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Wideband Substrate Integrated Waveguide Filter for 60GHz Applications

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Abstract— **In this article, A wide band filter is designed for 60GHz in the millimeter wave frequency range for upcoming new technologies in wireless communications. RT/Duriod 5880 Substrate material is used to design this wide band filter with 2.2 as dielectric constant and 0.0009 as electric loss tangent. This wide band filter gives 2 resonance peaks. First one occurs at 60 GHz with a maximum reflection coefficient of -43.41dB and second one occurs at 65 GHz with -61.53dB. This wide band filter gives 16.72 GHz as bandwidth. Wide band filter dimensions are 6.8*3.5*0.508mm^3. Due to this filter dimensions and available bandwidth this wide band filter structure is suitable for upcoming high bandwidth applications like short distance RADAR applications at 60 GHz.**

Keywords-Wideband filter; Rogers; short distance RADAR; FCC;

I. Introduction

Due to high data and fewer delay requirements in wireless communications high bandwidth is required. Due to high bandwidth high free frequency spectrum is required. Above 30 GHz heavy free space spectrum is available [1]. According to federal communication commission (FCC) 57GHz to 64GHz i.e 7GHz frequency is unlicensed frequency range and 66GHz-71GHz i.e 5GHz frequency ranges used for RADAR applications [2]. At this frequency range Substrate Integrated Waveguide (SIW) technology is used to fabricate all the components [5]. This technology gives low loss, complete shielding and high power handling capability, easy fabrication, low cost, compact size and low weight. Here RT duriod 5880substrate material is used to design the filter component. Grounded Coplanar Waveguide (GCPW) [2-4] is used as a transmission path. Because in the fabrication of System on Substrate (SOS) and System in Package (SIP) all the devices are connected in either series and shunt manner. GCPW gives this feasibility and also gives good impedance matching between components. Now a day's short distance high data rate RADAR systems are very essential. In RADAR system band pass filters design is very important and very challenging also. If the filter is good so it gives more bandwidth with good reflection coefficient.

In this article the next section explains the design of the wideband filter structure. Then next section explains the result of the proposed wideband filter. Finally compare the filter results with survey results finally explains the conclusion of the proposed wideband filter.

II. STRUCTURE OF WIDEBAND FILTER

A. *SIW design*

Rectangular Substrate Integrated Waveguide (RSIW) is filled with duriod 5880 substrate material. These substrate material top and bottom coated with copper material 0.035mm as thickness. Top and bottom copper layers are connected with array of row vias shown in fig.1. To design this RSI, via dimensions i.e d and p and width between rows of via Wsiw are calculated by using equations (1) to (3), which shown in below. [1-3], [5-6].

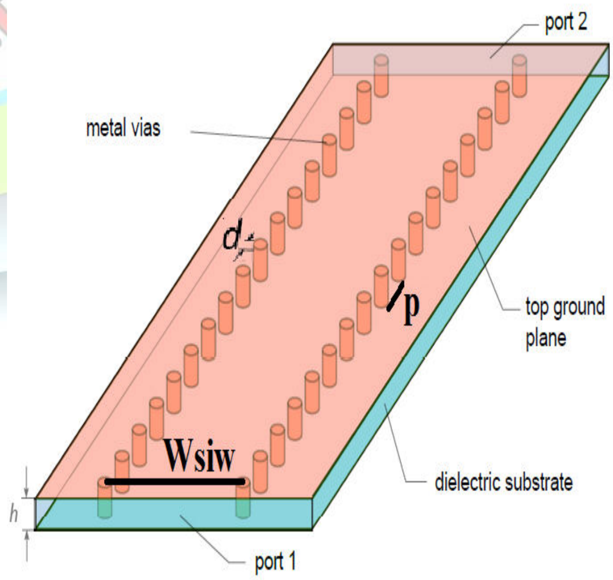

Fig.1. SIW structure and its parameters.

$$\mathrm{Weff} = \mathrm{Wsiw} - \frac{D^2}{0.95 * P} \qquad (1)$$

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$$\mathrm{Weff} = \frac{a}{\sqrt{\epsilon_r}} \quad (2)$$

$$P \leq 4D \quad (3)$$

According to standard rectangular waveguide dimension WR15 width i.e a is3.7592mm. By using equation (2) RSIW width is calculated, which shown in table.1. Substrate height is0.508mm is taken.

B. CPW design

In short distance RADAR applications all the components are constructed on single substrate chip which is nothing but system In Package i.e SIP and System On chip (SOC). The entire system operated at higher frequency, good impedance matching is requiring. Not only impedance but also place of components either in series or in shunt manner. These requirements fulfilled by Grounded Coplanar Waveguide (GCPW). By using GCPW cross take is decreases. GCPW is used as good transmitting path between SIW components. GCPW design parameters are calculated using below formulas [4]. Structure of GCPW shown in fig.2 below. Here in GCPW tapering section is used for impedance matching.

$$0.2 \leq \frac{S}{S+2W} \leq 0.8 \quad (4)$$

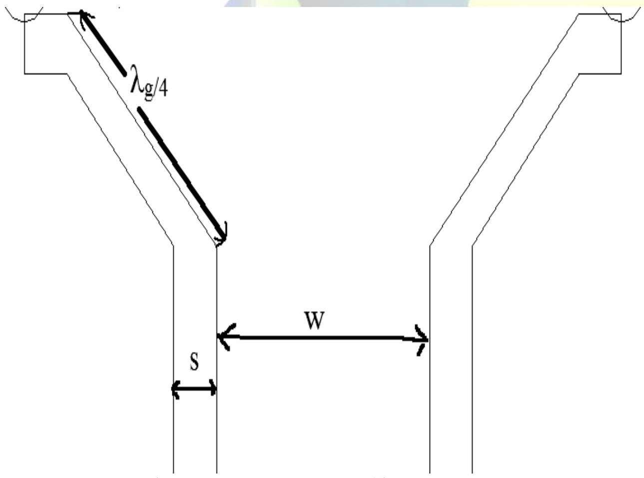

Fig.2. GCPW structure and its parameters

C. Filter design

In any RADAR wireless communication systems bandpass filter (BPF) is playing a very important role. BPF is used to select a particular band and reject remaining band. Here filter is designed by using SIW technology with inductive post method. Which gives a good result. The order of the filter is calculated by

$$N \geq \frac{\cosh^{-1}\sqrt{\frac{10^{0.1\,LAs}-1}{10^{0.1LAr}-1}}}{\cosh^{-1}(\Omega s)} \quad (1)$$

Order of the filter is N, L_{As} is the level of out of band reject at pulsation Ωs= 1 rad/sec and L_{Ar} is maxed amplitude of ripple.

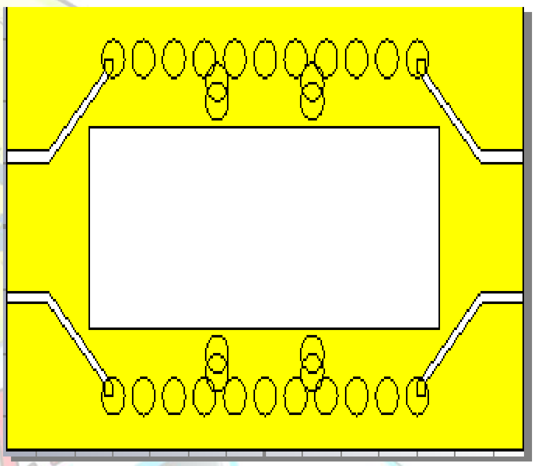
Fig.3.Proposed Wideband Filter structure

TABLE.1.Proposed Wideband Filter structure design parameters

Parameter	Value(mm)
L	6.8
W	3.5
λg	3.371
Wc	1.008
Wsiw	2.67
d	0.3
P	0.4
S	0.1
Lc	0.552

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III. RESULTS AND DISCUSSIONS

The Wideband SIW filter simulation result is in fig.4. In this simulation result graph red color line indicates reflection Coefficient (S_{11}) and green line color indicates Insertion losses (S_{21}). This wide band SIW Filter gives two resonant peaks, which is shown in fig.2. First resonance peak occurs at 60 GHz with maximum reflection Coefficient (S_{11}) of -43.41dB and second one occurs at 65 GHz with maximum reflection Coefficient (S_{11}) of -61.53dB. The -20db line is considered to calculate the bandwidth of proposed Wideband SIW filter. This -20dB line touches reflection Coefficient at f2=74.703GHz and f1=57.98GHz. The band width of the wideband filter is f2-f1=16.72GHz. At 60GHz insertion loss of wideband SIW filters is-0.19dB. This insertion loss is maintained thought out the band is same which is shown in fig.2.

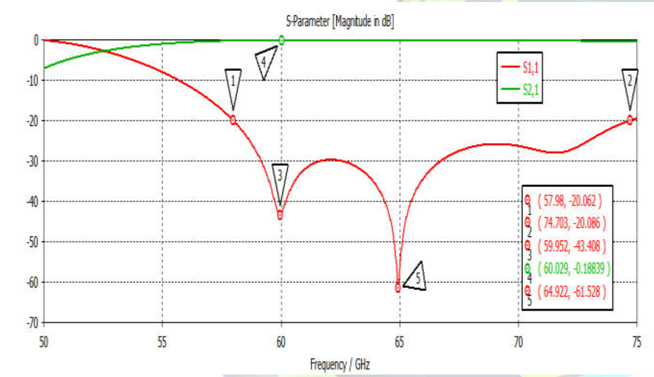

Fig.4.Simulation results of Proposed Wideband Filter

Fig.5 indicates Voltage Standing Wave Ration (VSWR) graph of Wideband SIW filter. This Wideband SIW filter structure gives VSWR as 1.07 at 60GHz.

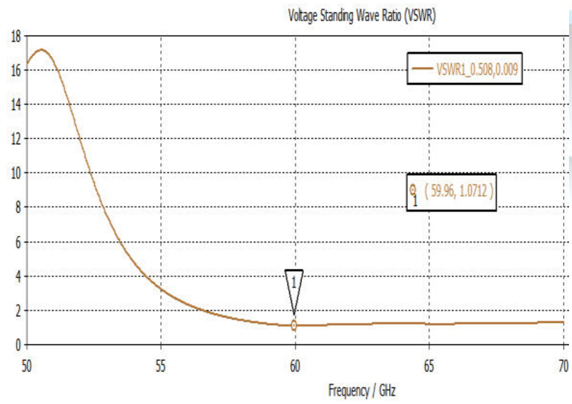

Fig.5.VSWR curve of proposed Wideband Filter structure

IV. COMPARISON

In table.2, proposed structure results are compared with exist structure results.

Table.2.Comparisons between existing structures to proposed Filter

Parameters	Ref[5]	Ref[6]	Prop. Filter
εr	2.2	4.4	2.2
Reflection Coefficient (S_{11})(-dB)	52	64	61.5
S_{21} (-dB)	1	1	0.19
Bandwidth (GHz)	1.5	41.4	16.72
Dimensions (mm^3)	10.11*3.3* 0.25	6.8*3.5* 0.508	6.8*3.5* 0.508

Here Proposed filter gives good result compared with another ref[2,3] filters. Compared with ref[2,3] insertion loss is very less and gives good reflection coefficient. Due to its bandwidth this structure dimensions this filter is applied to RADAR application like unlicensed industrial (59 to 64 GHz), medical communication devices(71.5 to 72 GHz) [3]. This RT duriod 5880 substrate material is mainly used in millimeter wave, missile guide system, military RADAR system, point to point digital radio antennas. Because of dispersion, losses are very less and cost of material is very high.

V. CONCLUSION

This Wideband SIW filter is mainly designed for V-band millimeter wave frequency range applications especially for 60GHz short range RADAR applications. This Wideband SIW filter gives 16.72GHz as bandwidth. This Wideband SIW filter gives max reflection co-efficiency of -61.53dB and insertion loss of -0.19dB. Due to its GCPW transmission path this Wideband SIW filter provide good impedance matching in the design of SOS and SIP. Due to proposed Wideband SIW filter dimension and bandwidth this structure is most suitable to design short distance RADAR applications in 57GHz to 64GHz frequency range in millimeter wave frequency range.

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