DESIGN OF A SQUARE CAVITY DUAL-BAND SIW BANDPASS FILTER

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Abstract -This project presents the design, simulation and fabrication of a substrate integrated wave guide band pass filter. Band pass filter is used to receive the desired band of frequency and to reject the frequency which is outside the band. A Microwave system is generally designed by using fundamental components such as filters, couplers, dividers etc... Micro strip based devices can be used up to certain frequencies. The conventional microwave components which are heavy, bulky in size, high cost. In order to overcome these drawbacks we have chosen substrate integrated wave guide as an alternative approach. The design and results will be obtained from the CST software.

Index Terms - CST Software, Wave guide, Filter, simulation, frequency

Introduction

Filters are electronic circuits that remove any unwanted components or features from a signal. In simple words, you can understand it as the circuit rejects certain band of frequencies and allows others to pass through. They are widely used in instrumentation, Electronics and communication systems. These are essential building blocks of any Electronic and Communication Systems that alter the amplitude and/or phase characteristics of a signal with respect to frequency. Filter is basically linear circuit that helps to remove unwanted components such as noise, Interference and Distortion from the input signal. Ideally Filter alters the relative amplitudes of the various frequency components and the phase characteristics and its Gain depends entirely on the frequency.

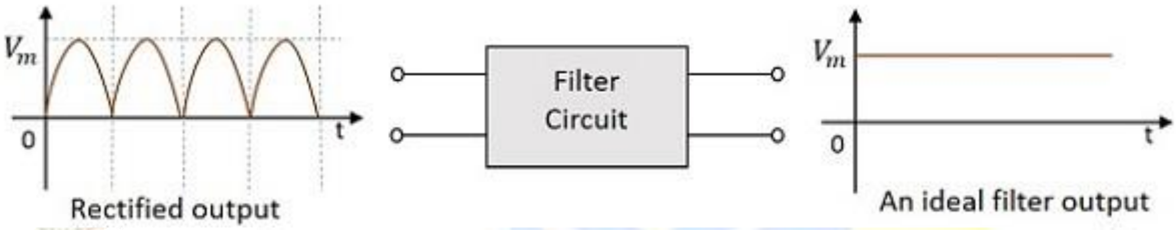


Fig.1.1 Block diagram of filter

1.1 TYPES OF FILTERS:

Filter is mainly classified into two types such as Active filter and Passive filter.

1.1.1 Active filter:

Filter circuit which consists of active components like Transistors and Op amps inaddition to resistors and capacitors is called Active filter.

1.1.2 Passive filter:

Filter circuit which consists of passive components such as Resistors, capacitors and inductors is called passive filters. The types of passive filters are low pass filters, Highpass filter, Band pass filter, Band stop Filter and all pass filter.1.1.3 Low pass filter:

It is a type of filter which attenuates all the frequencies above the cutoff frequenciesIt provides a constant output (gain) from zero to cutoff frequency.

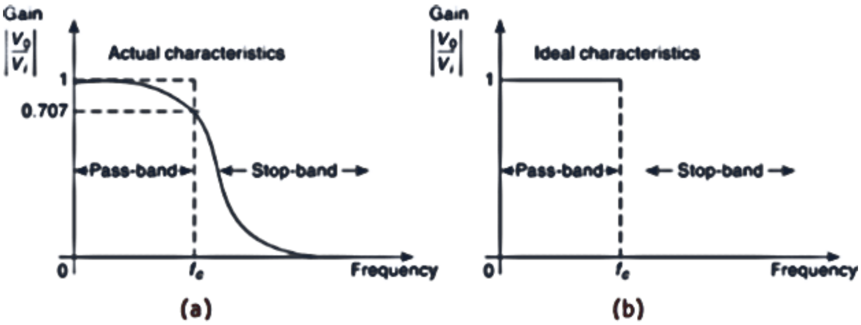


Fig.1.2(a) Actual and (b) Ideal low pass characteristics

1.2.3 *High-pass Filters*

Allow transmission of signals with no or little attenuation at frequencies higher than the cut-offfrequency and reject the signals at frequencies lower than the cut-off frequency.

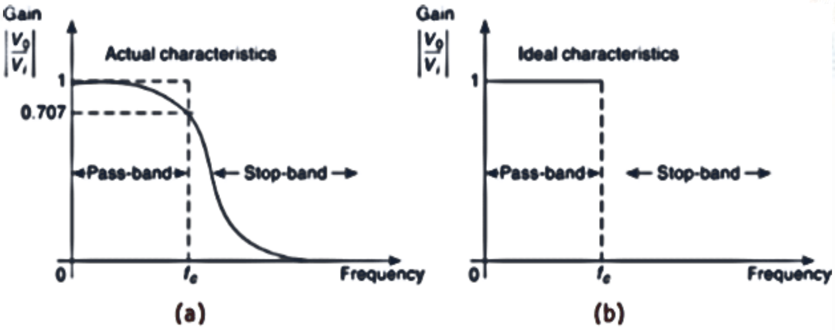


Fig.1.3 (a) Actual and (b) Ideal High pass characteristics

1.2.4 *Band-pass Filters:*

Allow transmission of signals with frequencies within a band bounded by a lowerand an upper cut-off frequencies and reject signals out of this band.

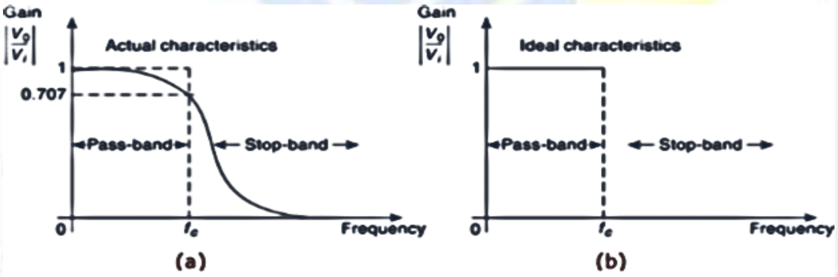


Fig.1.4 Band pass filter characteristics

III PROPOSED METHOD

Substrate Integrated Wave guide (SIW) is a promising candidate for mm- wave technology because it is easy to fabricate, flexible and cost effective. This technology also preserves most of the advantages of conventional metallic wave guide namely complete shielding, low loss, high quality-factor and high power handling capability. SIW has receivedtremendous attention at mm wave frequencies of around 60 GHz.Recently, substrate integrated wave guide (SIW) based devices have attracted the attention of many researchers due to low cost, lightweight and efficient high frequency characteristics. SIW is the printed circuit realization of a wave guide. SIW is fabricated on adielectric material with top and bottom sides are conductors, and two linear arrays of metallic vias form the side walls. In this thesis, by using SIW structure, iris type band pass filters are designed, analyzed and fabricated for verification. Good agreement between simulated and fabricated results are observed. SIW structure is fabricated by using two periodic rows of metallic vias connecting the top and bottom groundplanes of a dielectric substrate.

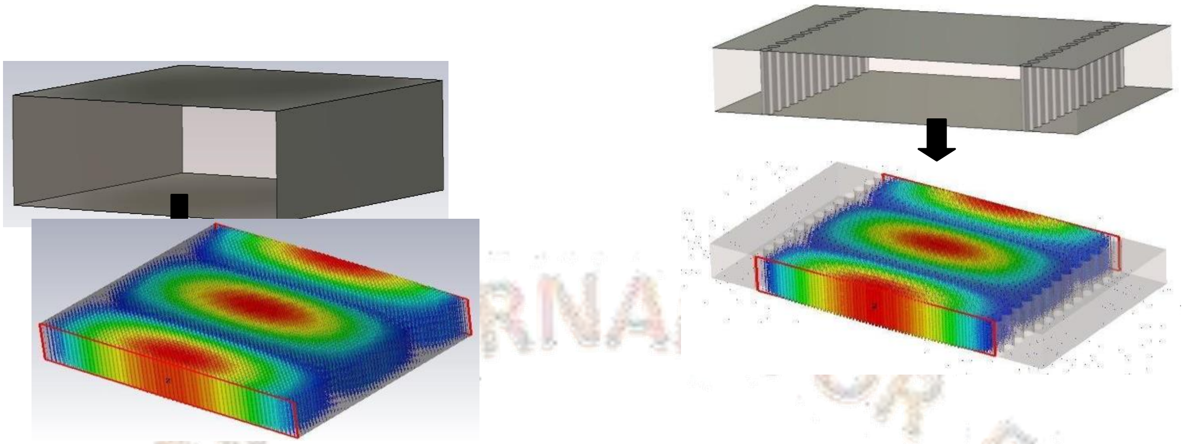


Fig.3.1 Field Distribution of a wave guide structure (left) and SIW structure (right)

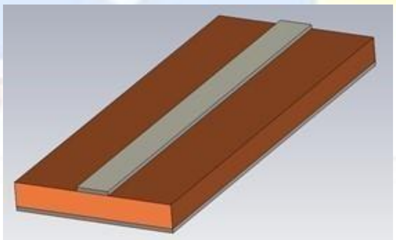
The relationship between the cut-off frequency, fc, and the dimensions a and b of anair-filled wave guide (AFWG) and a dielectric filled wave guide (DFWG) are the starting points of a SIW design. For an AFWG (refer to Fig. 3.5), the cut-off frequency of a **mode** isgiven by

$$(f_c)_{mn} = \frac{1}{2\cdot\pi\cdot\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m\cdot\pi}{a}\right)^2+\left(\frac{n\cdot\pi}{b}\right)^2}\ [\![Hz]\!]$$

IV EXITING METHOD

A microwave circuit (or a system) is, in general, an interconnection of many fundamentalmicrowave devices such as filters, couplers, power divider/combiners, etc. However, an essential requirement in all these devices is the ability to transfer signal power from one point to another as efficient as possible (i.e., with minimum amount of loss). This requires the transport of electromagnetic energy in the form of a propagating wave. Therefore, all the aforementioned fundamental microwave devices are designed and manufactured in the formof a guiding structure so that electromagnetic waves can be guided from one point to anotherwithout much loss.Micro strip lines are among the most widely used guiding structures at relatively lowermicrowave frequencies because of their simple construction, low cost. and high integrabilitywith surface mount components.

Fig.2.1 Micro strip line



Transverse Electric Mode (TE mode):

The total reflection inside the rectangular wave guide results in either an electric fieldor magnetic field component in the direction of propagation. When the electric fields are normal to the direction of S propagation, they form the TE modes in a rectangular wave guide.

Transverse Magnetic Mode (TM mode):

When a wave passes through the rectangular wave guide, total internal reflection occurs and the electromagnetic field aligns inside the wave guide. When the magnetic fields are normal to the direction of propagation, they form the TM modes in a rectangular wave guide.

Transverse Electromagnetic Mode (TEM mode):

The Transverse electromagnetic wave cannot be propagated within a wave guide, butis included for completeness. It is the mode that is commonly used within coaxial and open wire feeders.

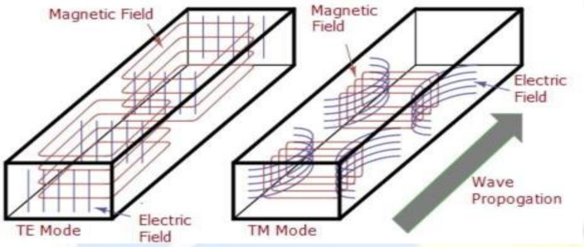
The electric field changes over time with the frequency, and has in the longitudinal direction of the wave guide maxima and minima in the distance of half the wavelength. Highfrequency energy that is fed into a wave guide, generates an electromagnetic transverse wave(TEM mode) whose electric and magnetic fields are perpendicular to each other. The electricfield is established between the two wider wave guide walls, the magnetic field lies betweenthe two narrower walls. These fields do not remain in the respective states.

TE and TM Modes in Ideal Wave guide must satisfy Maxwell's equations and are basedon certain assumptions:

I) The Wave guide is considered to be infinity long, oriented along the Z-axis,and uniform along its length.

II) The Wave guide is constructed from a perfectly conducting pipe (PEC) andis filled with a perfect insulator (lossless dielectric).

III) The Electric and magnetic fields are time-harmonic.



V RESULTS AND DICUSSIONS

The dual-band filter is simulated and fabricated using the commercial software CST Microwave Studio and the standard printed circuit board (PCB) process, respectively. A prototype of dual-mode dual band filter was designed and simulated to validate the design concept. R/Duroid 5880 (thickness 0.508) with a dielectric constant εr = 2.2 and a loss tangentof 0.0009. The dimensions of the cavity for the designed filter are as follows (referring to Figure 1): The size of the cavity is weff ×weff = 19.4×19.4 mm, ls = 4 mm, lf = 2.9 mm, wmf = 1.55 mm, wf = 0.55 mm, dx = 2.55 mm, p = 1.0 mm, p1 = 1.3 mm, dy = 1.45 mm, d= 0.6 mm, d1 = 1.6 mm, d2 = 0.8 mm, x1 = 3.5 mm, x2 = 7.85 mm, y1 = 3.5 mm, y2 = 7.85mm.Now we found the dimensions of the SIW structure, a micro strip transition is used tointerconnect SIW to the planar transmission lines. This is used to match the impedance between a 50 Ω micro strip line and the SIW. The 50 Ω micro strip line, in which the dominantmode is quasi-TEM, can excite well the dominant mode TE_{10} of the SIW, as their electric fielddistributions are approximate in the profile of the structure.

The measured dual-band filter's central frequency for the first band is 17.1 GHz; thefractional bandwidth of this band is 2.01%; the return loss (RL) is greater than 21 dB; and the minimum insertion loss (IL) is 2.1 dB. The central frequency of the second band is 19.38GHz, the fractional bandwidth is 4.1%; the RL is greater than 17 dB; and the minimum IL is1 dB. Due to fabrication tolerance, there is a relatively small frequency shift.

It is noted that the traditional design methods give relatively large sizes as compared to single resonant design methods, our proposed filter has a more compact size than others, as well as competitive performance in terms of flexible center frequencies and adjustable pass band bandwidths. Through the foregoing, it clearly shows the novelty and advantage ofthe proposed filter.

Fig.5.1 Frequency v/s gain

Fig.5.2Frequency v/s gain

Fig.5.3frequency v/s gain

V CONCLUSION

A dual-band pass filter with flexible center frequencies is designed and fabricated ona single SIW. The proposed filters exhibit low loss, low cost and dual band response.Due to its low cost, easy integration with printed devices, light weight, compact size,it attracts the attention of many researchers and it is widely used in modern and communication applications. In this project we studied and analyzed the desired frequency bands and the simulation results agree well. They work well with good matching and low loss.

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