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DESIGN OF BAND PASS FILTER USING SUBSTRATE INTEGRATED WAVEGUIDE STRUCTURE FOR 5G APPLICATION

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***Abstract*— This paper present filter design using Substrate Integrated technology for 5G application. Which is suitable for Radar, 5G, Etc., Millimeter wave application Combining planar and non-planar technologies a new SIW technology has been developed). 5G will utilize the range in existing LTE recurrence run (600MHZ to 6GHZ) and in millimeter Wave groups (24GHZ - 86GHZ). 5G speed will range 50Mbps to 2Gbps and even to grow 100Gbps which is hundred times faster than 4G. In order to develop 5G application we need to design Band pass filter using SIW structure.**

We need to design the microstrip transmission line in CST studio. Microstrip is the sort electrical transmission line which can be created utilizing printed circuit board. it issued to convey micro wave frequency signal.

***Index Terms*— SIW, 5G, Band pass filter, Slots, Vias, CST microwave studio**

I. Introduction

Substrate incorporated waveguide (SIW) is a kind of transmission line that has created since the twenty-first century. This new innovation has gotten well known as it has opened different approaches to the plan of productive microwave and millimeter wave circuits requiring little to no effort. This new innovation executes a regular air-filled rectangular waveguide on a bit of printed circuit board (PCB) the side dividers is supplanted with two lines of metallic posts otherwise called through gaps. The SIW acquires the upsides of the microstrip, for example reconciliation and minimized size, keeping up a portion of its waveguide trademark, for example low radiation misfortune, quality factor just as the powerful dealing with attributes. SIW as a transmission line is set up with conditions administering its physical structures.

Different creators have announced bandpass channels (BPFs) actualized with various transmission line advances including: microstrip, waveguide, and SIW.

A BPF is a gadget that passes frequencies inside a solitary band while dismissing every single other recurrence outside the band. BPFs are essential parts in remote correspondence frameworks to dismiss undesirable range from the correspondence channels.

Some structure elements or parameters of channels, for example, selectivity, cost, size, affectability to natural impacts, power taking care of limit, in-band and out-of-band execution measurements, are basic particulars with regards to the advancement of microwave correspondence front finishes and radio recurrence (RF).

Architects are frequently required to make bargain between a few clashing necessities as it is fairly troublesome or even genuinely or potentially electrically difficult to at the same time accomplish all plan standards or determinations. For example, accomplishing higher channel selectivity typically requires the utilization of more resonators, which will bring about higher inclusion misfortune along the transmission way.

Progress between SIW structures and planar transmission lines are an indispensable component identified with SIW gadgets. Various distributions have given SIW inquire about discoveries different sorts of information/yield changes. Microstrip-to-SIW changes dependent on a straightforward shape. The tightened segment associates a 50 Ohms microstrip line and the SIW structure

In this paper to design the band pass filter characteristics slots are introduced between the two rows of via holes. The width of the slot is 0.2mm and length of the slot is 10mm.

Now different slots are introduced using formulae.

$$h_i = h-(1.6i) \text{ where } i = 1,2,3,4.$$

The SIW filter is made up of three layers ground, substrate and patch. These layers are designed by placing upon each other, first ground is placed. Upon the ground, substrate layer is placed and the patch layer is placed upon the substrate. All these have specific dimensions.

After the completion of the layers, the via holes is introduced in two rows in the filter. These via holes play crucial role in making of good filter. The via holes inserted into the layers of filter and these vias has specific diameter based on working frequency we are selected for performing results. Transverse magnetic (TM) modes do not exist, TE10 therefore is the dominant mode because there are vias at the sidewalls.

Then microstrip transmission line is attached to the filter to transfer or to send waves in and out of the filter and all these are normalized to 50ohm.

Later the slots are introduced between the two rows of vias, and the length and the breadth of slots can be altered as required for frequency we selected by trial and error method.

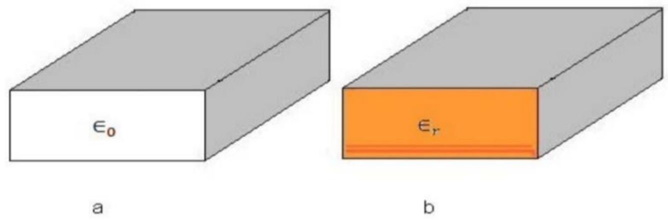
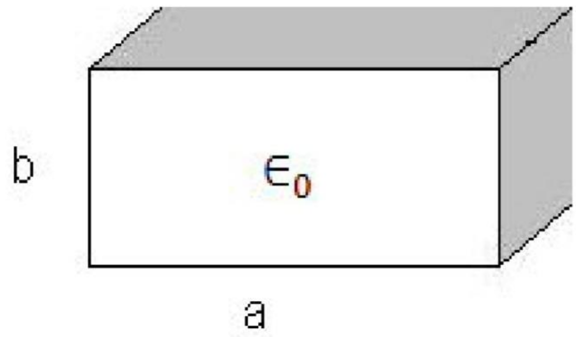


Figure 1: (a) Air filled waveguide, (b) dielectric filled waveguide, (c) substrate



II. DESIGN OF THE SIW TECHNOLOGY

The SIW consists of two metallic plates above and of the substrate metals. SIW specification parameters.

D is the vias diameter.
P is the separation between two nearby focuses to the focal point of the vias.
Wsiw is the genuine separation between two columns of vias.

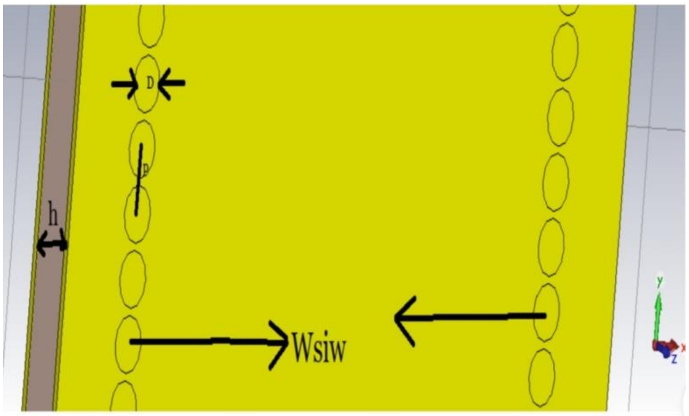


Fig 1. General siw structure

Here "a" is the standard element of ordinary rectangular waveguide.

$$W_{eff} = W_{siw} – D^2/ (0.95\, p)$$
$$W_{eff} = a/\sqrt{\varepsilon r}$$
$$P \le 4D$$

III. SIW DESIGN EQUATIONS

SIW gadgets might be known as a dielectric type filled waveguide (DFW), so beginning stages could be DFW. For TE10 the measurements b isn't significant as it doesn't influence that cut off recurrence of the waveguide.

A. *cut off frequency*

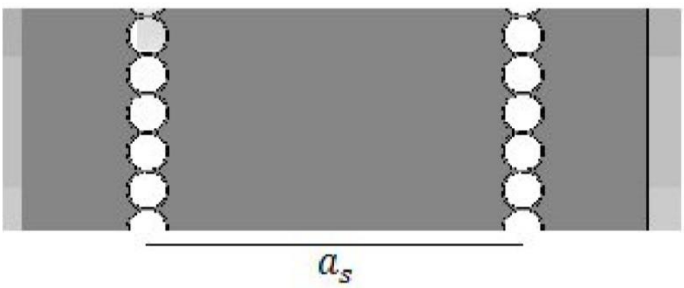
$$f_c = \frac{c}{2\pi}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$$

where:
c: speed of light
m, n: indicates mode numbers
a, b: measurements of the waveguide

B. *simplified formula*

$$f_c = C/2a$$

where:
c: speed of light
a: dimension of waveguide



$$a_d = \frac{a}{\sqrt{\varepsilon_R}}$$

$$a_s = a_d + \frac{d^2}{0.95p}$$

where

d: diameter of the via

p: pitch (distance between the vias)

C. Guided wavelength

$$\lambda_g = \frac{2\pi}{\sqrt{\frac{\varepsilon_R (2\pi f)^2}{c^2} - \left(\frac{\pi}{a}\right)^2}}$$

D. Diameter and Pitch

$$d < \frac{\lambda_g}{5}$$

$$p < 2d$$

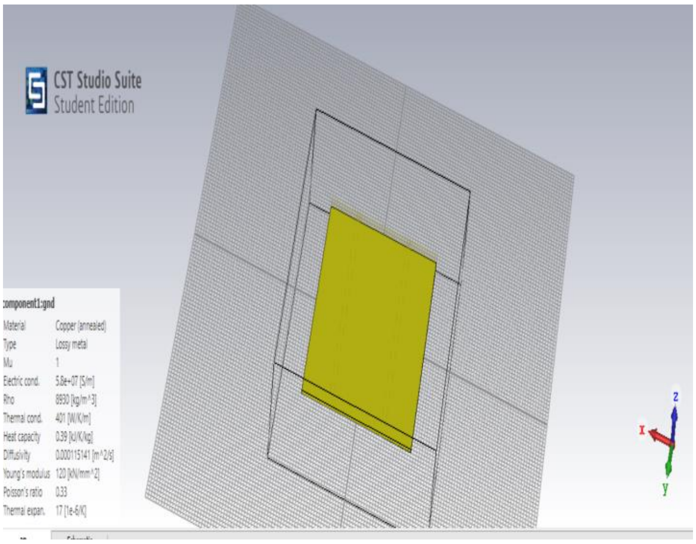
IV. DESING DETAIL

For design and simulation process we have used CST microwave studio suite. This suite is a very useful application which helps us to know the outcomes of the particular design without manufacturing it. It also reduces the money that we waste for fault component. In this project we have designed two components and an antenna. The design of all the components are based on three-layer structure. The thickness of each respective layer is me in all three designs. It is as shown in the below table.

S.no	LAYER	THICKNESS
1.	GROUND	0.012mm
2.	SUBSTRATE	0.500mm
3.	PATCH	0.012mm
4	VIAS	0.8(diameter) 0.524mm(thickness)
5	SLOTS	8mm (length) 0.2mm(breadth) 0.524mm(thickness)

A. GROUND:

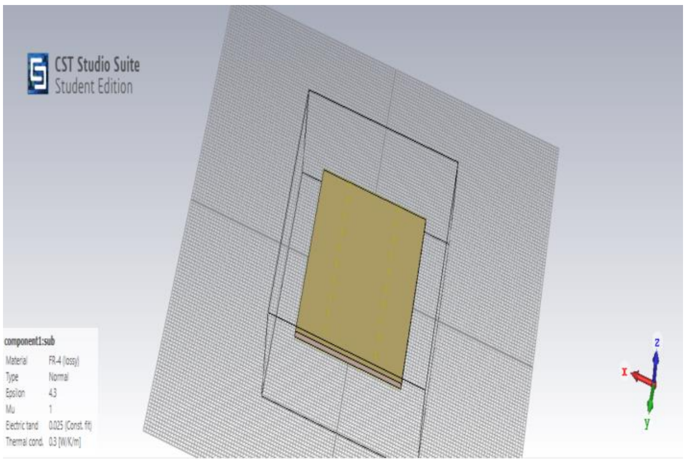
From the ground all other components are build up. The Thickness of the ground is based on projects specifications.



GROUND

B. SUBSTRATE:

It is built up on the ground. The material used for the substrate is Rogers5880. The thickness of the substrate is depending upon the project specification.



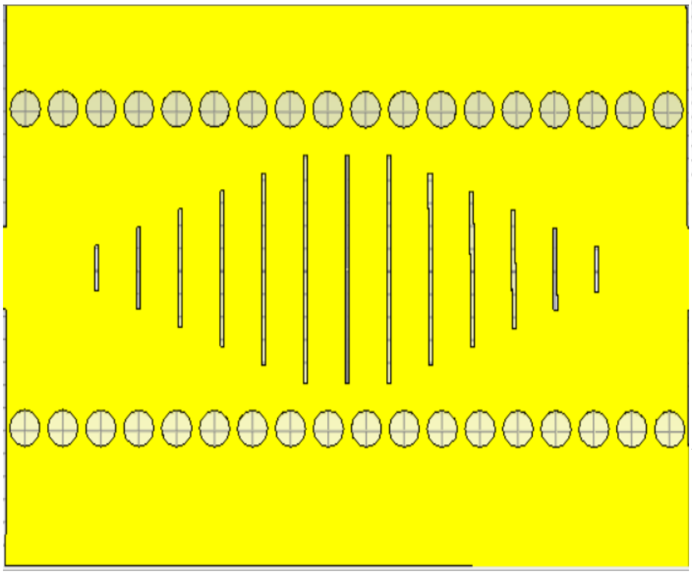
SUBSTRATE

C. PATCH AND VIAS:

This is the main part in design we send waves through vias inserted in the patch

For transmitting the input signal. This will be connected to the feed port with a copper layer as shown in the fig.5.4. the component is made of copper, the substrate dimensions are as x-axis length as well as the y-axis length is 50mm and is made "Rogers5880" material.

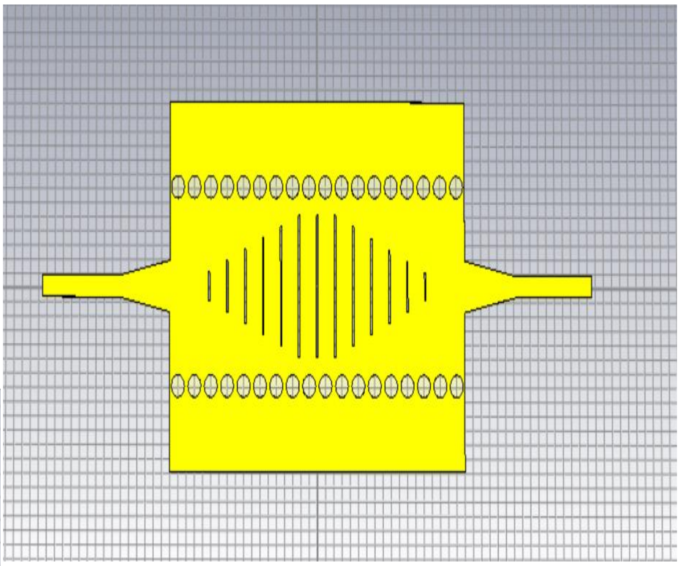
The ground is also designed with same dimensions but the material with which it is made is pure copper.



PATCH AND VIAS

D. D. MICROSTRIP FEED / TRANSMISSION LINE:

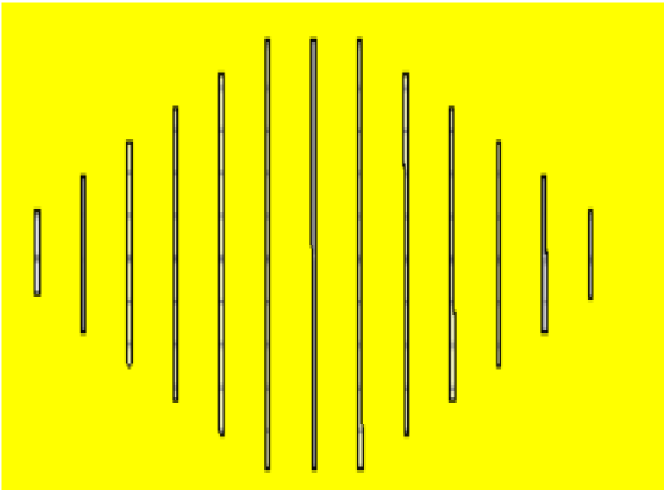
we can see two shapes connecting with filter on both sides, this is known as microstrip feed/transmission line. From this, waves are sent into and out from the filter.



SIW MICROSTRIP

E. SLOTS:

By using these slots waves are filtered in the siw filter between the bandwidth of band pass filter. The gap between each slot is 2mm.



SLOTS

V. PROPOSED WORK

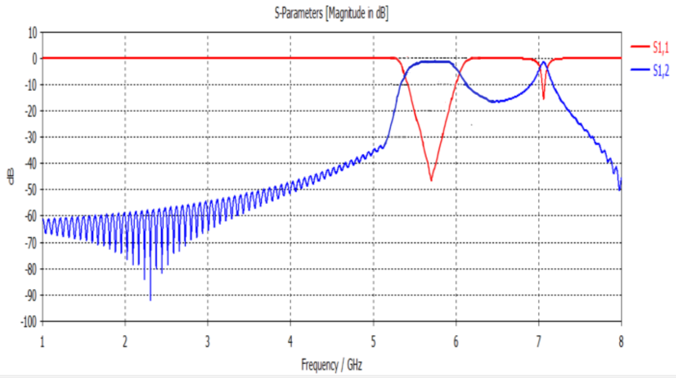
In this project we are going to do design a Band pass filter using substrate integrated waveguide for5G application

5G is intended for different purposes, giving us quicker download speeds, greater limit, and low idleness network for billions of gadgets particularly in the zones of augmented reality (VR), IoT, and man-made brainpower (AI).

The band pass filter will be designed in CST Microwave studio. In order to design the filter, we need to calculate the design required parameters

VI. RESULTS AND DISCUSSION

From below results, maximum resonance peak is available in Graph which is 5.7GHz. To calculate the bandwidth on S_{11} graph -10dB is taken as reference. Red line S_{11} is reflection coefficient and the blue line S_{12} is the transmission coefficient.



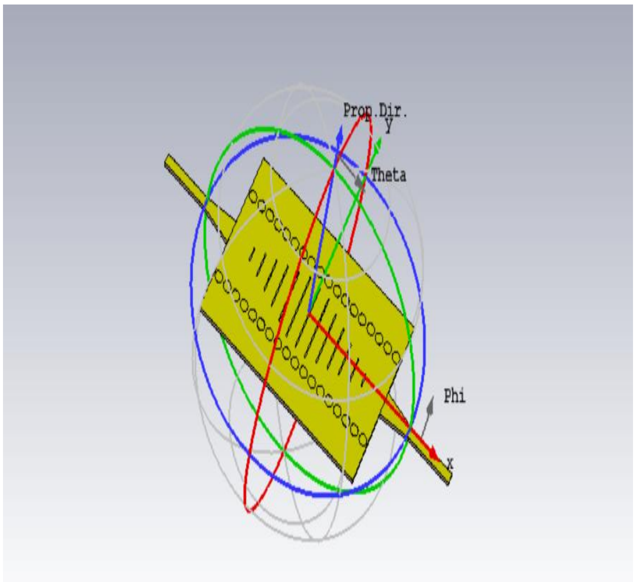
Filter S-parameters

From the graph bandwidth at resonance peak is 600MHz.which describes lower band of 5G frequency range.

This can be used in mobile towers. From above results the start frequency is 1GHz and stop frequency is 8GHz. Lower band 5G frequency range is 600-700MHz.

In this $S_{11}=S_{22}$ and $S_{12}=S_{21}$.

FAR FIELDS VIEW:



VII. CONCLUSION

The project is designed and simulated using CST microwave studio suite. These components that we designed have shown the results that proves that they can be used for developing 5G applications. We can say that these components can also reduce the insertion loss and the discontinuity in the network. So, the output will be very effective. This concludes that this band pass filter can achieve lower band 5G application through this siw structure. By changing the slot length and altering via diameter we can achieve higher 5G bandwidths. This can be developed in future.

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