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Microwave Band Pass Filter Design Realization in Micro strip Patch

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Abstract:
In this paper, a new band pass filter design and realization is proposed. The topology used is π -configuration of LC components and it is converted in to dielectric patch. FR4 dielectric material of dielectric constant 4.4 with thickness 1.6 mm and loss tangent value of 0.025 is selected to design the filter. IE3D EM simulator is used to realize the design in microstrip patch. The pass band of the filter ranges from 900 MHz to 2500 MHz. At the center frequency of 1500 MHz with 1600 MHz bandwidth is realized in microstrip patch. Third order butterworth band pass filter is arrived with -10 dB rejection at f_L and f_H. Insertion loss of <4 dB within f_L-f_H band and return loss better than -10 dB within the pass band is achieved. Good frequency response characteristics of the filter are arrived during the design and simulation. The proposed design is useful for wireless radio communication systems.

Keywords:*Band pass, filter, microstrip, microwave.*

1. INTRODUCTION

Wireless communication field growth is extraordinary nowadays in the engineering. The key factor is the components used in the systems giving high performance characteristics. In that order, band pass filter design components take part important part in communication equipments. A new method of realizing filter is presented here by designing in small area and with high performance. The novel method is derived from the literature survey in the filters on microstrip patch. Instead of designing components, it is etched on the planar dielectric material on one side of the patch with specified dimensions. This work is realized simulation by the electromagnetic simulator. The literature survey, filter design with simulation, results and discussion are described in the following sections.

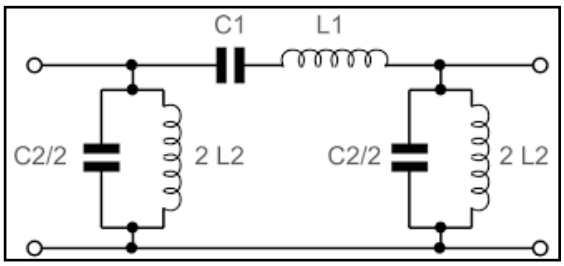

Fig. 1. Band Pass Filter with LC Components in π - Configuration topology

2. LITERATURE SURVEY

The research study is made to design band pass filter on microstrip patch. It is studied and analyzed by the following research works. Mudrik Alaydrus (2010) presented the work of Microstrip Band pass Filter Designing at 3.2 GHz with 50 MHz bandwidth. Veerendra Singh Jadaun et al (2012), Designed a Microstrip Band Pass Filter for 6 GHz with a frequency bandwidth of 2.8%. Cansever Cem, (2013) displayed the subtleties identifying with structure of a Microstrip Bandpass Filter for 3.1-10.6

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GHz Ultra wide band Systems. M.A. Othman, et al, (2013) exhibited the Development of Bandpass Filter for Wireless Communication System at 5.8 GHz by utilizing Microstrip Parallel Coupled Line.

K.S.Khandelwal et al, (2014) understood the structure of Microstrip Band-Pass Filter. Shreyasi Srivastava, et al, (2014) proposed a Microstrip Band pass Filter Design, Simulation and Fabrication at 2.44 GHz with a recurrence transmission capacity of 3.42%. Avishek Das, et al, (2014) structured and dissected Microwave Planar Band Pass Filter for WiMAX Application. M.Taghizadeh, et al, (2015) mimicked the Design of Band-Pass Filter by utilizing Microstrip Lines at focus recurrence of 1.1 GHz. Orhan Yeşilyurt et al, (2015)presented Microstrip band pass channel structure configuration utilizing open ring resonator. Satish R.Gunjal, et al (2016) proposed Design and Implementation of Microstrip Band pass Filter by utilizing Parallel Coupled Line for the utilizations of ISM Band with 288 MHz data transfer capacity.

Ki-Hun Lee, et al (2018) proposed Design and Realization of a Compact High-Frequency Band-Pass Filter with Low Insertion Loss Based on a Combination of a Circular-Shaped Spiral Inductor. Jun Xu, et al, (2019) planned Compact third-order microstrip band pass channel by utilizing the distributed- to lumped-element equality. Salai Thillai Thilagam.J, et al, (2019) introduced the acknowledgment of Butterworth Low Pass Filter Design in Microstrip. From the above overview, it is expected that the channel structure for pass band applications for the microwave band is dissected.

3. MICROSTRIP FILTER DESIGN

Third request band pass channel circuit is taken to acknowledge in microstrip fix on FR4 dielectric material. Here the primary component is accepted as shunt to get the π - design. L1 and C1 are inductor, capacitor in the main component set. The L2 and C2 are second component set and third component set comprises of L3 and C3. Second arrangement of component parts are associated in arrangement while first and third component set segments are associated in parallel.

Plan method is given as configuration stream.

i. Filter selection response
ii. Type of filter technology chosen
iii. Number of elements calculation
iv. Pass band frequencies selection
v. Meshing frequency chosen
vi. Declaring the centre frequency
vii. LC components values calculation
viii. Transforming the LC values in dimension of patch
ix. Physical layout preparation
x. Filter design on patch

The response of the filter is Butterworth third order design. It is shown in figure 1. The filter is designed on FR4 dielectric material. The specifications of the material are shown in table 1. The impedance value is considered as 50 ohms. For the band pass filter design, the lower cut off frequency is 900 MHz and the higher cut off frequency is 2500 MHz with centre frequency of 1500 MHz. With the zero insertion loss, the design started with the help of expressions that were given by David M.Pozar. The values of LC components of filter design are tabulated in table. The 'g' values are taken as g(1)=1, g(2)=2 and g(3)=1 for the elements. The lumped components values are transformed in to the planar dimensions for the design on patch by using Filtsoft tool. The values are displayed in the table 2. The frequency response characteristic for ideal band pass filter is shown in figure 2.

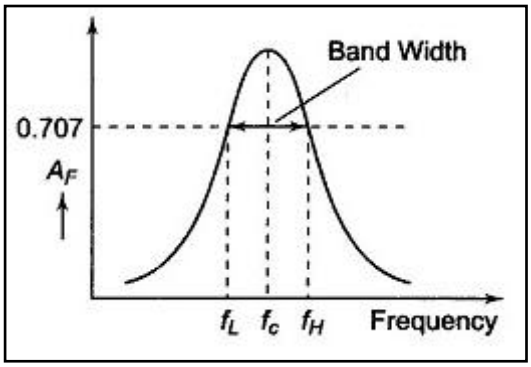

Fig. 2 Frequency Response characteristics of a Band Pass Filter

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Table 1: Band Pass Filter Material Specifications

Dielectric Material	FR4
Conductor thickness (mm)	0.035
Dielectric constant	4.4
Height (mm)	1.6

The inductors L1, L2, and capacitors C1, C2 values are derived from the Formulas, which are given below.

$L_1 = \frac{Z_0}{\pi(f_2 - f_1)}$ --------(1)

L1=9.947 nH

$L_2 = Z_0 \cdot \frac{f_2 - f_1}{4\pi f_2 f_1}$ ---------(2)

L2=L3=5.659 nH

$C_1 = \frac{f_2 - f_1}{4\pi f_2 \cdot f_1 \cdot Z_0}$ ----------(3)

C1=1.132 pF

$C_2 = \frac{1}{\pi Z_0 \cdot (f_2 - f_1)}$ ----------(4)

C2=C3=1.989 pF

The Centre frequency f_c, is calculated as

$f_c = \sqrt{f_H \times f_L}$ ----------(5)

f_c =1500 MHz

The bandwidth BW, is the difference of the higher cut off frequency and lower cut off frequency.

$BW = f_H - f_L$----------(6)

BW=1600 MHz

The Q-factor is given by

$Q = \frac{f_c}{BW} = \frac{f_c}{f_H - f_L}$----------(7)

Q=0.9375

If it is Q<10, this filter is wide band pass filter. It has the components values in nano henry and pico farads for inductors and capacitors. These LC components can be realized in microstrip patch. The patch dimensions are tabulated in table 3. Using the patch dimensions, layout of the filter is designed by the Electromagnetic simulator. The designed layout is drawn and displayed in figure 3. For the inductor and capacitor components shown in the figure 1, the corresponding values are listed after the calculation in the table 2.

Table 2: Design values of LC components in band pass filter of circuit

Design	**Band pass filter Components values**
C1	1.132 pF
L1	9.947 nH
C2	1.989 pF
L2	5.659nH
C3	1.989 pF
L3	5.659 nH

The schematic structure on the microstrip patch is drawn and shown in the figure 3.

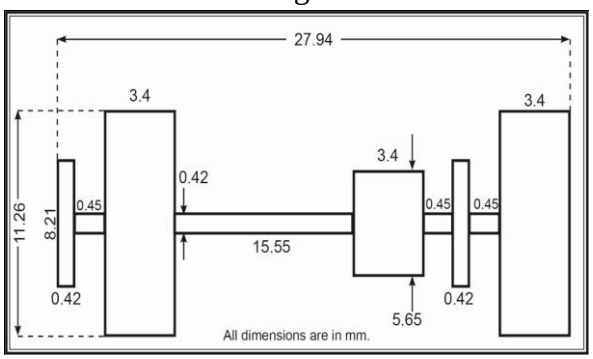

Fig. 3 Layout structure of a Band Pass Filter in Microstrip patch

The dimensions of the filter components corresponding to their values are tabulated in the table 3.

Table 3: BPF filter layout dimensions

BPF components	Length, L(mm)	Width, W(mm)
L1	8.21	0.42
C1	11.26	3.4
L2	15.55	0.42
C2	5.63	3.4
L3	8.21	0.42
C3	11.26	3.4

3. RESULTS AND DISCUSSION

The filter design, simulation results are furnished in this section with discussion. The band pass filter with 900 MHz as f_L and 2500 MHz as f_H is designed in microstrip patch form by the EM simulator software. It is checked with simulation. The

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schematic diagram is shown in figure 4. After the designing of the filter, the three dimensional view was seen and is shown in figure 5.

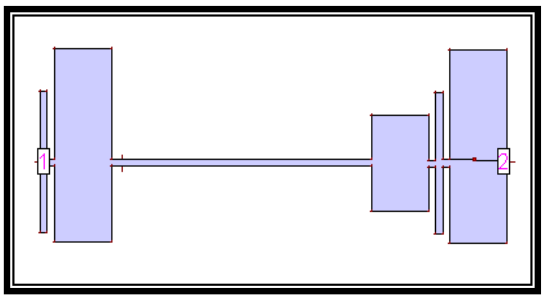

Fig. 4 Band Pass Filter (BPF) schematic diagram

The geometry contains the ground plane at the bottom. Patch area is on top side of the dielectric material. The filter design assumed the area of 27.94 mm X 11.26 mm. The height of the dielectric is 1.6 mm and overall dimension of the ground plane is 30 mm X 15 mm.

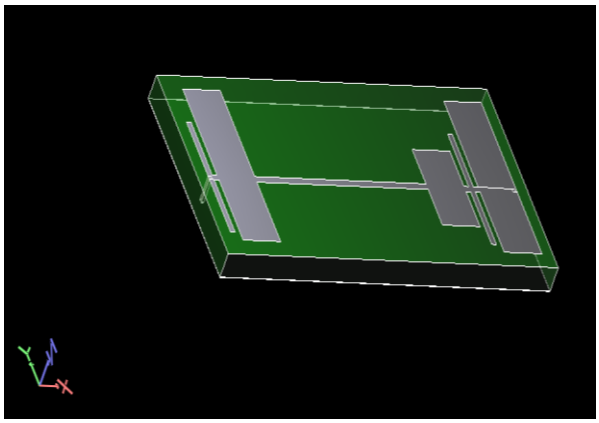

Fig. 5 Three Dimensional geometry of the Band Pass Filter (BPF) Layout

Freq response

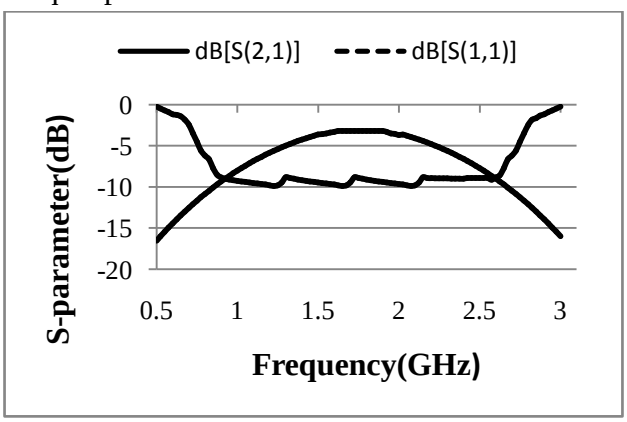

Fig. 6 Frequency Response with Reflection and transmission factor of the Band Pass Filter

Three D full wave simulator, IE3D is used here for the simulation of the filter.

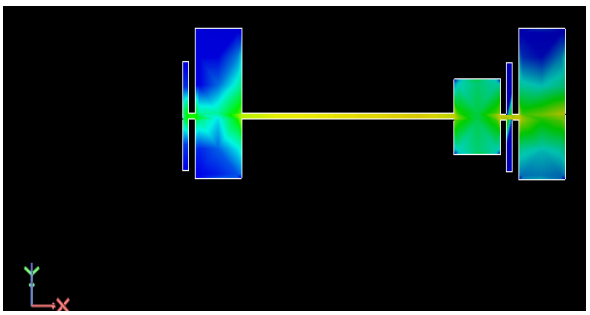

Fig. 7 Current distribution on the microstrip patch of the Band Pass Filter

The presented band pass filter has the advantages of less occupying area, less insertion loss and high isolation.

4. CONCLUSION

A new method of Band Pass Filter is designed and realized on microstrip patch of dielectric constant 4.4 with a height of 1.6 mm. The values are calculated from the mathematical formulas and the Filtsoft tool. The filter is designed and realized with the lower frequency of 900 MHz and higher frequency of 2500 MHz. The Band Pass Filter is centered at 1.5 GHz with a bandwidth of 1600 MHz. The Band Pass Filter is achieved good rejection rate of -10 dB at f_L and f_H. Further, it can be improved with less insertion loss in the pass band and high rejection for out of band design as a future work.

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