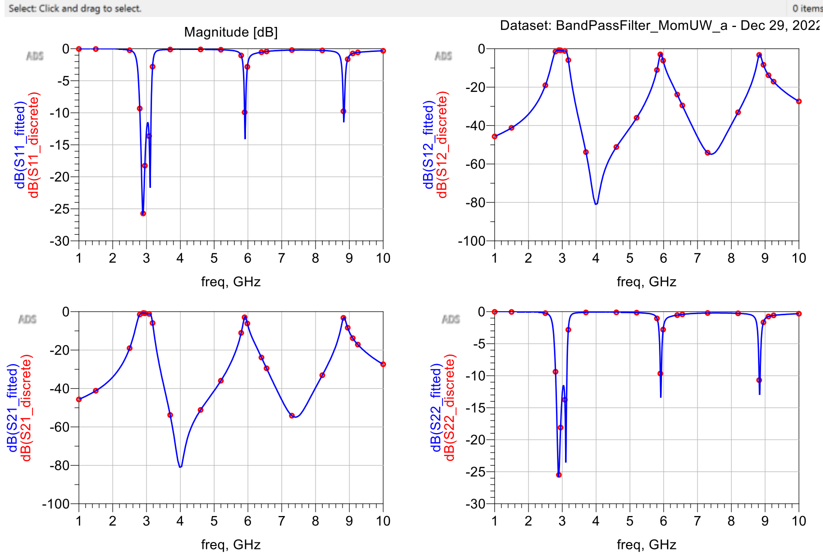
-5.9846, -10.6794
mm



Magnitude [dB]
Dataset: BandPassFilter_MomUW_a - Dec 29, 2022
dB(S11_fitted)
dB(S11_discrete)
dB(S12_fitted)
dB(S12_discrete)
dB(S21_fitted)
dB(S21_discrete)
dB(S22_fitted)
dB(S22_discrete)
freq, GHz