Design and Implementation of Hairpin Bandpass Filter

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***Abstract* : Band pass filter plays an important role in Microwave applications. A filter represent a class of electronic filter. In this project, the bandpass filter is designed using hairpin structure. A compact microstrip Hairpin line bandpass filter design is presented in this paper for a centre frequency of 2.4 GHz. The hairpin structure makes the filter structure more compact in size. Finally, the simulation is done using the Advanced Design System software and simulated on FR4 substrate as the dielectric material with the thickness of 1.6 mm and the conductor thickness of 45 µm. Those filters have wide application in modern wireless communication system.**

Keywords : Bandpass filter, Floating slot, Hairpin structure.

I INTRODUCTION

Band pass filters are essential part of any signal processing or communication systems, the integral part of superhetrodyne receivers which are currently employed in many RF/Microwave communication systems. At Microwave Frequencies the discrete components are replaced by transmission lines, for low power applications microstrip are used which provide cheaper and smaller solution of Band Pass Filter. A band pass filter is an electronic device or circuit that allows signals between two specific frequencies to pass, but that discriminates against signals at other frequencies and it can be formed by combining a low pass filter and a high pass filter.

A filter is a two port network used to control the frequency response at a certain point in a system by providing transmission at frequencies within the pass band of the filter and attenuation in the stop band of the filter. Typical frequency response include low pass, high pass, band pass and band reject characteristics. Some band pass filters require an external source of power and employ active components such as transistors and integrated circuits , these are known as active band pass filters. Other band pass filters use no external source of power and consist only of passive components such as capacitors and inductors; these are called passive band pass filters. Microstrip Band pass filters plays important role in all communication systems. Microstrip is a popular type of planar high frequency due to its ease of fabrication and its ability to integrate it with the other devices. The basic structure of Microstrip line consists of a conductive strip separated from ground plane by dielectric.

The microstrip circuits has their own advantages compare to other microwave transmission like waveguide, coaxial cable, strip line as filter realized with wide bandwidth, compact size, easy to fabricate, good reliability and reproducibility. The filter is designed and simulated in ADS (Agilent's Advanced Design systems) software. Microstrip filter based on printed circuit board (PCB) offers the advantages as easy and cheap in mass production with different Dielectric constants. The advances of telecommunication technology arising hand in hand with the market demands and governmental regulations push the invention and development of new applications in wireless communication. Microwave band-pass filter plays an important role in the microwave systems especially in transmitting and receiving systems to identify and transmit the desired signals. In case of planar microwave band-pass filters, there are four different types: the combline filters, the interdigital filters, the hairpin-line and the parallel coupled filters. In modern communication systems, the size of the planar microwave filters is one of the major concerns. The basic third order bandpass filter as shown in figure 1.

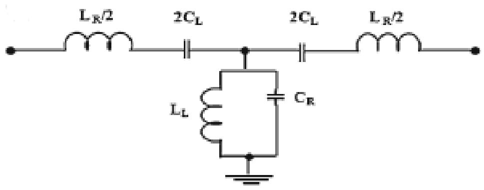

Fig.1 Bandpass filter

High-Performance microwave filters are essential circuits in many microwave systems where they serve to pass the wanted signals and suppress unwanted ones in the frequency domain .Parallel coupled microstrip filters are widely used in microwave circuits due to their insensitivity to fabrication tolerances, wide realizable bandwidth, and simple synthesis procedures.

II LITERATURE SURVEY

1. K.S.Khandelwal and Dr. A.K.Kureshiz "*Realization of microstrip band- pass filter".* It clearly reveals design of Microstrip BPF. The theoretical calculation done is in close agreement with the simulation results. It is noticed that Microstrip BPF showed improved performance as compared to filter designed using lumped components. It only explains design and simulation using ADS tool. It is also possible to generate layout using ads tool and fabricate the same.

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2 . Arabinda Roy , Pratik Mondal and Susanta Kumar Parui " *Designing of Bandpass Filter using CRLH Transmission Line and Floating Slot"* . Design of bandpass filter using composite right/left-handed (CRLH) transmission lines (TL) and floating slot is proposed here. This has been implementation by symmetric coupled microstrip lines and Hairpin type coupled lines. It is observed that OSO model have wider bandwidth in comparison to the SOS model. Both the design are simple, one may be changes to other by altering the position of the vias. The proposed floating slot arrangement in the ground plane offers tight coupling, which results low passband insertion loss of the filter. Such CRLH filters may be found suitable in various microwave applications.

III DESIGN OF HAIRPIN BANDPASS FILTER

The hairpin filter is one of the most popular microwave frequency filters because of it is compact size and does not require grounding. Hairpin-line band pass filters are compact structures. The concept of hairpin filter is same as parallel coupled half wavelength resonator filters. The advantage of hairpin filter over end coupled and parallel coupled microstrip is its low space utilization. In hairpin filter space is saved by folding the resonator which is half wavelength long. Also the hairpin design is simple then the other microwave filters. They may conceptually be obtained by folding the resonators of parallel-coupled, half-wavelength resonator filters, Many people have presented numerous design techniques for the realization of band pass filters such as parallel coupled line, comb line and split ring resonators. The disadvantage of parallel coupled line filter is that it suffers from spurious response which degrades the pass band and stop band performance of the filter. The advantage of hairpin filter over edge coupled and parallel coupled microstrip realizations, is the optimal space utilization. This space utilization is achieved by folding of the half wavelength long resonators. The absence of any via to ground plane or any lumped element makes the design simpler and fabrication of the filter made easy.

The normal-modes of symmetrical coupled lines are normal & coupled mode. Normal modes are classified as even and odd mode. The coupling between two microstrip lines can be described using homogeneous dielectric medium equations, where the electrical lengths are same for both the modes. Homogeneous symmetrical coupled lines, a four port

Network, may be described by the impedance matrix [Z]. The sixteen elements of the impedance matrix [Z] are given as,

$$Z_{11} = Z_{22} = Z_{33} = Z_{44} = -j(Z_{0e} + Z_{0o})cot\theta/2$$

$$Z_{12} = Z_{21} = Z_{34} = Z_{43} = -j(Z_{0e} - Z_{0o})cot\theta/2$$

$$Z_{13} = Z_{31} = Z_{24} = Z_{42} = -j(Z_{0e} - Z_{0o})csc\theta/2$$

$$Z_{14} = Z_{41} = Z_{23} = Z_{32} = -j(Z_{0e} + Z_{0o})csc\theta/2$$

Consider the four port network, Voltages and currents on the four ports are related by, **V = ZI.** The design equations for the hairpin bandpass filter terminating impedance ($Z_0 = 50\ ohm$)

$$Z_0^2 = Z_{0e}Z_{0o}\left(\frac{Z_{0e}-Z_{0o}}{Z_{0e}+Z_{0o}}\right)^2$$

Where Z_{0e} is the even mode characteristic impedance Z_{0o} is the odd mode characteristic impedance and Z_0 is the characteristic impedance.

IV IMPLEMENTATION OF HAIRPIN BANDPASS FILTER

To get the high coupling, the floating slot on ground plane is used, while the hairpin model is used to achieve the compactness. As, the bandpass filter with wide bandwidth for the models. Here, the gap between two coupled lines Sg = 0.5 mm is considered. To realize Zoe = 185.46 ohm and Zoo = 72.7 ohm, the values of width (W) = 0.6 mm, Sg = 0.5 mm and the gap between slots Ss = 5 mm are obtained. The length of the coupled line of the unit cell is taken as 26.2 mm and length of the floating slot as 25.7 mm as illustrated in Fig 2. Figure 2 shows the schematic diagram of the hairpin bandpass filter and figure 3 shows the S parameter of hairpin bandpass filter. The proposed structure is simulated by ADS (Agilent's Advanced Design systems) software and the S-parameters curves are plotted in Fig.3. The centre frequency at 2.4 GHz and 3 dB bandwidth of 0.9 GHz is observed. The prototype filter for models has been simulated on FR-4 substrate with the thickness of 1.6 mm and the conductivity (conductor) thickness is 45 µm. Table 1 shows the design specification of bandpass filter. The hairpin bandpass filter as the centre frequency 2.4 GHz and the upper cut-off frequency is 1.56 GHz and lower cut-off frequency is 2.53 GHz and the Bandwidth is 0.9 GHz. In figure 3, the S parameter curves are S(1,1) is the return loss or reflection loss and S(2,1) is the insertion loss.

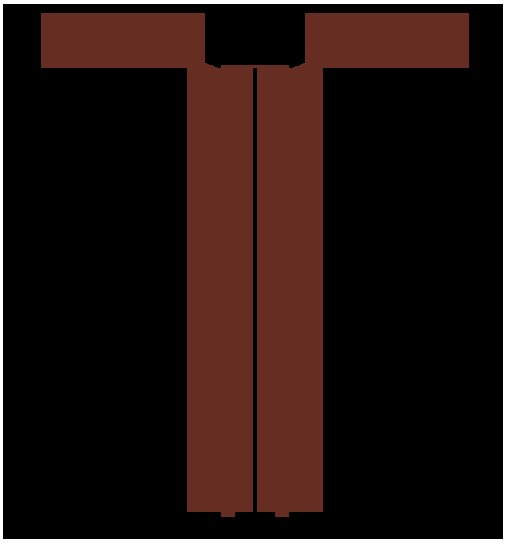

Fig 2 Schematic diagram of the hairpin bandpass filter

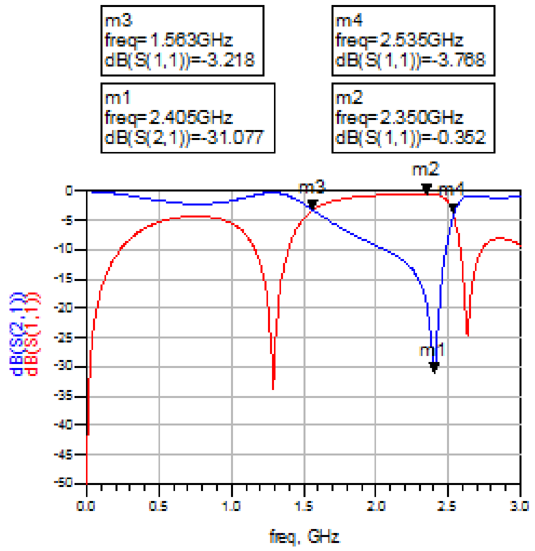

Fig 3 S parameter of hairpin bandpass filter

TABLE 1: BPF DESIGN SPECIFICATION

Centre frequency	2.40 GHz
Lower cut-off frequency	1.5 GHz
Higher cut-off frequency	2.5 GHz
Bandwidth	0.9 GHz or 900 MHz

V CONCLUSION

A new design methodology of hairpin bandpass filter is simulated. The layout of the final filter design with all the determined dimensions is illustrated. It is observed that the proposed filter have wider bandwidth. The proposed floating slot arrangement in ground plane, which results low passband insertion loss of the bandpass filter. Insertion loss (IL) in pass band is less than 1 dB and Return loss (RL) is greater than 25dB with good out of band rejection. The filter can be useful for WiMAX unlicensed applications and other modem wireless communication system applications which operate within this frequency range. Such bandpass filters may be found suitable in wireless applications like WLAN, UWB and ISM band.

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