System Driven Hardware Design

Summer Semester 2021

Bandpass Test Assignment Report

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Introduction

A bandpass filter has been designed for 24GHz movement detection. The system takes the required signal and amplifies it for further processing.

We use a FreeSoC 2 as a test bench and measure the magnitude response in dB from the lower 3dB corner frequency to the upper 3dB corner frequency. We take 10 frequencies which are spaced equally along the logarithmic scale. A sine wave test signal is generated using a waveform DAC for different frequencies. These signals are fed to the amplifier input. The output of the amplifier is sampled with a 16-bit SD-ADC and the time domain data is transferred to MATLAB.

Schematic and Experimental Setup:

The bandpass filter is designed as shown in the figure. The stabilizing capacitor is removed and designed for an amplification factor of 300. We reduce the voltage to the ADC by giving the DAC input to a voltage divider. Input to the Bandpass filter is to be less than 8.3mV hence we select R1 and R2 as 1k ohm and 270 ohm.

DAC is configured to 40mV. The first stage of the amplifier provides a gain of 100 and second second a gain of 3, combining to give a gain 300. The amplifier acts as 4th order bandpass filter. We use the FreeSoC 2 as a testbench.

As the voltage from a radar is very less (in the range of uV), DAC is not able to get this range of values, hence reduction of gain is necessary, to get the voltage input of the ADC, hence we change the value of R7 to 6.8k ohm. Also, that we have to give buffered input so as to isolate output to input.

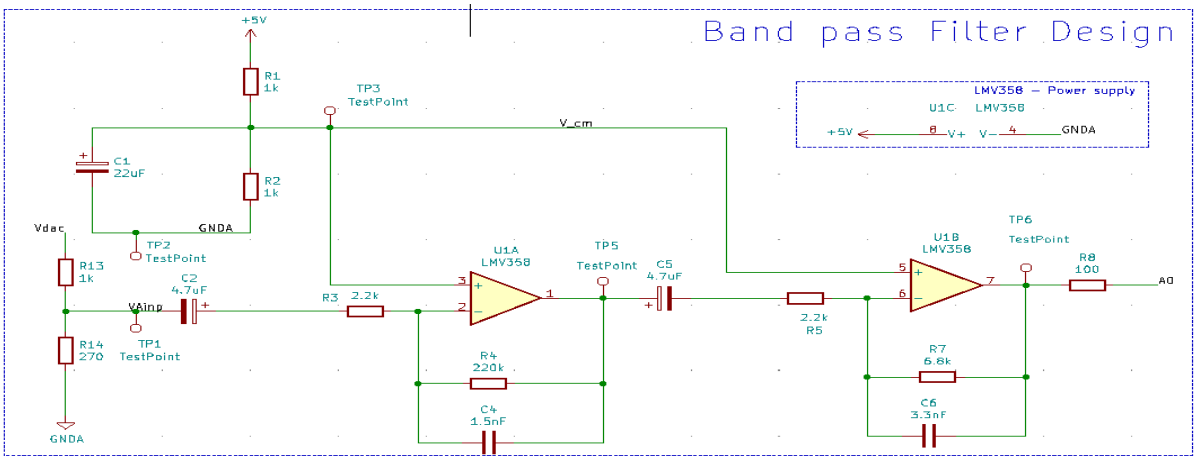

Figure 1: Bandpass filter schematic

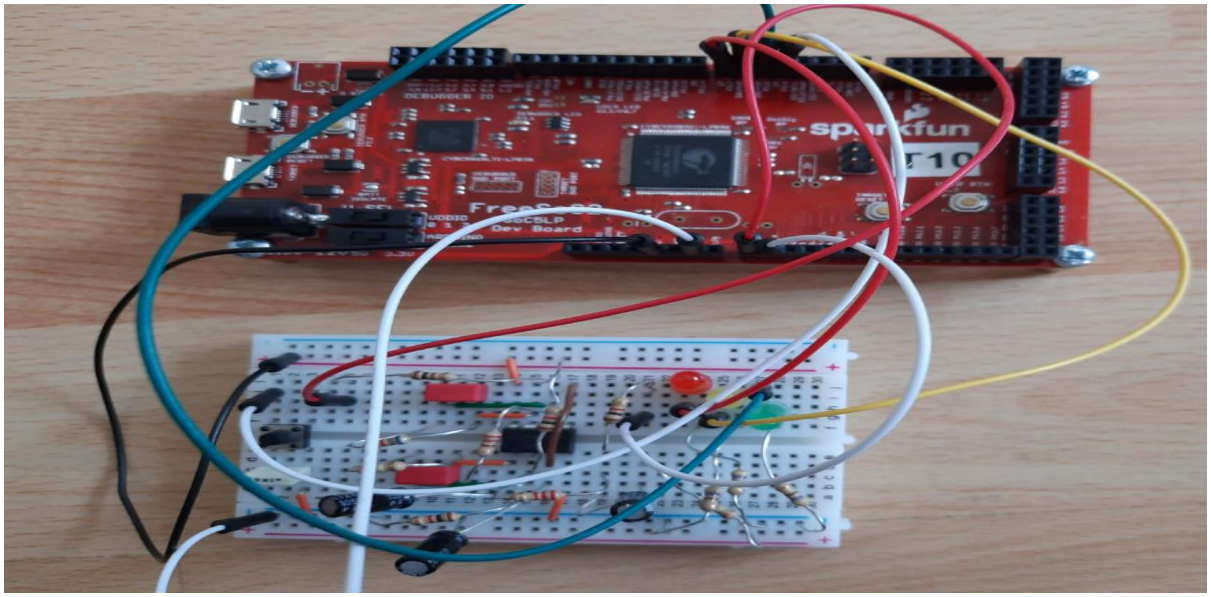

Figure 2: Experimental setup of Bandpass Filter

Measurement Table

We calculate the gain corresponding to the values of stage 1, stage 2 and input voltages.

Gain of first stage A1 in dB= 20* log (Vout1_pp/Vin_pp)

Gain of second stage A2 in dB= 20* log (Vout2_pp/ Vout1_pp)

Overall gain in dB A = 20*log (Vout2_pp/Vin_pp) or 20*log(A2*A1)

A	B	C	D	E	F	G	H	I	J	K	L
Frequency(Hz)	50	100	150	200	250	300	350	400	450	500	20
Vin_pp(V)	0.0103	0.0115	0.0107	0.0126	0.0124	0.0124	0.0128	0.0128	0.0139	0.0145	0.0084
Vout1_pp(V)	0.8768	0.9594	0.969	0.9599	0.9939	0.9691	0.9945	0.9743	1.0098	1.053	0.514
Vout2_pp(V)	2.6396	2.6422	2.6461	2.6463	2.6497	2.6522	2.652	2.6536	2.6537	2.6534	2.1793
A1	85.126214	83.42609	90.56075	76.18254	80.15323	78.15323	77.69531	76.11719	72.64748	72.62069	61.19048
A2	3.0104927	2.754013	2.730753	2.75685	2.665962	2.736766	2.666667	2.723596	2.627946	2.519848	4.239883
A	256.27184	229.7565	247.2991	210.0238	213.6855	213.8871	207.1875	207.3125	190.9137	182.9931	259.4405
A1(dB)	38.601266	38.42604	39.1388	37.63711	38.07842	37.85894	37.8079	37.62965	37.22441	37.22121	35.73368
A2(dB)	9.5727516	8.799319	8.72565	8.808262	8.51708	8.744754	8.519375	8.702855	8.392329	8.027487	12.54708
A(dB)	48.174018	47.22536	47.86445	46.44537	46.5955	46.60369	46.32727	46.33251	45.61674	45.24869	48.28075
A(Ltspice)	48.56	48.97	48.8	48.57	48.21	47.8	47.5	46.93	46.3	45.97	45.46

Table 1: Measurement table for the Testing of amplifier

Simulation Results in MATLAB

A modified MATLAB program is used to simulate and measure the voltages. ADC values are sent to quantize and waveform for different samples are obtained. We get a plot that is scaled in both the signal and FFT. Another MATLAB program calling a LTspice2Matlab function is ran, which gives a plot for the LTspice and MATLAB values. LMV385.raw extracts Vout1 and Vout2 using LTspice2Matlab.m and then the data is then plotted with the measured values.

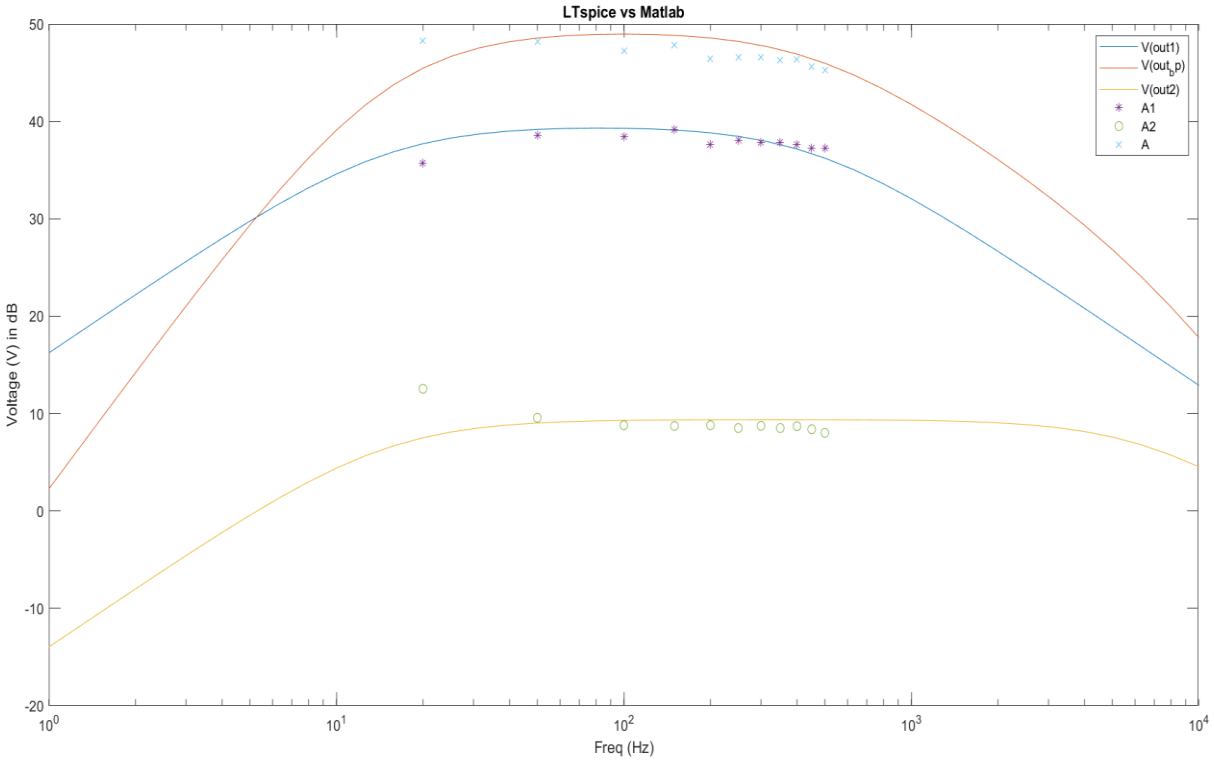

Figure 3: Result plotted for LTspice vs MATLAB.

Conclusion

The readings are plotted from the simulation. The values almost match with the values from LTspice. There have been small variations in the values as approximations are considered in ADC and is not run in an ideal environment.

Future Scope

We have run the experimental setup using a DAC. If the actual Radar system is used, the amplification and pass band could be modified to get better data for processing.