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Design, Simulation and Analysis of Hairpin Filter using Defected Ground Structure

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ABSTRACT

This paper describes a new structure to implement compact microstrip hairpin filter with the advancement of U-shaped defected ground structure. This proposed bandpass filter is designed, analysed and then simulated on the substrate having relative permittivity of 12.9. The overall simulation of the present work has been created on HFSS software. Proposed hairpin bandpass filter shows improved bandwidth and good return loss. The analysis of results indicates the return loss of -17.5dB at 4.2 GHz, -23.63dB at 4.8 GHz, and -17.9dB at 5.6 GHz, -16.03dB at 6.5GHz, -14.69dB at 7.3 GHz. and the insertion losses with U-shaped DGS are 0.6dB/0.09dB/0.13dB/0.23dB/0.94dB. The area is reduced by 16%.

Keywords: Microstrip Hairpin Filter, Insertion loss, Return Loss, DGS.

I. INTRODUCTION

Recently, RF and microwaves are being used widely in astronomic research, radio spectroscopy, radars, transmission of television programmes, domestic ovens, mobile communication and many other things. This rapid progress in RF and microwave electronics has created an increasing demand for much more development in the particular field. Filters are most widely used and play an important role[1] in microwave communication, There is a requirement for filter with antennas to achieve the high performance because in an antenna at receiver section there are some bands of frequencies which are not desired and needed to be eliminated first before processing the signal, so that there is a requirement of band pass filter [2,3]. Defected Ground Structure(DGS) is one of the most popular method amongst all other techniques which are used for enhancing the parameters such as harmonic suppression etc. Literature [4-6] reveals the performance of bandpass filter and microstrip antennas by means of defected ground structure.

II. DESIGN AND SIMULATION

Hairpin filter is the most popular and widely used configuration in microstrip bandpass filters due to

their compact design. Hairpin line filter are formed by folding the resonators of parallel-coupled half-wavelength resonator filters. The filter is designed on a substrate Gallium Arsenide having a relative permittivity of 12.9. For designing of hairpin filter, the central frequency is 6.1 GHz. The low pass prototype parameter are $g_0=g_6=1$, $g_1=g_5=1.1468$, $g_2=g_4=1.3712$ and $g_3=1.9750$, having obtained the low pass parameters, the design parameters can be calculated by-

$Qe_1 = g_0g_1/FBW$.....(1)

$Q_{en}=g_ng_{n+1}/FBW$ …… (2)

Where, Qe_1 and Qen are external quality factor of resonator at input and output.

$M_{i,i+1}=FBW/\sqrt{g_ig_{i+1}}$ ..(3)

For i= 1to n-1 are the coupling coefficient between adjacent resonator.

The input and output quality factor is Qe_1= 7.456, Qe_5=7.45 and the coupling coefficient $M_{12}=M_{45}$=0.1250, $M_{23}=M_{34}$ = 0.0934,

Dimensions of Hairpin Band Pass Filter are shown in Table-1. Dimensions of U shaped defect are shown in Table-2 and Fig.1, shows top view of hairpin bandpass filter. The back view of hairpin bandpass filter is shown in the Fig.2 shown below.

Fig. 1: Top view of Hairpin bandpass filter.

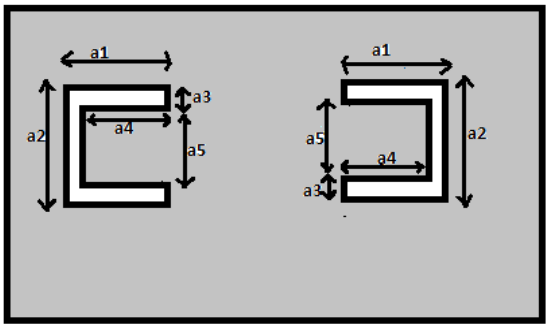

Fig 2: Bottom view of Hairpin bandpass filter

Table-1 Parameters for Hairpin filter

Parameters	Value
Internal gap of hairpin(L_1)	1 mm
Length of hairpin(L_2)	4.1 mm
Length of feed line(L_3)	1.55 mm
Width of feed line(L_4)	0.12 mm
Width of hairpin(L_5)	0.2 mm
Gap width	0.06 mm
Length of substrate	7 mm
Width of substrate	10.79 mm

Table-2 Parameters used in designing U-shaped defect

Parameters	Value
a_1	1.5mm
a_2	2mm
a_3	0.3mm
a_4	1.2mm
a_5	1.2mm

III. RESULTS AND ANALYSIS

In the present work, Proposed hairpin bandpass filter shows improved bandwidth and good return loss. The proposed hairpin bandpass filter shows return loss of -17.5dB at 4.2 GHz, -23.63dB at 4.8 GHz, and -17.9dB at 5.6 GHz, -16.03dB at 6.5GHz, -14.69dB at 7.3 GHz. The insertion losses with U shaped DGS are 0.6dB/0.09dB/0.13dB/0.23dB/0.94Db.Fig.3 and Fig.4 shows, S_{11} and S_{21} plots of the hairpin bandpass filter with U-shaped DGS.Area of the bandpass filter in previous work[7] is 75.53mm^2.Area of hairpin bandpass filter in proposed work is 65.53mm^2.Thus Area is reduced by 16 %.

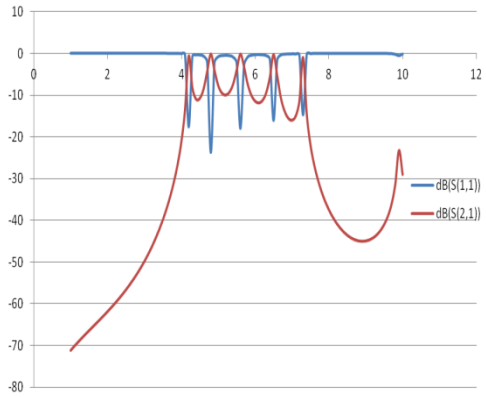

Fig.3: S_{11} and S_{21} plot with U-Shaped DGS

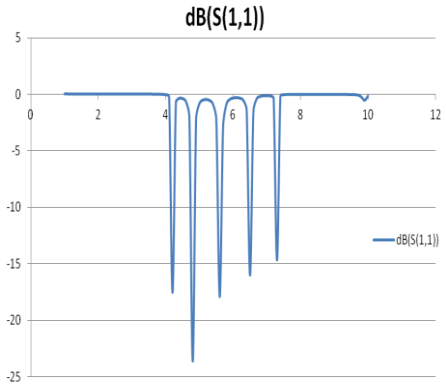

Fig.4: S_{11} plot with U-Shaped DGS

IV. CONCLUSION

In the present work, multiband hairpin band pass filter is designed with U shaped defected ground structure and its performance is analyzed. Proposed hairpin bandpass filter shows improved bandwidth and good return loss. Area of the bandpass filter in previous work[7] is 75.53mm ^{2}. Effective Area of hairpin bandpass filter with U-Shaped defected ground structure in proposed work is 63.53mm^2.Thus Area is reduced by 16 %. Proposed hairpin bandpass filter with defected ground structure has resonant frequencies 4.2GHz, 4.8 GHz, 5.6 GHz, 6.5GHz, 7.3 GHz, so that it covers C band. The frequency range for C band is from 4GHz to 8 GHz. This filter can be used for surface ship radar, weather radar, optical communication, cordless phones, some Wi-fi devices and for satellite applications.

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