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Dual Symmetric Multiple-mode Resonators (MMRs) Designed with Defective Ground Structure for UWB Applications

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Abstract. This research paper discussed on the design of UWB-BPF with defected ground structure for microwave applications. The designed UWB-BPF is made up of four meandered line type of defective ground structures and dual symmetric multiple-mode resonators (DSMMRs). Rogers RO4003C substrate is used to fabricate the proposed design BPF which have a relative permittivity, ε_r of 3.38 and R&S Vector Network Analyzer is used for the measurement of the Fabricated BFP. As a result, passband performance and skirt selectivity were improved. The proposed BPF has a passband frequency range of 3.0-10.6GHz and the size of the UWB-BPF is approximately 21.6mm ×30 mm.

INTRODUCTION

The emergence of the ultra-wideband (UWB) frequency spectrum for WLAN range from 3.1GHz up to 10.6GHz, radio communication and microwave imaging has gained considerable attention [1], [2]. In UWB radio communication systems, UWB bandpass filters (BPFs) are key passive elements. UWB BPFs that's achieved performance both in in and out-band have been extensively studied as the implementation reduce the interference from network systems [3]. UWB-filters must satisfy several conditions, including cheap, compact, wide frequency range, and ease of component integration [1], [2].

Numerous approaches and characteristics have recently been employed to build novel UWB-filters with enhanced bandwidth (FBW) of up to hundred and ten percent [4]–[8]. The initial UWB BPF is designed with dual stop bands towards the lower and higher ends of the UWB passband using microstrip ring resonators with loaded open stubs [4]. Therefore, using MMRs, which were initially described in [5], is the method that is most frequently used to create UWB BPFs. To increase selectivity, the stubs are fed into MMRs to generate transmission zeros and multiple resonant modes [6]–[8]. A single high pass filter and a single low pass filter can be cascaded on a microstrip line simultaneously [9], as well as cascading microstrip-to-coplanar waveguide (CPW) broadside coupling sections, are investigated [10]. However, the existing studies have several drawbacks, such as high circuit size, a small stopband area and low selectivity. As a result, designing tiny UWB BPFs with wide stopband and strong selectivity remains a challenge.

In this paper, an UWB-BPF with DSMMRs and four defective ground structures (DGS) is designed. The proposed BPF is fabricated on Rogers RO4003C substrate with a relative permittivity, ε_r of 3.38. Simulation is being carried out using Electromagnetic Simulation Tools and measurement is conducted using Rohde & Shwarz Vector Network Analyzer.

DESIGN SPECIFICATION

Figure 1 depicted the proposed DSMMRs BPF with DGS where parallel coupled feed lines and meandered line-based DGS backed at the two sides are designed. Detail parameter of DSMMRs UWB-BPF is shown in Table 1.

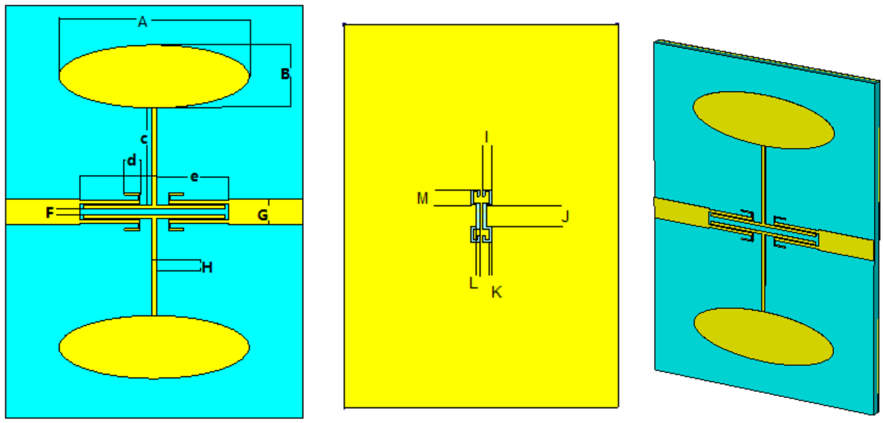


FIGURE 1. Configuration of proposed DSMMRs BPF

TABLE 1. Parameter of DSMMRs UWB-BPF

Parameter	Value (mm)
A	8.38
B	3.1
c	8.26
d	1
e	9.6
F	0.62
G	1.7
H	0.26
I	0.5
J	1.7
K	0.15
L	0.25
M	1

RESULT AND DISCUSSION

The proposed BPF is analyzed using Electromagnetic Simulation Tools. The proposed DSMMRs UWB-BPF shows the 3-dB passband has a fractional bandwidth of 100 percent and includes UWB frequency band with measured return loss is less than 9.5dB.

Sharp selectivity is accomplished due to the two transmission zeros at the lower and higher cut-off frequencies. The attenuation at the lower and upper cut-off frequencies is 58.9 and 41.7dB, respectively. Figure 2 demonstrates that the filter has an average insertion loss of 0.5 dB across the UWB passband of 3.0–10.6 GHz. The simulation findings demonstrate that the various resonances generated within the structure function as UWB BPFs.

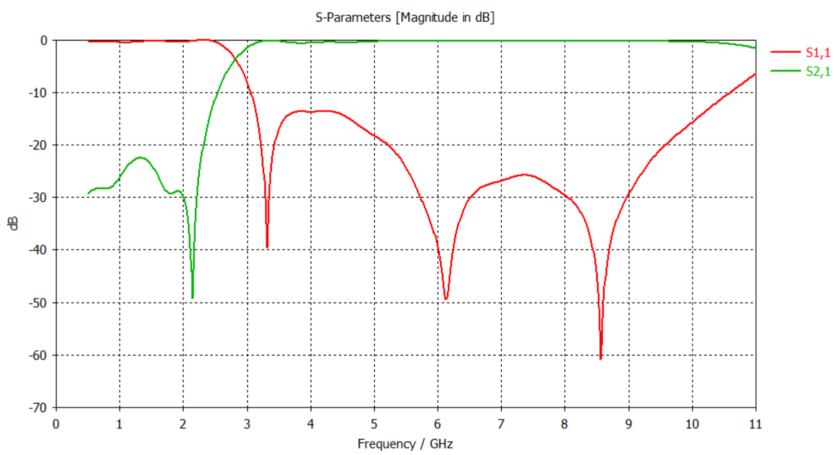


FIGURE 2. Simulated S11 and S21-magnitudes of filter.

Modification on resonator of filter with meander line

The modification on resonator of filter with meander line is done and studied in Figure 3. From the result, it shows that bandwidth of filter has been enhanced.

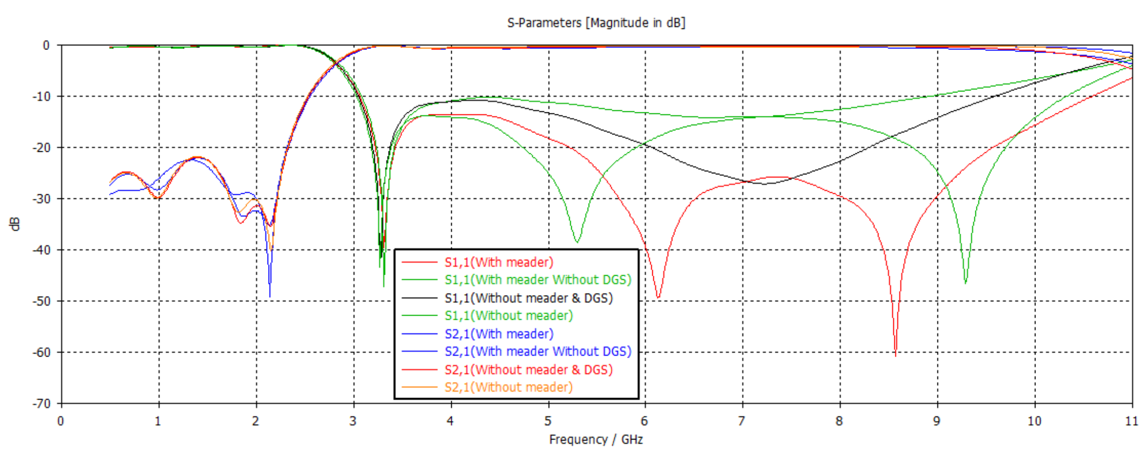


FIGURE 3. Result of S_{11} (dB) with and without the presence of meander line

Parametric studies on proposed filter

Figures 4-7 illustrate the parametric analysis of the proposed DSMMRs UWB-BPF. The suitability of values of parameter can be visualized from the S_{11}-dB variations given in Figures 4-7. Result in Figure 4 and 5 shows the parametric studies on resonator length, L_8 and width, W_8 of the filter.

The length, d_0 in the proposed structure determines the filter's higher cutoff frequency. Upon increasing its value by keeping other values constant, the inductive effect of structures increases and because of this, the higher cut-off frequency of filter decreases, as shown in Figure 7.

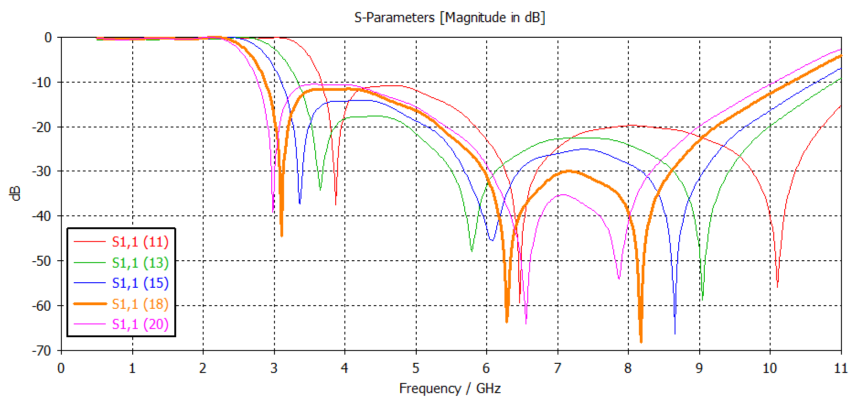


FIGURE 4 Varying the value of W_8 of proposed filter

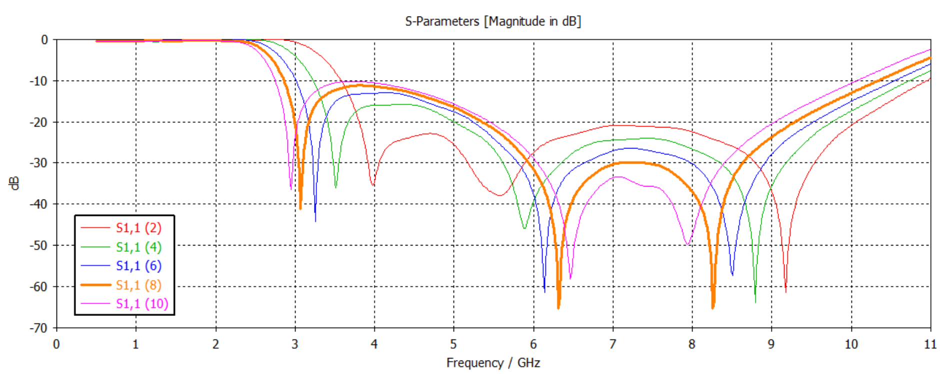


FIGURE 5. Varying the length of L_8 of proposed filter

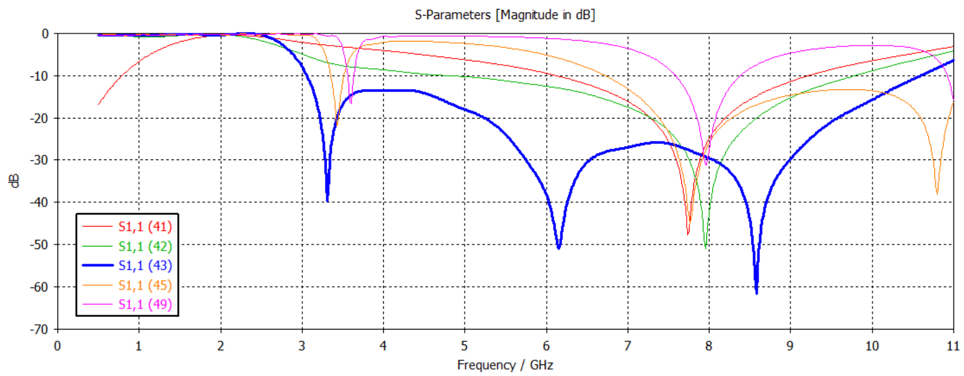


FIGURE 6. Varying the gap of gw of proposed filter

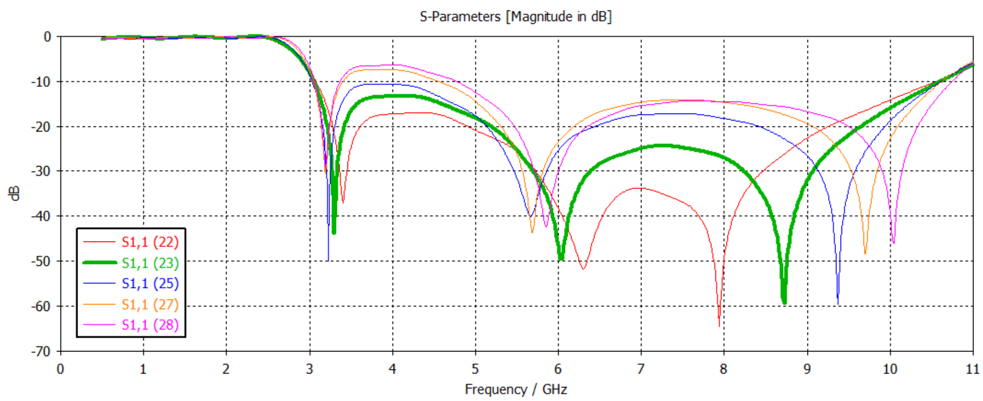
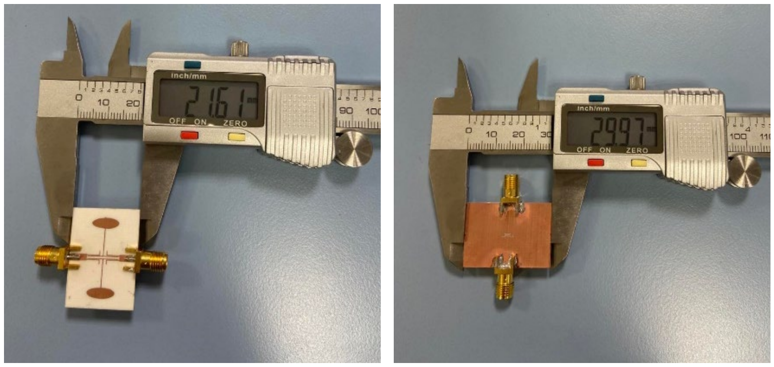


FIGURE 7. Varying the d_0 of proposed filter

Measurement result

The suggested filter is created by utilising a three-layer PCB and is depicted in Figure 8 as a result of the numerical investigation. SMA connections are soldered onto two of the filter's ports. The measurement of S_{11} (dB) of the filter is performed by using an R&S VNA. The measurement result can only reach a maximum of up to 8GHz due to the limitation of R&S VNA. The simulated and measured results of the proposed DSMMRs UWB-BPF are shown in Figure 9.The results from simulation and measurement correspond rather well. The measured value of impedance bandwidth becomes narrows and switches to a lower frequency, which is a significant difference. The following troubleshooting is looked at in order to understand the problem may be caused by variations in the substrate's dielectric constant. Some significant measured such as ripple occurred due to the calibration of the equipment itself and uncontrollable environment.



(a) (b)

FIGURE 8. The DSMMRs UWB-BPF (a) top view, and (b) bottom view

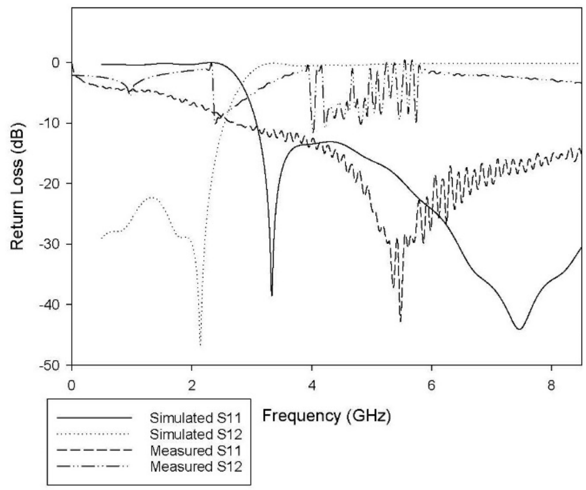


FIGURE 9. The simulated and measured results of proposed DSMMRs BPF

Table 2 shown the comparison of the proposed BPF with previous published research. Based on the table, the proposed DSMMRs BPF has better performance (both in terms of bandwidth and dimension) than the previously published filter which is stated in the literature.

TABLE 2. Recent Research and proposed DSMMRs UWB-BPF

Ref.	3dB BW	Size(mm^2)
[8]	3.1 to 10.4 GHz	16×14.5
[11]	0.5 to 1.9 GHz	64×34
Proposed filter	3.0 to 10.6 GHz	21.6×30

CONCLUSION

A compact planar UWB BPF with symmetric coupled line feeding, DGS backed on ground plane, and symmetric MMRs is shown in this paper. The lower and higher cutoff frequencies have two transmission zeros, which produces a sharp passband performance. Both bandpass and bandstop characteristics are present. From 3.0 to 10.6 GHz, it can accomplish bandpass in the lower UWB band. Low passband insertion loss, excellent return loss, and acute selectivity were identified in the simulation and measurement data. The result of measurement and simulation are in excellent agreement.

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