A Design of SIW Filter with DGS for 5G Applications

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Abstract— ***This paper presents filter design using Substrate Integrated Waveguide (SIW) technology with rectangular Waveguide (RWG) as a transmission path. Defective Ground Structure (DGS) is implemented to improve the efficiency. Which is suitable For Millimeter Wave applications like RADAR, 5G, etc. In this Design two resonance peaks are available; first one occurs at 37GHz with return loss of -3db and gain is 2db and second resonance occurs at 30.9GHz with a return loss of -11.08db and the gain is 1.3db. Both resonance are given greater than 1GHz. This filter design frequency is mainly designed for 5G Applications.***

Keywords—SIW; DGS; 5G; RADAR; RWG; BPF.

I. INTRODUCTION

NOW a day's design of good wireless communication system is big challenging for RADAR and 5G application issues. Because a number of applications and technology increases which require high bandwidth, not only require high bandwidth but also consider design parameter like high selectivity, compact size, low cost and insertion loss is low. Planar and Non-planar technologies are incapable of providing these characteristics at the time of design. Non-planar circuits provide good quality factor but not in size and cost. Planar circuits provide compact size but not in quality factor. so the combination of planar and non-planar advantages developed new technology Which is Substrate Integrated Waveguide (SIW). This is a most suitable method for high-frequency applications especially for millimeter and sub millimeter applications. SIW is made up of sandwiching two metal layer by a substrate and the side faces by rows of the array of metallic holes. These holes have a diameter and spacing small to appear as electric walls, which implies that certain modes cannot resonate.

Generally,49.2GHz to 50.2GHz frequencies are used for geostationary satellites with fixed earth stations. Which require high bandwidth with the good quality factor. But bandwidth and quality factors are inversely proposnal. so it is impossible to get good bandwidth as well as a quality factor but millimeter wave require both are in good manner. Millimeter wave applications like RADAR ,5G etc,Require above 1GHz of bandwidth .

In this paper the second section design of SIW, third section explains the design of Band pass filter and use of RWG transition. fourth sections explains the Implimentation of DGS method in the filter and fifth sections explains the results.

II. DESIGN OF THE SIW TECHNOLOGY

SIW is made of two metallic are placed above and below of substrate metal, replacing two arrays of side holes are shown in below Fig.1 . SIW design parameters.

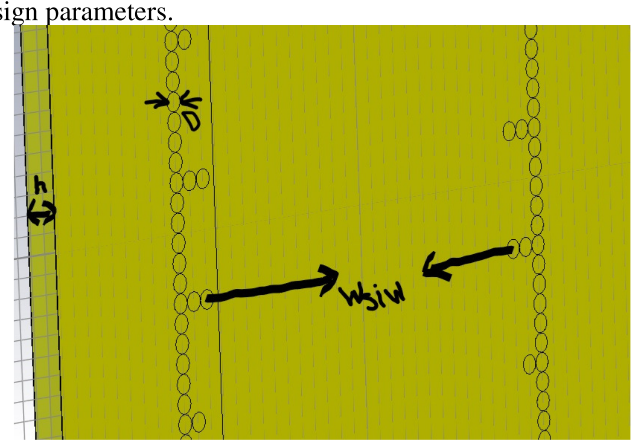

Fig.1. SIW structure and it's parameters.

Here "h" is the thickness. "D" is the diameter of the holes. "Wsiw" is the length of the holes from one end to another in the patches.

$$W=\left(\frac{c}{2f_\circ} \; \frac{\sqrt{2}}{\sqrt{(\varepsilon_r+1)}}\right) \quad (1)$$

$$\varepsilon_{reff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2} \quad (2)$$

$$\Delta L = 0.412h\left[\frac{\varepsilon_{reff+0.3\left(\frac{w}{h}\right)+0.264}}{\varepsilon_{reff-0.256\left(\frac{w}{h}\right)+0.8}}\right] \quad (3)$$

This formula's are used to calculate the Theroretical value for the Width (W) of the Substrate. εreff is to calculate the Effective Dielectric Constant (εreff) the dielectric constant shows the conductivity of the Substrate. and change of length (ΔL) of the substrate with respect to time.

The propagation properties and electromagnetic field distribution of SIW and conventional cylindrical coplanar waveguide are similar.

III. THEORECTICAL STUDY OF BANDPASS FILTER

The advanced technology allows integrating all the components (active and passive) by using various topology in packing nothing but system on package(SOP) and System in package(SIP). For RF circuit and other components are designed by adopting (SIP) technology which is extended into system on substrate(SOS). To implement Millimeter wave system ,SOS is the ideal flat form. In SOS all the components are connected in series or shunt manner. Microstrip transition connection is not supported by series or shunt manner. Microstrip transition connection is not supported by shunt types of components which are supported by series components only. But rectangular waveguide(RWG) transition provide good impedance but quality factor is and dispersion is medium .But microstrip provides 20-150Ώ but it provides good quality factors but no suitable for the design of all types of components on the single substrate.

The design of RWG is shown in fig.2.The GRWG must respect the form factor. By changing S bandwidth is also changes.

Bandpass Filter (BPF) that passes signal with frequency in particular range and reject frequency outside this range. The compliment to Bandpass filter is the band reject or band stop filter. We choose the selective frequency of 28GHz to 50GHz so this is SIW filter called as Bandpass filter.

$$L_{eff}=\frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \quad (4)$$

Band pass filter consist of parallel resonance circuit. Here Effective dielectric length of the substrate can be calculated from (4). Length of the Substrate is calculated by using below formula.

$$L=L_{eff}-2\Delta L \quad (5)$$

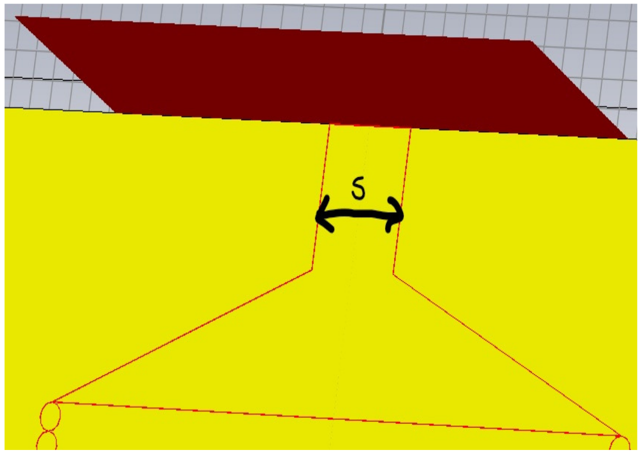

Fig.2. RWG structure and its parameters

IV. DEFECTIVE GROUND STRUCTURE

In this filter implementing a DGS method to improve the efficiency as well as bandwidth . That is nothing but the small defect (i.e.,small rectangular shape cut) in the ground plane is shown in fig.3.

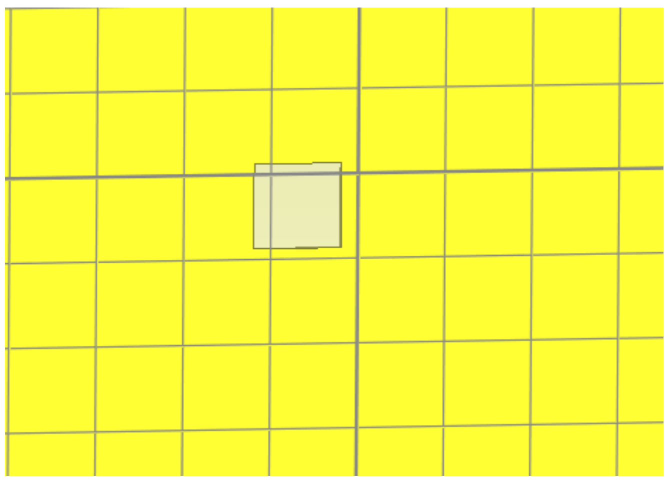

Fig.3.DGS is Implimented in the ground plane.

V. RESULTS AND DISCUSSION

To design a filter, Rogers RT 5880 substrate is used. It's εr = 2.2. height of substrate 1.6mm copper plate thickness is 0.035. From (1), (2) and (3) via width W is 0.3mm, Effective dielectric constant $\varepsilon reff$ is 1.6mm and change of length (ΔL) is0.5mm. These parameters are used to calculate the Length , Width and Conductivity of the substrate. A spacing between holes from one end to another in the patches Wsiw is 23mm.

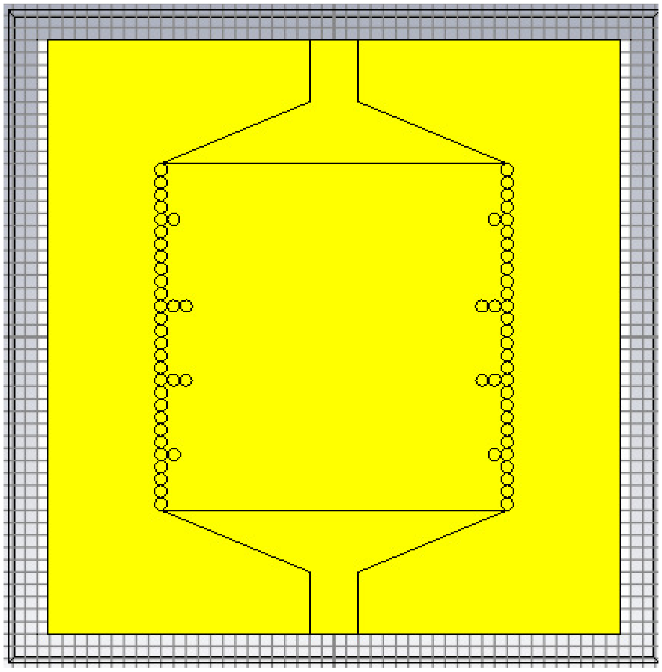

Fig.4.Proposed SIW Filter Design structure and its parameters.

Designing a filter with DGS in the frequency of 28GHz-50GHz for the 5G Applications.

$$W_g = 6h + w \tag{6}$$

$$L_g = 6h + L \tag{7}$$

From (6) and (7) a length and width of the ground can be calculated

TABLE.1.proposed siw filter design structure parameters.

parameters	***Values (mm)***
Lsiw1=Lsiw3	7.0
Lsiw2	5.0
Dsiw1=Dsiw4	24.9
Dsiw2=Dsiw3	23.0

By using CST software we run the structure and get, the results shown below figure 5. In the results, we analysed the return loss and efficiency of the SIW filter using DGS method.

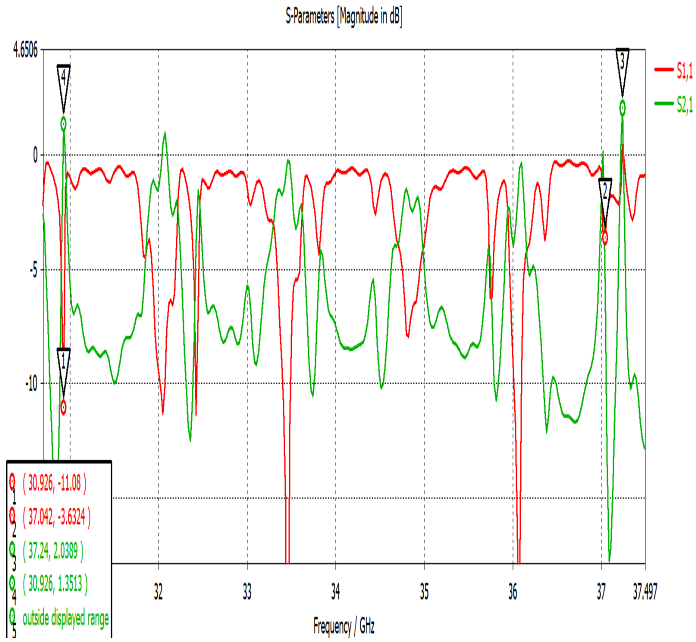

Fig.5.Simulation results of proposed filter

From the results, two waveform can be occurred. To calculate the bandwidth on S11 graph -36.3dB in the frequency of 33.4GHz is taken as reference. Red line S11 is reflection Coefficient and Green line S21 is calculate the efficiency. In the S12 graph 2.03dB is occurred in the frequency of 37.2GHz its represent the efficiency of SIW filter.

In this result not only concentrate on the bandwidth as well as to improve efficiency also to perform in a good manner.

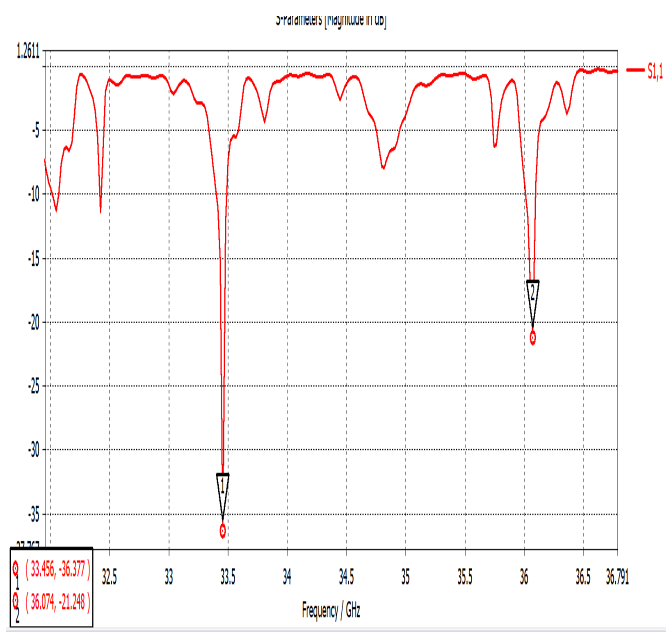

Fig.6.Return loss of proposed filter

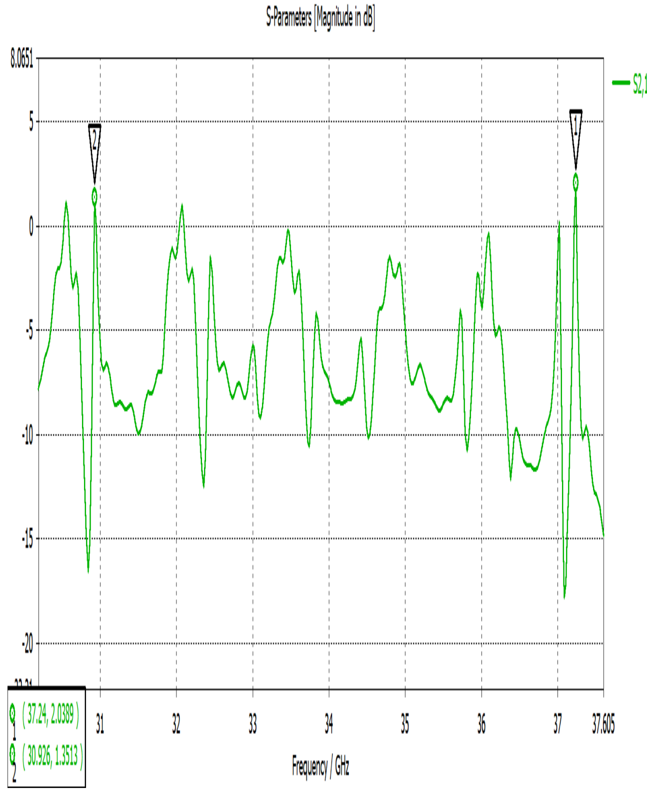

Fig.7.Gain of proposed Filter

VI. CONCLUSION

This paper discussed the use of SIW using DGS method in RWG as a transmission path and also discussed the designs are suitable for millimeter application like RADAR, 5G Application with good reflection coefficient and efficiency. In future bandwidth is increased these device also suitable for the machine to machine communication because also a compact size.

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