Design and Performance Analysis of G-Shape Microstrip Filter for Wireless Communication Using DGS Techniques

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Abstract-Wireless communication systems, satellite communication and radar systems are generally used band pass microwave filter for frequency selection. Microstrip filters play very important roles in wireless or mobile communication systems. The presented paper is a multi band BPF with defected ground microstrip structure used for wireless communication applications from 1GHz to 8GHz. We presents two microstrip filter each having G-Shape patch but with different DGS shape in each design. On the basis of proposed design we investigate the effect of DGS shape on Insertion loss, reflection coefficient, VSWR and Q factor. The proposed design with properties of DGS ,increase the operating band of BPF with better bandwidth.

Keywords-Multiband Band pass Filters (MBPFs), Defective Ground Structure (DSG), Strip Line.

I. INTRODUCTION

As the technology changes rapidly, there is a great demand of compact size, high selectivity, low cost, and high performance components in any modern wireless communication system. Filter is an essential component in modern communication system. In response to this demand, recently many planar filters with band pass, low pass or band stop performances have received wide attention. Many more techniques and methodologies have been investigated in designing such filters. Narrow and wide band stop filter (BSFs) is the key component in modern communication system. It plays a major role of filtering out undesired frequencies and passing the desired signal [1]. Active devices such as oscillator and mixer are often followed by BSF shaving wide stop band to remove the higher order harmonics and other unwanted spurious signals, respectively [1]. BPF can be used for wireless Local Area Network (WLAN) and Bluetooth application such as low earth orbit satellites, military satellites ,and terrestrial wireless connections like GSM mobile phones[2]. The contents of the paper are organized in following manner. Section II, describe the basic concepts and equations for Defective Ground Structure (DSG). Section III presents two DSG designs proposed for microstrip band pass filter with different DSG Shapes. Section IV illustrates the simulation results and performance parameters using HFSS software for the proposed design, and finally, a conclusion is reached in section V.

II. CHARACTERISTIC OF DSG

For microstrip line with DGS, electrical length is given by:

$$\theta=\beta L=\sqrt{\varepsilon_{eff}}\,k_o L$$

Here, θ is microstrip line electrical length, β is the propagation constant, L is the length of line, εeff is effective permittivity of the microstrip line, and kois the wave number. As the DGS is introduced in the ground plane of the microstrip line, the effective inductance and capacitance will change and these in turn will change the resonant frequency of the microstrip line. For keeping the resonant frequency at its initial value, we have to compensate for the length of the transmission line[1][2].Owing to the incorporation of DGS, there will be variation in inductance and capacitance. The quality factor will also change due to change in inductance and capacitance. The quality factor can be written as: Q = f_o/BWHere, fo is the resonating frequency, BW is the bandwidth of operating devices, and Q is the quality factor. If the quality factor decreases, bandwidth will increase but circuit performance is degraded because of increased losses. Therefore, there is a tradeoff between the value of L and C in such a manner that the performance of the filters is not reduced. The inductance and capacitance depend on the lattice dimensions and slot gap of the DGS.

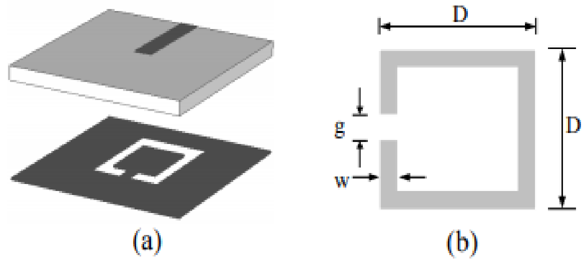

Figure 1: DGS resonator configuration

Fig. 2 demonstrates a DGS resonator setup. The resonator resembles a folded half wavelength resonator. One of the benefits of this setup is that the magnetic and electric fields are focused close to the holeg and the opposite side, separately. Both positive and negative coupling coefficients can be acknowledged effectively.

III. PROPOSED MICROSTRIP FILTER

In this section we have presentedtwo unique design ofmicrostripBPF structure the proposed design is a G-Shape microstrip filter with different DSGsubstrate of thickness of 1.6 mm. We use two design in both we are using G-shape patch but different shape of ground defects like H and G shape for 1st and 2nd design respectively.

A. H-Shape DGS filter Design

First proposed design is a G shape Patch basedMicrostrip filter, made-up of G shape PEC removalfrommetallic patch which is grown on a FR-4 dielectric substrate of thickness 1.6 mm.The total area of ground plane and substrate is 32 mm × 26 mm. which is shown in the Figure 2.

The physical dimension of the proposed microstrip filters are designed through ansys-HFSS software. The analysis of design is performed of frequency range of 1 to 8 GHz. We use two input/output port as lumped port, both of them are alike and symmetrical to each other and their dimensions are 6mm ×6 mm. dimension of substrateis 32 mm × 26 mm × 1.6 mm. and dielectric constant of 4.4.

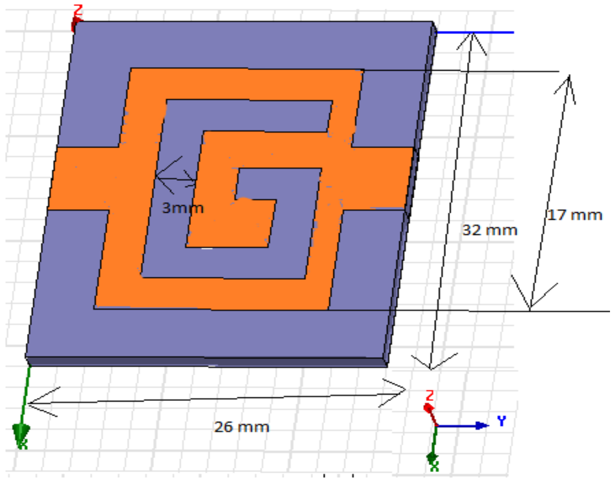

Figure.2 Top View of 1st Design model.

On the other hand we can classify the shape and dimension ground plane for the first design in fig 3. here we can see that the overall dimension of the ground plane is same as that of the substrate structure i.e 32 mm × 26 mm. The H-Shape is symmetrical in design and having an opening of 3 mm.

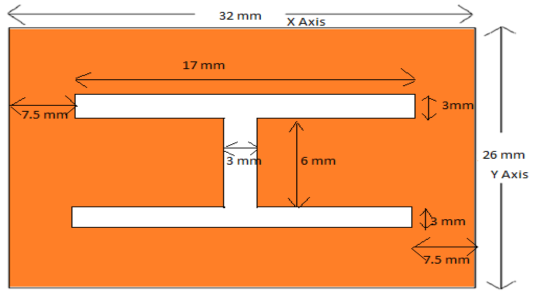

Figure.3 Bottom view of 1st Design ground plane.

B. G-Shape DGS filter Design

In the second design we again use same patch but different ground structure, here also the patch has G shape structure which is feed bytwo input/output strip line of dimension of 6mm×6 mmshown in figure 2. The substrate and ground plane has same area of dimension 32 mm ×26 mm and height of substrate is 1.6 mm. the ground plane is G shapeDSG shown in fig. 4.

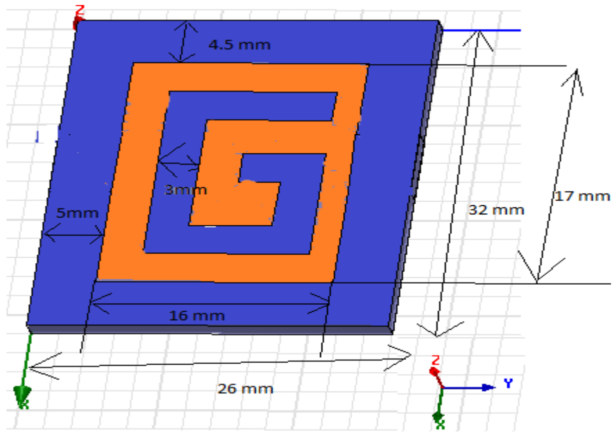

Figure.4 Bottom view of 2nd Design ground plane.

IV. RESULTS

The major performance parameter [10,13] we have taken in account for filter design is VSWR, Return Loss,Q Factor, Bandwidth, Insertion Loss, and band of operation. In1stdesign we achieve a bandwidth of with bandwidth of 353 MHz, 1043 MHz, and 250 MHz at center frequency 2.9 GHz, 5.6 GHz and 7.4 GHz respectively.

Table 1: Result Analysis of First Design with FR-4 Substrate.

Centre Frequency (GHz)	Insertion Loss (dB)	Bandwidth at -10dB (MHz)	VSWR (dB) minimum	Return loss (dB) Minimum	Q-factor
2.9	-3.6	353	1.30	-17.0	8.144
5.6	-6.0	1043	1.13	--24.2	5.482
7.4	-7.0	250	1.8	-11.2	29.695

Table 2:Result analysis of Second Design With FR-4 substrate.

Centre Frequency (GHz)	Insertion Loss (dB)	Bandwidth at -10dB (MHz)	VSWR (dB) minimum	Return loss (dB) Minimum	Q-factor
1.2	-1.844	152.34	1.211	-20.42	7.97
2.0	-1.160	634.3	1.523	-13.67	3.14
4.1	-1.972	1067.4	1.320	-17.21	3.81
5.7	-3.463	811.67	1.108	-25.84	7.02

On the other hand when we use G- Shape DSG we get four band of operation with bandwidth of 152.34 MHz, 634.3 MHz, 1067.4 MHz and 811.67 MHz at center frequency 1.2 GHz, 2.0 GHz , 4.1 GHz and 5.7 GHz respectively for 2nd design, the summary of overall results is tabled in table 1and table 2.

In the figure 5, 6 and 7 represents return loss S11, VSWR, Insertion loss S21,and -10 dB Bandwidth for 1st design.

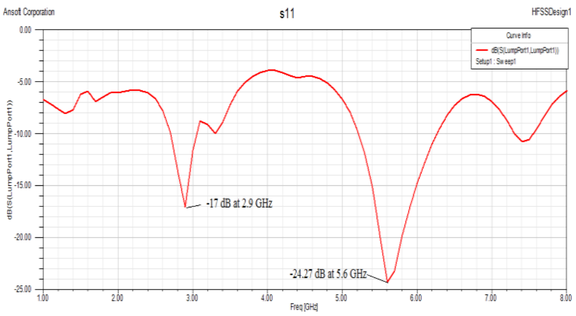

Figure.5:Return loss of simulation result for Design 1 With FR-4 substrate.

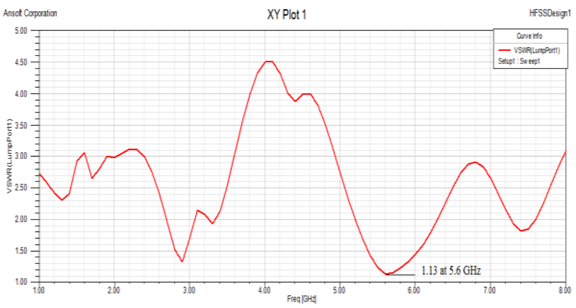

Figure.6:VSWR of simulation result for Design 1 With FR-4 substrate.

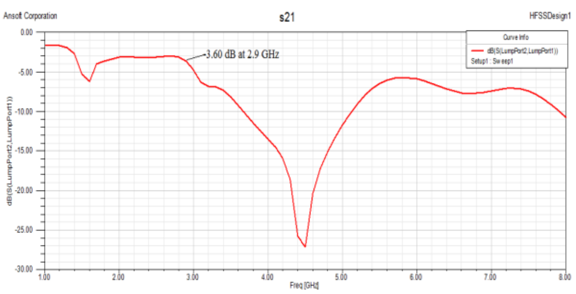

Figure.7:Insertion Loss of simulation result for Design 1 With FR-4 substrate.

In the figure 8, 9 and 10 represents return loss S11, VSWR, Insertion loss S21,and -10 dB Bandwidth for second design.

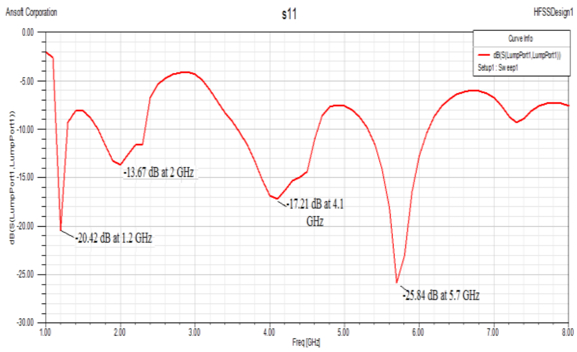

Figure.8: Return loss of simulation result for Design 2With FR-4 substrate.

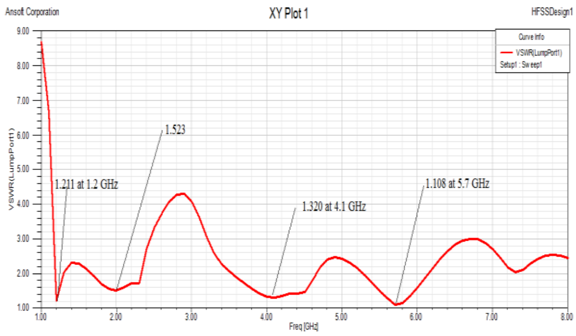

Figure.9: VSWR of simulation result for Design 2With FR-4 substrate.

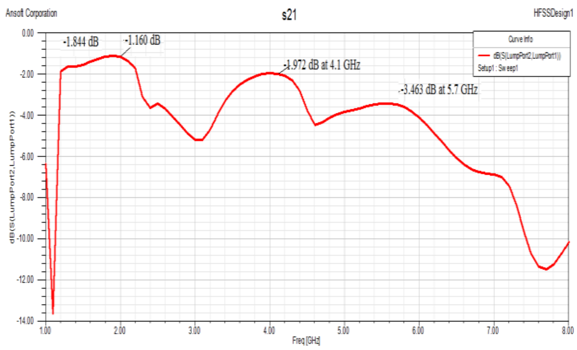

Figure.10: Insertion Loss of simulation result for Design 2With FR-4 substrate.

V. CONCLUSION

In this paper, The best results is obtained in terms of bandwidth is design 2nd. In this cases we have Four-band (Multi Band) of operation with Bandwidth of 152.33 MHz, 634.3 MHz, 1067.4 and 811.67 MHz at center frequency 1.2GHz, 2.0 GHz, 4.1 GHz and 5.7 GHz respectively.

In 1st design we have Three-band of operation with Bandwidth of 353 MHz, 1043 MHz and 250 MHz at center frequency 2.9 GHz, 5.6 GHz and 7.4GHz respectively. For Q-Factor best value is obtained in 1st design i.e 29.695 at 7.4 GHz centre frequency.

Thus for all proposed design we can see that the introduction of G shape DGS increase the number of operating band shift the center frequency towards lower frequency range with better Bandwidth.

REFERENCES

[1] Mohamed.K.Rashad, MostafaAshraf , Ahmed A.Ibrahim, “Compact High Selective DGS Band-Pass Filters for WLAN Applications,” IEEE International Conference 2017.

[2] XuemeiZheng, Yanjie Sun, Hengxu Wang, Jiahe Mei, and Tao Jiang “MicrostripBandstop Filter Using G-shaped Defected MicrostripStructure ,” IEEE International Conference in Electromagnetics Research Symposium Spring (PIERS) 2017.

[3] Yanyan Wang, Tao Jiang, and Yingsong Li, “A Miniaturized Dual Stop-Band Filter Using Meander Defected Microstrip Structures,” IEEE International conference 2016.

[4] JuilyJagdishSaptarshi, and UdayPanditKhot , “Low Profile Wide Stop Band Microstrip Filters for Wireless Communication Applications using Defected Ground Structures ,” IEEE International conference on Advances in Signal Processing (CASP) 2016.

[5] BudhadebMaity, “Stepped Impedance Low Pass Filter using MicrostripLine for C- Band Wireless Communication ,” IEEE International Conference on Computer Communication and Informatics (ICCCI -2016), 2016.

[6] J.S. Hong and M.J. Lancaster “Couplings of microstrip square open-loop Resonators for cross - coupled planar microwave filter,” IEEE Trans. Microw. Theory Tech., vol. 44, no. 12, pp. 2009-2109, Dec,1996.

[7] M.G. Banciu, R. Ramer, A. Ioachim, “Microstrip filters using new compact resonators’, Electron. Lett., vol. 38, no.22, pp. 228–229, Aug, 2002.

[8] D. M. Pozar, Microwave Engineering, 2nd ed. New York: Wiley, 1998.

[9] W. Li, et al., “Novel microstripbandpass filter with slotted hexagonal resonators and capacitive loading,” in Proc. EuMC 2008 38th European Microwave Conf., Amsterdam, Netherlands, 2008, pp. 991-994.

[10] H. Madan, “Design of microstripbandpass filters,” College of Engineering, Pune, 2007.

[11] P. S. Kildal, E. Alfonso, A. Valero-Nogueira and E. Rajo-Iglesias, ”LocalMetamaterial-Based Waveguides in Gaps Between Parallel Metal Plates,”in IEEE Antennas and Wireless Propagation Letters, vol. 8, no. , pp.84-87, 2009.

[12] D. Sievenpiper, Lijun Zhang, R. F. J. Broas, N. G. Alexopolous and E.Yablonovitch, ”High-impedance electromagnetic surfaces with a forbidden frequency band,” in IEEE Transactions on Microwave Theory and

[13] Techniques, vol. 47, no. 11, pp. 2059-2074, Nov 1999.

[14] Yang, Ning, Chen, ZhiNing, Wang, Yun Yi, and Chia, M. Y. W., "A two-layer compact electromagnetic bandgap (EBG) structure andits applications in microstrip filter design,” in Microwave and Optical

[15] Technology Letters, vol. 37, no. 1 , pp. 62-64, 2003.

[16] L. Inclan-Sanchez, J.L. Vazquez-Roy, and E. Rajo-Iglesias “Considerations on designing microstrip gap waveguide slot arrays”, 9th EuropeanConference on Antennas and Propagation, april 2015.

[17] H.Kiumarsit, K.Wasa, H.Itot, N.Ishiharat, and K.Masu,” E-band filters based on substrate integrated waveguide octagonal cavities loaded by complementary split-ring resonators,” in 2015 IEEE MTT S Int. Microwave Symp., USA, 2015.

[18] Jia Sheng Hong and M.J.Lancaster, Microstrip Filters for RF / Microwave Applications, 2nd ed. New York: Wiley, 2011.

[19] Y. K. Singh ,P. Abdulla P, A. Chakrabarty "Miniaturized bandpass filter using a dual-mode octagonal patch resonator,” in Proc. APMC 2009 Asia Pacific Microwave Conf., Singapore, 2009, pp. 2511-2514.

[20] X. L. Lu et al., “Design of a high-order dual-band superconducting filter with controllable frequencies and bandwidths,” IEEE Trans. Appl. Supercond., vol. 24, no. 2, pp. 3–7, Apr. 2014.

[21] H. Liu, B. Ren, F. Liu, X. Guan, P. Wen, and Z. Ma, “Dual-band hightemperature superconducting bandpass filter using dual-mode hairpin ring resonator,” IEEE Trans. Appl. Supercond., vol. 26, no. 7, Oct. 2016, Art. no. 1501704.

[22] E. G. Cristal and S. Frankel, “Hairpin-line and hybrid hairpin-line/halfwave parallel-coupled-line filters,” IEEE Trans. Microw. Theory Techn., vol. MTT-20, no. 11, pp. 719–728, Nov. 1972.

[23] J.-S. Hong and M. J. Lancaster, ‘‘Couplings of microstrip square open-loop resonators for cross-coupled planar microwave filters,’’IEEE Trans. Microw. Theory Tech., vol. 44, no. 11, pp. 2099--2109, Nov. 1996.