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Chebyshev Filter at 197.12 MHz Frequency for Radar System

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Abstract *: This paper describes the design and simulation of bandpass filter at 197.12 MHz frequency cut off. which use Chebyshev methode, Chebyshev Filter is allowing ripple on the frequency response. But this type of filter is easy for tunning at cut off frequency. This Filter is used for Radar system, which have small bandwidth, it's around 4 MHz, and also compatible to baseband frequency. In order to design this filter, first of all, we calculate the value of inductor and capasitor, and then simulate it with software. The design filter was simulated using Elsie Tonne version 2.4. From the simulation results, we can see that the VSWR is 1.0021, return loss -59.74 dB.*
Keywords *– Filter, Chebyshev, bandwidth, insertion loss, vswr,*

I. INTRODUCTION

Every Project in Radar Communication needs special specification for each component which can't find in the market. One of this component is Band Pass Filter at 197.12 MHz, which use Chebyshev method. Chebyshev method used to make special specification because the order of the filter can be higher than Butterworth. Bandpass filter is combination of low-pass filter and high-pass filter. So the bandwidth of this filter is between upper and lower cut off frequencies, it can be measured at half power points (gain -3dB).

The "ideal" Bandpass filter is no ripple and attenuate all frequencies outside the passband. But sometime we need Bandpass Filter which have some ripple on the Frequency respons, because we can tune the cut off frequency more easier. However the filter which use this type is more difficult to pabricated.

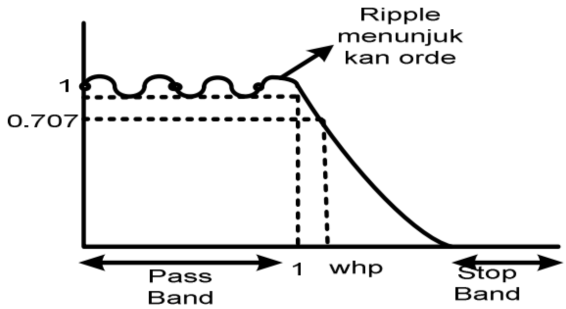

Figure 1. Respon Frequency of Chebyshev Filter

Chebysev filter have ripple in passband and stopband. From the figure we can see the respon frequency of chebysev which has ripple in passband. This filter used to separate one band of frequencies from another.

II. FILTER DESIGN

First of all for this design we have to calculate the element value of series capasitor , series inductor, parallel capasitor and parallel inductor as follows :

$$L_{series} = \frac{\left(\frac{R_0}{(f_{c2}-f_{c1})\pi}\right)}{2} \quad (1)$$

$$C_{series} = 2\left(\frac{f_{c2}-f_{c1}}{R_0(f_{c2}\cdot f_{c1})4\pi}\right) \quad (2)$$

$$L_{parallel} = 2\left(\frac{R_0(f_{c2}-f_{c1})}{(f_{c2}\cdot f_{c1})4\pi}\right) \quad (3)$$

$$C_{prallel} = \frac{\left(\frac{1}{R_0(f_{c2}-f_{c1})\pi}\right)}{2} \quad (4)$$

From the formula we can calculate element value of component and put to the figure 4. So the design filter can be simulate with elsie Tonne.

According to formula (1), (2), (3), and (4) we can calculate series capasitor , series inductor, parallel capasitor and parallel inductor with some of parameter such as lower frequency cut off (fc_l), upper frequency cut off (fc_2), Impedance input (R_o), Bandwidth (BW).

fc_l = 195.12 MHz = 195.12 x 10^6 Hz

fc_2= 199.12 MHz = 199.12 x 10^6 Hz

BW = fc_2- fc_l = 4 MHz

R_0 = 50 Ω

To find the value of

1. L_{series} =

$$L_{series} = \frac{\left(\frac{R_0}{(f_{c2} - f_{c1})\pi}\right)}{2}$$

$$L_{series} = \frac{\left(\frac{50}{(195.12\ x\ 10^6 - 199.12\ x\ 10^6)\frac{22}{7}}\right)}{2} = 1{,}988\ uH$$

2. C_{series} =

$$C_{series} = 2\left(\frac{f_{c2} - f_{c1}}{R_0(f_{c2}.f_{c1})4\pi}\right)$$

$$C_{series} = 2\left(\frac{(199.12 - 195.12)10^6}{50\big((199.12\ x\ 10^6)x\ (195.12\ x\ 10^6)\big)4\frac{22}{7}}\right) = 0{,}3275809\ pF$$

3. $L_{parallel}$ =

$$L_{parallel} = 2\left(\frac{R_0(f_{c2} - f_{c1})}{(f_{c2}.f_{c1})4\pi}\right)$$

$$L_{parallel} = 2\left(\frac{50\big((199.12\ x\ 10^6) - (195.12x\ 10^6)\big)}{\big((199.12\ x\ 10^6)x\ (195.12\ X\ 10^6)\big)4\frac{22}{7}}\right) = 0{,}8189524\ nH$$

4. $C_{parallel}$ =

$$C_{prallel} = \frac{\left(\frac{1}{R_0(f_{c2} - f_{c1})\pi}\right)}{2}$$

$$C_{prallel} = \frac{\left(\frac{1}{50\big((199.12\ X\ 10^6) - (195.12\ X\ 10^6)\big)\frac{22}{7}}\right)}{2} = 0{,}795454\ nH$$

III. SIMULATION

Before realization the filter based on the element value from calculation with formula (1), (2), (3) and (4). We can simulate the element value on the software simulation which called Elsie Tonne 2.4 version. Some parameters needs to design such as the type of filter (Chebysev or Butterworth), Bandwidth, order etc, as can see in the figure 2.

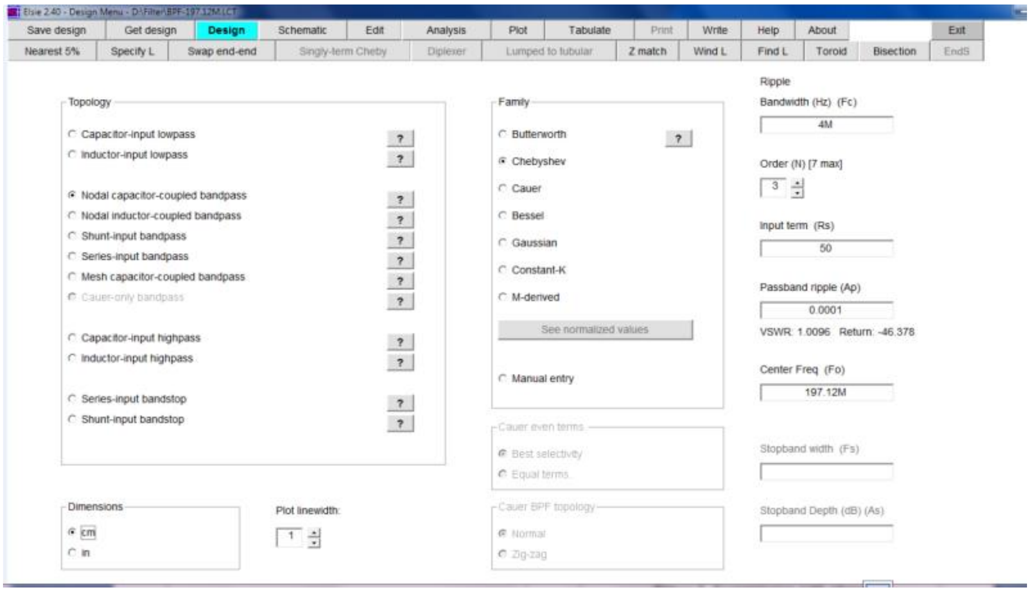

Figure 2. The parameter of filter design

We choose topology from the filter use shunt-input bandpass with compare the element value in the market. Other parameters are needed to analysis such as start and stop frequency, VSWR (Voltage Standing Wave Ratio), Q of inductor and Q of capasitor etc, as can see in figure 3.

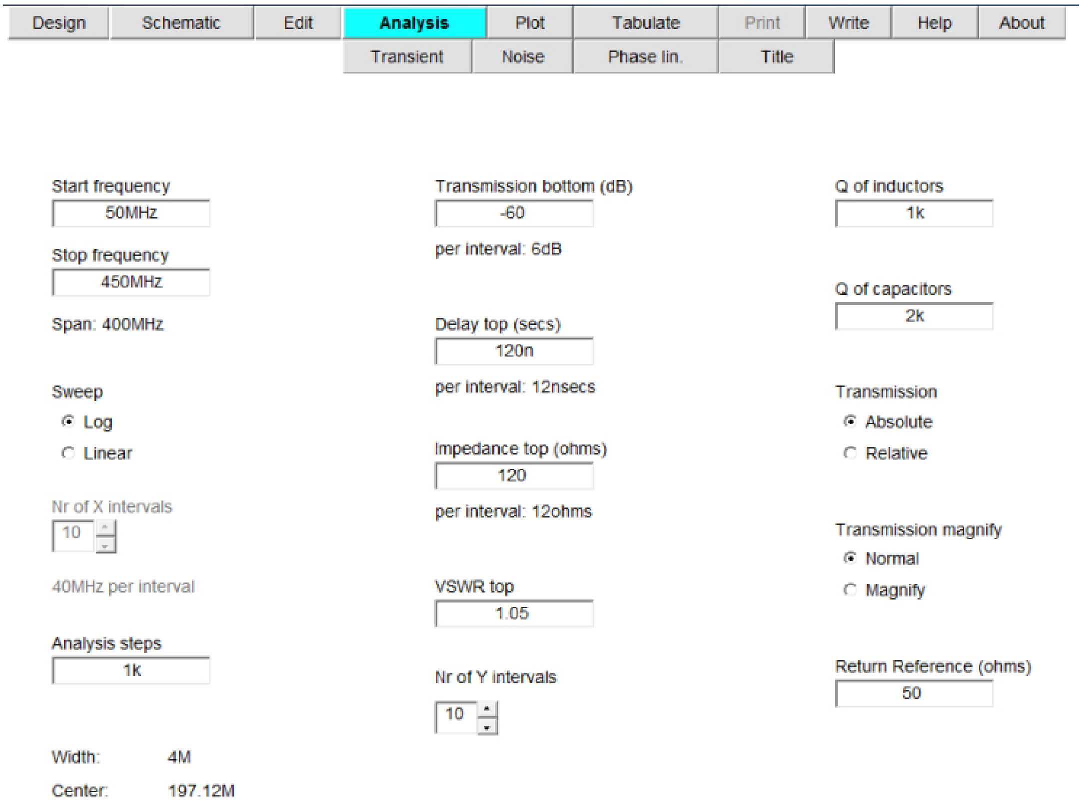

Figure 3. Analysis Parameters

The frequency response from simulation, we get the response wich no ripple and have steepness of the response curve as can see in figure 4.

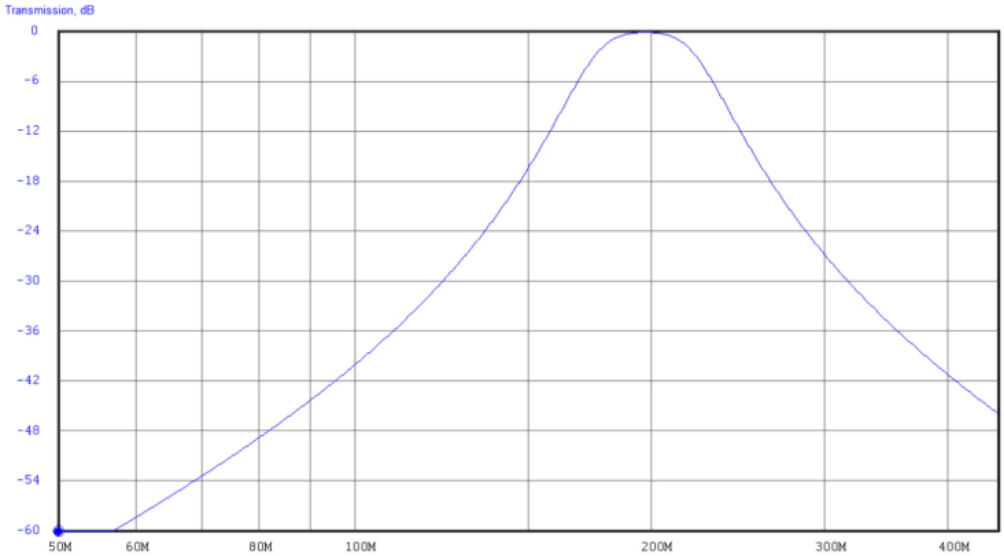

Figure 4. Frequency Response at BPF 197.12 MHz (dB)

The Phase on 197.12 MHz is 0 degree , it means the input signal and output signal have a same position wave degree. We also can see the result in the figure 5.

Frequency, Hz:	Transmission, dB:	Phase, degrees:	Return, dB:	Delay, seconds:	VSWR:	Zin, ohms:	Zangle, degrees:
187.05M	-10.3	-1.355	-0.69251	29.18n	25.098	48.896	85.436
187.46M	-9.3046	-6.075	-0.84477	32.05n	20.58	52.979	84.427
187.87M	-8.3027	-11.279	-1.041	35.27n	16.708	57.881	83.076
188.28M	-7.3035	-17.019	-1.295	38.81n	13.44	63.847	81.232
188.69M	-6.319	-23.338	-1.6244	42.63n	10.725	71.196	78.666
189.1M	-5.3646	-30.266	-2.0514	46.64n	8.5076	80.298	75.025
189.52M	-4.459	-37.806	-2.6023	50.65n	6.7255	91.438	69.783
189.93M	-3.6226	-45.923	-3.3066	54.41n	5.3169	104.33	62.218
190.35M	-2.8753	-54.537	-4.1954	57.61n	4.2208	116.97	51.635
190.76M	-2.233	-63.517	-5.2982	59.93n	3.3799	124.41	38.162
191.18M	-1.7047	-72.701	-6.6401	61.15n	2.7424	121.6	23.781
191.6M	-1.2898	-81.913	-8.242	61.21n	2.2635	109.78	11.492
192.02M	-0.97918	-90.998	-10.121	60.23n	1.9063	95.097	2.9191
192.44M	-0.75738	-99.839	-12.299	58.49n	1.641	81.927	-2.1097
192.86M	-0.60597	-108.37	-14.804	56.29n	1.4447	71.605	-4.4667
193.28M	-0.50688	-116.55	-17.688	53.93n	1.3002	64.011	-5.027
193.7M	-0.44435	-124.41	-21.041	51.65n	1.1947	58.642	-4.4971
194.12M	-0.40596	-131.97	-25.021	49.58n	1.1189	54.988	-3.4173
194.55M	-0.38261	-139.28	-29.936	47.79n	1.0658	52.619	-2.1848
194.97M	-0.36813	-146.36	-36.491	46.29n	1.0304	51.185	-1.0707
195.4M	-0.35866	-153.28	-46.959	45.08n	1.009	50.401	-0.23498
195.83M	-0.35199	-160.07	-52.885	44.12n	1.0045	50.039	0.25612
196.26M	-0.34704	-166.76	-48.676	43.37n	1.0074	49.917	0.41115
196.69M	-0.34337	-173.37	-51.196	42.81n	1.0055	49.9	0.29401
197.12M	-0.34084	-179.93	-59.74	42.4n	1.0021	49.897	0.00547
197.55M	-0.33944	173.53	-49.9	42.12n	1.0064	49.869	-0.33427
197.98M	-0.33911	167	-45.115	41.98n	1.0112	49.823	-0.60237
198.41M	-0.33983	160.46	-44.011	41.96n	1.0127	49.812	-0.68921
198.85M	-0.34166	153.89	-46.882	42.09n	1.0091	49.935	-0.51342
199.28M	-0.34497	147.25	-49.809	42.38n	1.0065	50.323	-0.03613
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 5. The Tabulate Result of the design

For the VSWR in 197.12 MHz is 1.0021, so no reflected wave. It's indicate the input signal is wholly transferred by the filter 100%, the transmission is 0 dB and the return loss is more than -59.74 dB.

IV. PABRICATION

The Pabrication of this filter is use PCB duroid 5870, which has Dielectric constant is around 2.33, and the cut off of frequency is less than 1 GHz.

Using the Trimmer Capasitor is make us easy to find the value of capasitor because from the calculation result the value of the capasitor is not available in the market.

For the Inductor, we use the SMT Inductor to get the smalles dimention and appropriate the value that we needed.

After we made this filter, we can measure the characteristic of this filter with Vector Network Analyzer and the result is show in the fig. 7. we can see that the measurement result for this filter is approximately same with the simulation.

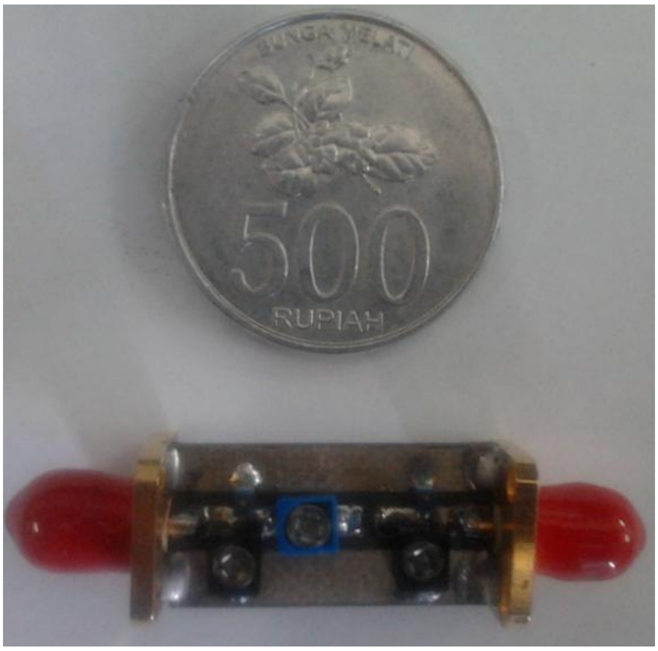

Figure 6. The Pabrication of 197.12 MHz Bandpass Filter

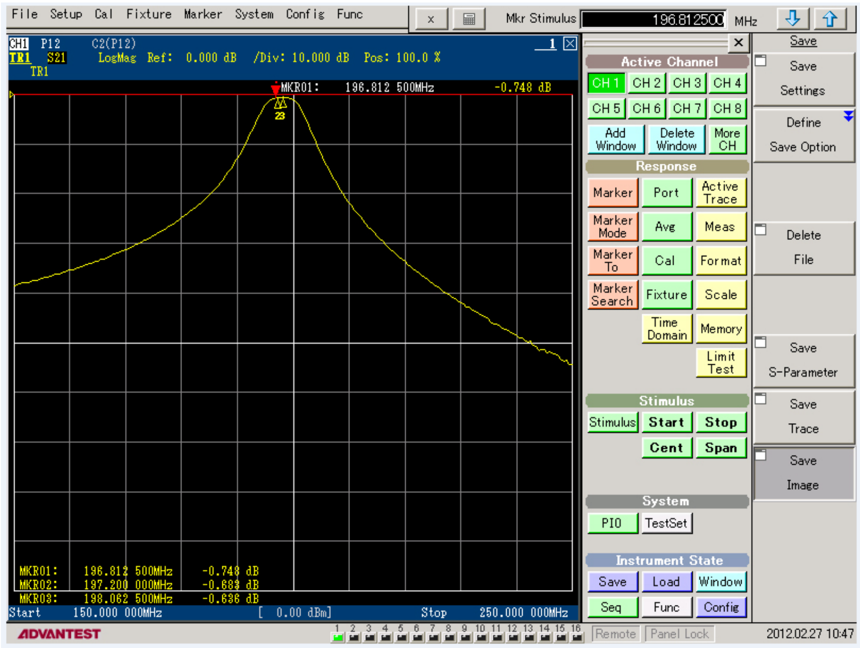

Figure 7. The Measurement of this Filter

For design the filter at the frequency 97.12 MHz we need to calculate the elements value with formula and we have to know about the components value in the market so we can approximately the values which we need and input the values in the parameters culomn at software simulation. In this design we get the good result as we know the frequency response of this filter have ripple because this design use Chebyshev type and use the third order to get steepness for the curve. For the transmission response the curve at the 197.12 MHz have 0.748 dB is approximately equal to 4 MHz bandwidth. The phase of the wave is 0 degree, at the 97.12 MHz and the VSWR is 1.0021, it's represent there are no reflection signal so the input signal is have same ratio with output signal, and the return loss is -59.74 dB, it's means no interference for this filter. From all result parameters are indicate the filter that we design have a good performance and also the pabrication.

V. Conclusion

The result of the simulation show that the calculation that we made is approximately with the real value of the capasitor and inductor. The design from simulation we can pabricated to get the real Bandpass filter, which has small dimention and good result for the measurement.

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