Design of the Edge-Coupled Strip-Line Based Tunable Band-Pass Filter Using Plastic and Ceramic Dielectric Materials

Poonam Sukla,
M.E.,IV Sem (Microwave Engineering),
Jabalpur Engineering college, Jabalpur.

Kanchan Cecil (Assistant Professor)
Department of Electronics & Communication Engineering
Jabalpur Engineering College, Jabalpur.

Abstract

The bandpass filter is very useful component for RF front end of various communications or processing electronics system. The stripline based filter & cavity based filter are able to provide the high Q band pass filter . At microwave frequency the stripline filter is simple filter which may be easily designed and By putting a variable capacitor in series, this filter may be used as a tunable filter . In this paper a 3 stage stripline band-pass filter design using MATLAB is illustrated using two different dielectric materials i.e. Plastic & Ceramic. The performance of the filter for both the materials has been given evaluated as S11 snd S12 parameter at frequency of interest.

1. Introduction

The filter design is always a topic of research in different aspect. The major feature of the filter is to pass the desired frequency contents and reject the remaining fuction . On the basis of the frequency of interest the filter may be classified as

- Low pass filter
- High pass filter
- Bandpass filter
- Bandstop filter
- All pass filter

The degree of rejection of the undesired frequency is depending on the order of the filter . But the increase of the order make the filter structure more complex [2]. The practical behaviour of component of filter may become unpredictable at microwave frequency .

The filter design at microwave frequency is very challenging task. The low pass filter design is simple . Normally the Low pass filter is used to avoid the aliasing in digital electronics system. The more common filter is band pass filter . The frequency response of bandpass filter is given in figure:1 .

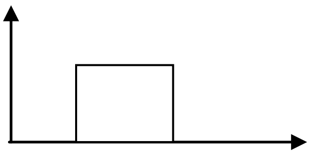

Figure:1 frequency response of BPF

The Q value of bandpass filter may be given by ,
Q= Fc / BW .
Where , Fc is centre frequency of filter and BW is 3 dB bandwidth.

2. Band Pass filter Design

The edge coupled band pass filter is taken for design which uses a flat strip of metal which is sandwiched between two parallel ground planes[1]. The insulating material of the substrate forms a dielectric.

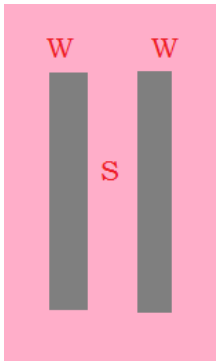

Figure:2 Edge coupled stripline

The design criteria for the filter topology sometimes demand higher skirt rate. The traditional method is to increase the number of sections. Another concept is to use cross coupling between the resonator section along with over coupling gives controllable zero producing mechanism. The placement of zero is determined by the polarity of the cross coupling. Due to inhomogeneous nature of the micro strip lines, the odd mode phase velocity is faster than the even mode phase velocity. For edge coupled filter, electromagnetic energy for the odd mode gathers around the centre gap, while for the even mode, it gathers around the outer metallic edges.

Calculation of Odd and Even Resistances to design the stripline filter, an approximate calculation is made based on the design equations. The no of stages is 3. The characteristic impedance Z0 is typically 50 Ohms. The unitary bandwidth BW is given by

$$FBW=(\omega 2-\omega 1) / \omega 0.$$

3. Simulation result

The designs of band pass filter have been done using the code developed in the MATLAB. The figure 2 shows a typical structure of edge-coupled microstripline BPF.

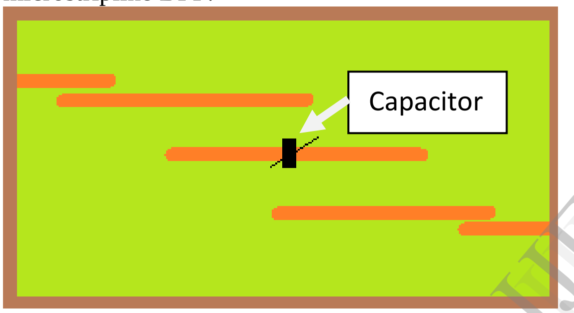

Figure:3 Edge coupled filter with tunable capacitor .

The following has been done,

1. Ceramic based BPF design
2. Plastic based BPF design

1. Ceramic based BPF design

The following parameters are used for BPF design,

S. No.	Parameter	Value
1	Centre Frequency	1.5 GHz
2	BW	< 1 MHz
3	Relative permittivity	7.4
4	Filter order	3
5	Tuning range	>50 MHz
6	Thickness of substrate	1 mm

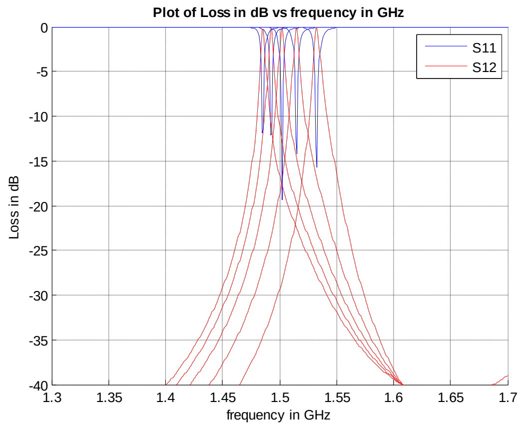

Figure -4 filter response for ceramic dielectric

2 Plastic based BPF design :

The plastic is most common dielectric material for filter design . the following parameters are used for band pass filter design

S. No.	Parameter	Value
1	Centre Frequency	1.5 GHz
2	BW	<5 MHz
3	Relative permittivity	2.1
4	Filter order	3
5	Tuning range	>250 MHz
6	Thickness of substrate	.8 mm

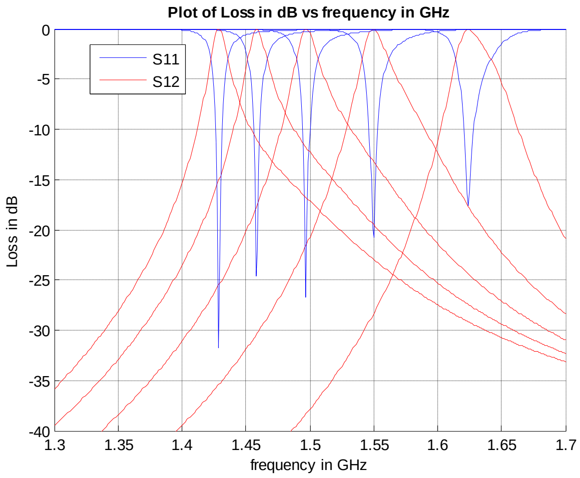

Figure -5 filter response for plastic dielectric

The comparative graph of the two designs in term of tuning of the centre frequency of BPF is shown in figure below. The coupler length ,width ,strip length and width is different for two filter .

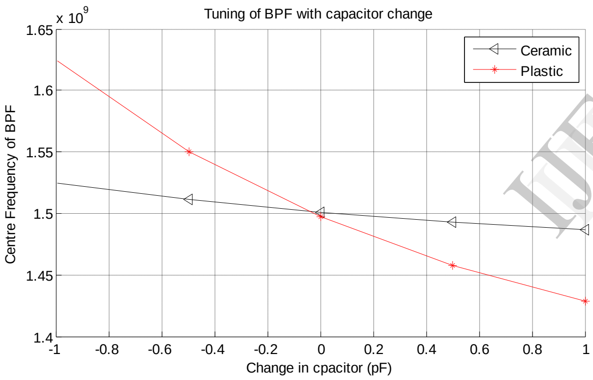

Figure -6 Comparison of filter response with capacitor tuning

4. Conclusion

The Ceramic PCB with the high dielectric constant has sharper S12 response or high Q value as compare to plastic dielectric material. The tuning range is wider for plastic dielectric compare to ceramic dielectric for same capacitor tuning range . The fine capacitor change is required for plastic material due to high sensitivity of the frequency change. The S11 is better than -15 dB which almost pass all the band with very small attenuation.

5. References

[1] Kamaljeet Singh et al, "Coupled Microstrip Filters: Simple Methodologies for Improved Characteristics".
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