Design and Fabrication of an U-Shape DGS with Openstub in CPW Bandpass Filter

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Abstract— **The design, simulation and fabrication of coplanar waveguide (CPW) bandpass filter (BPF) has been described in this paper. It mainly focuses on Defected Ground Structure (DGS), where U-shaped DGS with open stub in transmission line has been introduced. By etching the DGS pattern in ground and transmission will change the distribution of inductance and capacitance to produce filtering effect. This paper also discusses about the influence of geometrical parameter *l* for the improvement in the frequency response of bandpass filter. As increasing the dimension of the geometric parameter *l* shift the center frequency to the higher frequencies. This filter offers a bandwidth of 1.65 GHz with passband ranging from 2.1 GHz to 3.75 GHz with a stopband rejection is about -28 dB.**

Keywords: Coplanar waveguide, Defected Ground Structure, Bandpass filter

I. INTRODUCTION (*Heading 1*)

The explosive growth in wireless communication and other portable receiver and transmitter applications need a filter with low loss, smaller size, light weight, and low cost filters. More over filters are mainly used in front ends of microwave communication in radars and measurement system to select a required band of signal with reduced losses. The microwave filter can be designed with some of the techniques such as High Temperature Superconducting (HTS) material, Bulk Acoustic Wave (BAW) or Surface Acoustic Wave (SAW) devices. But all these techniques are fabricated using microstrip line technology. However, among the planar microwave transmission line topologies, the coplanar waveguide (CPW) has very good characteristics at high frequencies, and flexibility for assembling shunt as well as series components on a single plane.

Bandpass filters are essential components of most microwave and mobile communication system. Such system usually requires better filter structure. Additionally such filter must have a high rejection in the stop-band. The performance of the filter can be modified by following ways:

Asymmetric structure, where the gap between the transmission line and ground is varied [10] [14].

Defect on ground and defect on transmission lines are some other methods to improve the performance. The goal of the defected ground structure is to change the guide wave properties, by etching the lattice shape in the ground plane, for providing a better filtering effect [6]. In this some portion of the ground or transmission line is etched to change the characteristics without increasing the circuit size [4] [3] [6] [7] [9] [10] [11] [13] [15] .Defect on transmission line may use open stub, shorting stub for filter design ,which can be further modified to achieve better performance [2].

Selectivity of the filter is further improved by using a cascaded DGS. In this, defect on the ground or transmission line is cascaded to eliminate the unwanted response [1] [5] [12].The proposed filter consist of U-shape DGS with open stub in the transmission line.

II. EXISTING FILTER DESIGN

Tamasi Moyra et.al proposed T-shaped DGS in the ground of coplanar waveguide. The T-shaped DGS is a modified structure of dumbbell shape DGS, provides a wide stop band. The capacitance of T-shaped DGS is higher than the capacitance of dumbbell shaped DGS. It introduces low pass filter response. But it has an insertion loss of -1.2 dB in pass band. The insertion loss can be reduced with the help of high-low coplanar waveguide transmission line [11].

Amit Ghosh et.al proposed the open stub in transmission line. In this selectivity is improved by cascaded DGS. A Number of stubs were increased to improve the selectivity and insertion loss. As increasing the number of stub the insertion loss and size of the filter also increases [1].

The existing design has limitation on high insertion loss for increased number of stubs. As number of stubs increases, the size increases. So the number of stubs should be chosen minimum provided the insertion loss should be minimum and high selectivity.

III. PROPOSED FILTER DESIGN

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A. Novel Bandpass Filter

In order to provide solution to above problems, a bandpass filter with DGS has been designed with minimum number of stubs. The behavior of the structure has been simulated using

HFSS electromagnetic solver. The proposed filter introduces a high rejection in the stopband. The proposed bandpass DGS filter has produces a passband ranging from 2.1 GHz to 3.75 GHZ with a stopband rejection of more than -28 dB

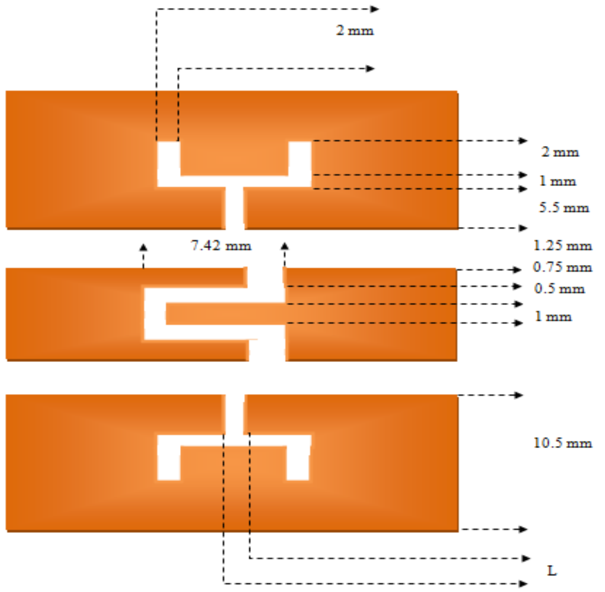

Fig.1 Schematic diagram of proposed bandpass filter

Figure 1 shows the schematic diagram of the proposed bandpass filter. It has been constructed with U-shape DGS with open stub in the transmission line. The U-shape DGS is etched in both side of the ground plane. The coplanar waveguide lines used for this filter were designed to have a characteristic impedance of 50 Ω. This impedance corresponds to G/W/G of 1.25/3.5/1.25.the filter has been built on FR4 substrate that has a relative dielectric constant of 4.5 and thickness of 1.6 mm. Geometrical parameter of the filter structure are l=2.42 mm. The total area of the bandpass filter is 29.42×27 mm^2. The substrate is covered by copper layer with a thickness of 0.017 mm. The layout and dimension of a designed filter is mentioned in figure 1. The response shows that the filter will allow frequency from 2.1 GHz to 3.75 GHz. open stub in the transmission line introduces a series inductor with parallel capacitor. The parallel capacitance produced due to the gap in the open stub and the inductance is due to the self inductance in transmission line. From the design made it has been found that Series inductance with parallel capacitance act as a resonant circuit so that it produces a response of bandpass filter.

The simulated filter is designed for a frequency of 3.2 GHz. From simulation it has been found that the insertion loss is -0.5356 dB, return loss is -25.8337 dB. Even though it has a better performance, the filter resonates at two frequencies that are 2.5 GHz & 6 GHz. So we go for further step of optimization. In which the dimension of the DGS is changed iteratively until achieving better performance.

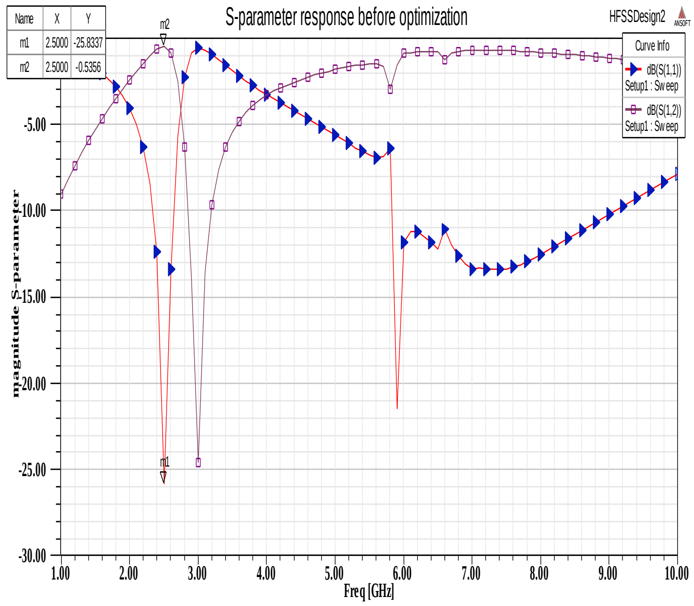

Fig.2 EM simulation result before optimization

B. *Optimization of proposed filter*

The length *l* is chosen for optimization based on current distribution in surface**.** By means of varying the length it has been found that an optimal length of *l*=2.42 mm produces a passband of 2.1 GHz to 3.75 GHz and has a resonance frequency at 3.2 GHz. More over a better insertion loss at the passband is -0.4179 dB and return loss is -30.4008 dB is achieved with filter as shown in figure 2. By inferring Table.1 the resonance at two frequencies is eliminated by increasing the length *l*. As further increasing the length *l*, losses of the filter also get increases. So the length *l*=2.42 mm is a minimum length for better performance.

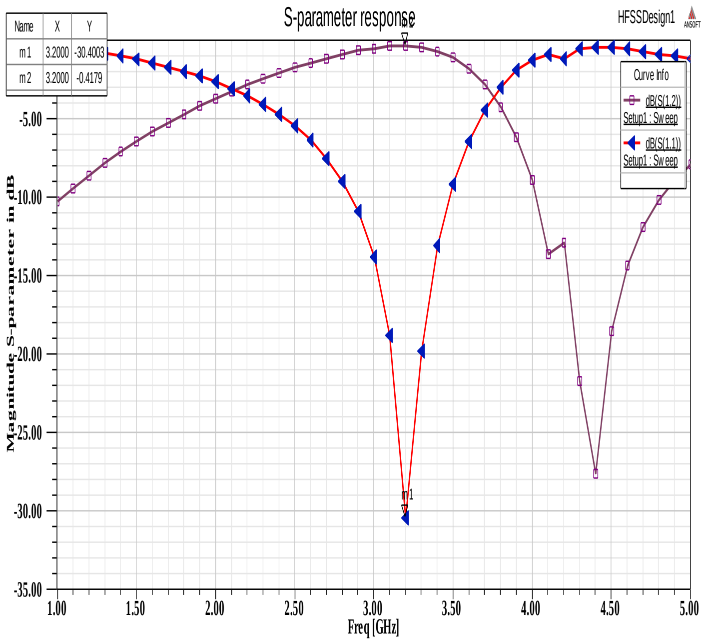

Fig.3 EM simulation result for the proposed bandpass DGS filter

TABLE I. COMPARISION OF FILTER WITH AND WITHOUT OPTIMIZATION

Filter	**Performance**		
	Resonant frequency (GHz)	***Insertion loss (dB)***	***Return loss(dB)***
without optimization	2.5 and 6	-0.5356	-25.8337
With optimization	3.2	-0.4179	-30.4003

C. *Control of frequency response*

For controlling the frequency response the geometrical parameter of length *l* has been used. Figure 4 and figure 5 shows the influence of length *l* on the filter response. As can be seen reducing the length of the DGS shift the center frequency to lower frequencies and vise versa. Figure 4 and Figure 5 shows the insertion loss and return loss response for various dimensions of Length *l*. Table.2 shows the characteristics of filter for various length *l*. Figure 4 and Figure 5 shows the insertion loss and return loss response for various dimensions of Length *l*. Table.2 shows the characteristics of filter for various length *l*.

TABLE II. CHARACTERISTICS OF FILTER FOR DIFFERENT LENGTH

Length (*l*) (mm)	**Pass band (GHz)**	**Center frequency(GHz)**	**Insertion loss (dB)**	**Return loss (dB)**
0.42	1.9-2.8	2.6 and 6	-0.7062	-18.1697
1.42	2.1-3.45	3.0	-0.4546	-25.4919
2.42	2.1-3.75	3.2	-0.4179	-30.4003

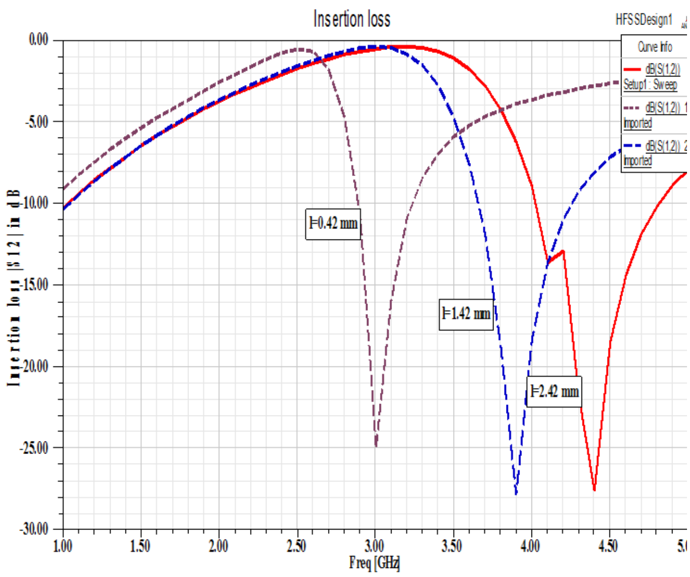

Fig.4 EM simulation of insertion loss for the different values of the geometrical parameter *l*

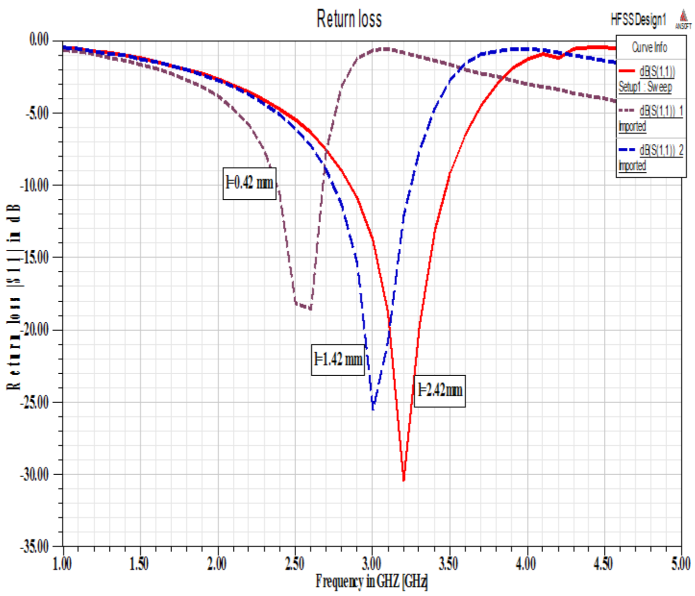

Fig.5 EM simulation of return loss for the different values of the geometrical parameter *l*

D. *Fabrication of the Structure*

The simulated design of U-shape DGS with open stub in transmission line has been fabricated using single side copper coated FR-4 substrate. The copper coated fr4 substrate has a relative permittivity (ε_r) of 4.4 and a substrate height of 1.6 mm. The DGS pattern is etched and then connected to the 50 Ω SMA connector for the measurement of results. The fabricated structure is shown in figure.6

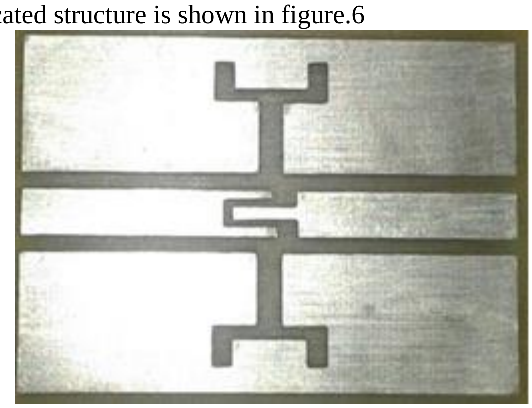

Fig.6 Fabricated U-shape DGS with open stub in transmission line

IV. COMPARISON OF SIMULATED AND MEASURED RESULTS

The proposed filter has been designed, simulated, and optimized, then fabricated and measured. A comparision of simulated and measured result of U-shape DGS with open stub in transmission line has been depicted in the figure.7 and figure.8. There is a good agreement between the simulated and measured result is achieved.

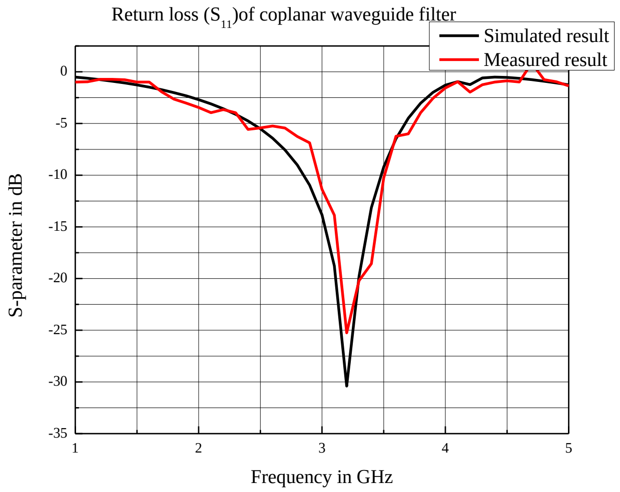

Fig.7. Simulated and measured insertion loss comparison

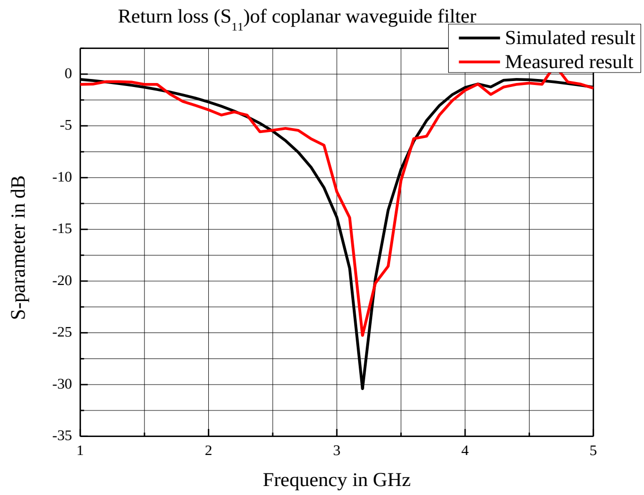

Fig.8. Simulated and measured return loss comparison

V. CONCLUSION

A compact bandpass filter using U-shape DGS with open stub in transmission line has been proposed. For the designed filter bandpass filter response has been introduced with single open stub in transmission line. So the total size of the filter has been reduced. The filter has been designed on FR4 substrate so the total cost of the filter design also reduces. The proposed filter has better stopband rejection of -28 dB. The proposed filter has a bandwidth of 1.65 GHz ranging from 2.1 GHz to 3.75 GHz. The Bandpass filter has an insertion loss of -0.4179 dB and return loss of -30.4003 dB by compromising the selectivity of the filter. That is the transition from stopband to passband and passband to stopband is gradual not a sharp transition. The filter has been fabricated and measured; good performance has been achieved in the passband of the filter.

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