Volume 4, Issue 5, May-2017, pp. 185-189 ISSN (O): 2349-7084

International Journal of Computer Engineering In Research Trends

Available online at: www.ijcert.org

An Ultra Wideband Bandpass Filter using Stepped Impedance Resonators and DGS Structures

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Abstract: -In this paper, a compact ultra wideband (UWB) bandpass filter (BPF) with a passband covering 4.73 GHz to 10.43GHz with a bandwidth of 5.7 GHz and a fractional bandwidth of 75.2% is proposed. The filter has three transmission poles in the passband and has a wide stop band. The design and the performance of the proposed UWB BPF are characterized by using full-wave electromagnetic simulator IE3D.

Keywords: Bandpass filter, Stepped Impedance Resonator, Ultra-wideband, Defected Ground Structure.

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1. Introduction

In the year of 2002 the Federal Communication Committee (FCC) allowed unlicensed use of ultra wideband frequency spectrum from 3.1GHz to 10.6 GHz, having a bandwidth of 7.5 GHz. Since then extensive work has been done in the area of Ultra Wideband devices and techniques to explore the advantages of this 7.5 GHz bandwidth. The advantages include high transmission data rates (up to 500 Mb/s), low energy density over a wideband spectrum, extremely low transmission energy (less than 0.1 mW), etc.

2. Literature Review

Ultra wideband technology which is an essential part of modern communication system finds application in a commercial radar system, military, medical imaging industrial sensing, etc. The key component of an ultra wideband system is UWB bandpass filters. In recent years some different techniques such as multiple mode resonators (MMR), a cascade of highpass and lowpass filters, stepped impedance resonators (SIR), combine filters, hybrid microstrip/ coplanar waveguide (CPW), etc. are used to design UWB bandpass filters. In this paper, we propose an ultra wide band-pass filter with a bandwidth of 5.7 GHz.

3. Proposed Work

In this paper, we propose a compact UWB BPF which is based on stepped impedance resonator. It uses defected ground structure (DGS) to improve the stop band response of the filter. The proposed UWB BPF shows a passband from 4.73 GHz to 10.43 GHz with a fractional bandwidth of 75.2 % at -10dB.

The return loss is less than -20dB, and the insertion loss is less than 1dB within the passband. The size of the proposed UWB BPF is 11.8mmX6mm which is very small. The filter has two stepped impedance resonators. One is above and another below the microstrip line filter. The frequency responses of the proposed ultra wideband filters are depicted here step by step.

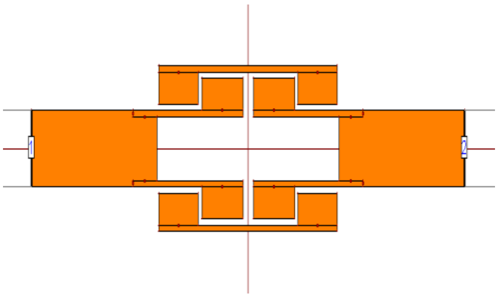

Fig. 1. Geometry of UWB filter without DGS

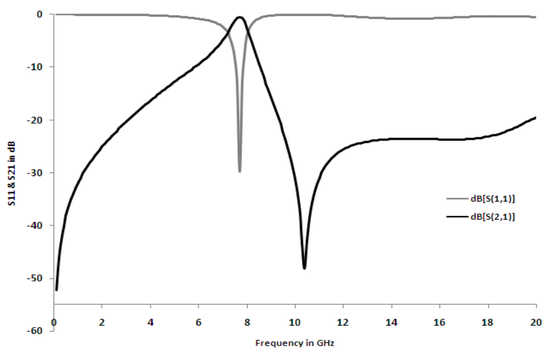

Fig. 2. Frequency Response of the proposed filter without DGS.

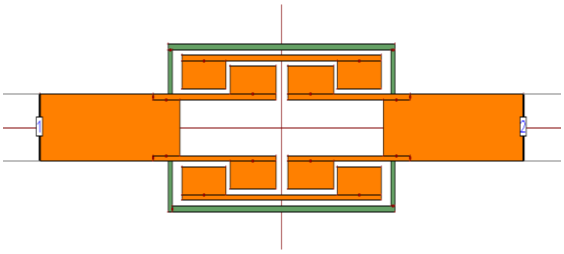

Fig. 3. Geometry of UWB filter with single DGS

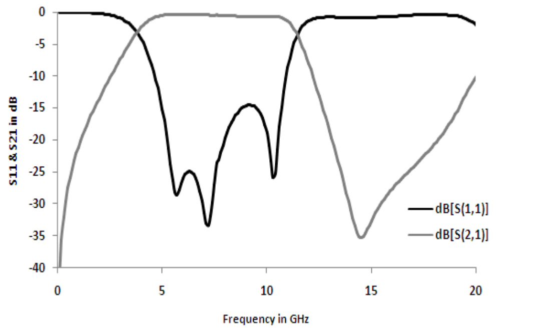

Fig. 4. The frequency response of the proposed filter with single DGS.

The proposed filter has been designed using RT Duroid 5880 as the substrate with a relative dielectric constant of 2.2 and a substrate thickness of 0.787mm. The proposed filter has a very simple design, and in this filter, minimum gap is maintained as 0.2mm, and the minimum strip thickness is also kept as 0.2mm to ease the fabrication process.

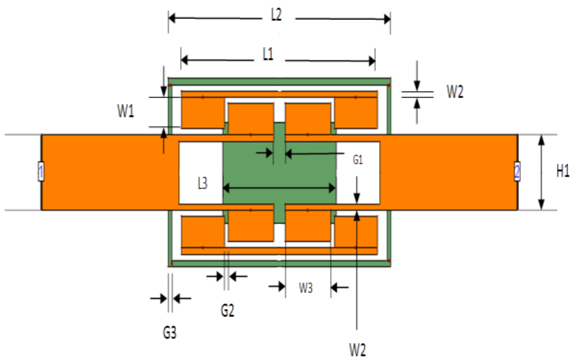

Fig.5. Geometrical parameters of the proposed UWB BPF

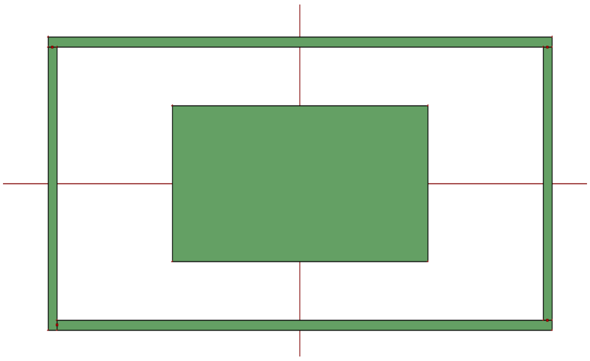

Fig. 6. DGS structure of the proposed UWB BPF

The dimensional details of the proposed UWB microstrip filter are given below:

Parameters	Values
L1	10.4 mm
L2	11.8 mm
L3	6.0 mm
W1	1.0 mm
W2	0.2 mm
W3	2.9 mm
G1	0.6 mm
G2	0.2 mm
G3	0.2 mm
H1	2.4 mm

Table 1. Details of Parameters of the proposed filter.

The filter structures are simulated by using the electromagnetic simulator IE3D, and the resonant characteristics of the filter are investigated.

4. Result and Discussion

The filter shows three transmission poles within its passband of 5.7 GHz, covering 4.73GHz to 10.43 GHz. In the cascaded structure, we obtained the insertion loss less than 1.6 dB and returned loss is greater than 20 dB at most of the frequencies within the passband. The minimum return loss obtained is better than -20 dB as shown in Fig. 7.

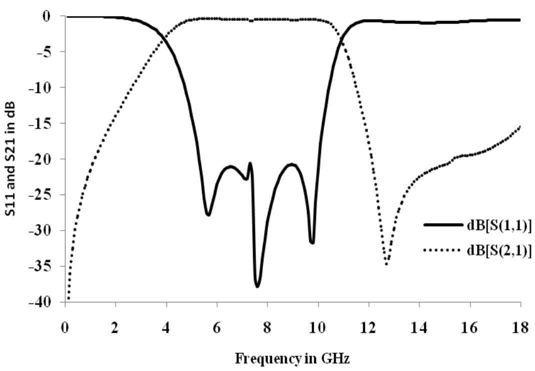

Fig.7. The frequency response of the final proposed UWB BPF.

The frequency response of the filter is simulated by using the IE3D software. In the simulation, the dielectric loss has been taken into account by using the loss tangent tanδ=0.0022 of the substrate. The proposed filter has a dimension of 25.2mm x 6mm.

5. Conclusion

In this paper, we have presented a UWB bandpass filter using microstrip stepped impedance resonator and DGS structures. The filter structure is simple. Three transmission poles are obtained within the passband which is spread over the frequency range of 4.73 GHz to 10.43 GHz. The fractional band width obtained is 75.2%. The proposed UWB BPF also has a wide stopband, and it has low insertion loss as well as high return loss. The minimum strip width and gap width are 0.2mm. Therefore, easy fabrication of the filter at low cost is ensured. Also, the FCC's indoor limit is satisfied quite well.

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