Performance Improvement of Parallel Coupled Band-pass Filter using Defected Microstrip Structure

Tamasi Moyra
National Institute of Technology, Agartala
West Tripura
India

Sukanta Roy & Pathik Mondal
Bengal Engineering and science University, Shibpur, Howrah
India

Susanta Kumar Parui
Bengal Engineering and science University, Shibpur, Howrah
India

Santanu Das
Bengal Engineering and science University, Shibpur, Howrah
India

ABSTRACT

Resent developments in wireless communication systems demand good Band pass filter (BPF) to select the required signal from the adjacent unwanted signals. In this paper one parallel coupled 3rd order Band pass filter with centre frequency 5GHz and 15% Fractional Bandwidth (FBW) has been designed with the conventional Microstrip transmission line. This designed BPF has been simulated with the help of MoM based IE3D EM simulation software and the corresponding equivalent lumped L-C circuit model has been extracted. The simulated results provide a good agreement with the circuit model results. Here it is found that the proposed parallel coupled BPF provides unwanted harmonics at 9.6GHz and 13.5GHz. Therefore, in this paper attention also has been given towards the suppression of those harmonics with the help of Defected Microstrip Structures (DMS) in addition with the proposed parallel coupled microstrip BPF. Finally, the proposed BPF filter has been fabricated and measured with an Agilent make vector network analyzer of model N5230A and good agreement between simulated and measurement results have been obtained.

Keywords
Microstrip, defected microstrip structure, parallel coupled filter, band pass filter, elliptic filter.

1. INTRODUCTION

Lots of filtering responses can be achieved with the help of microstrip transmission line. Lowpass filter can be easily designed by High-Low microstrip line. Electromagnetic coupling between two transmission lines is the key point for designing bandpass filtering response. End coupled, Inter digital coupled, Parallel coupled, Hairpin microstrip structures etc are examples of microstrip bandpass filters [1-2]. In this paper one parallel coupled bandpass microstrip filter has been designed in a conventional manner and the characteristic response has been find out. The performance of the BPF has been improved by suppressing the unwanted harmonics [3-5] with the help of defected microstrip structures (DMS) in the input and output line of the microstrip line.

2. DESIGN OF PARALLEL COUPLED BANDPASS MICROSTRIP FILTER

Here, corresponding parallel coupled bandpass filter is designed [1] using microstrip transmission line. The strips are arranged in parallel close to each other, so that they coupled with certain coupling factors.The parallel coupled BPF is implemented with the help of FR4 substrate with dielectric constant 4.4, substrate height 1.59 and loss tangent 0.0016. The different dimensions of resonators to satisfy the even-mode and odd-mode characteristic impedances are calculated [1] is shown in the Table1.

Table 1: The different dimensions of the designed parallel-coupled microstrip BPF structure

$l_1 = l_7$	$l_2 = l_6$	$l_3 = l_5$	l_4	$S_1 = S_4$	$S_2 = S_3$
10.2 mm	8.546 mm	8.367 mm	16.73 mm	0.2 mm	0.78 mm
$\omega_1 = \omega_9$		$\omega_2 = \omega_7$	$\omega_3 = \omega_8$	$\omega_4 = \omega_6$	ω_5
3.02 mm		1.87 mm	1.87 mm	2.72 mm	2.72 mm

The schematic diagram of the parallel-coupled Microstrip BPF is as follows:

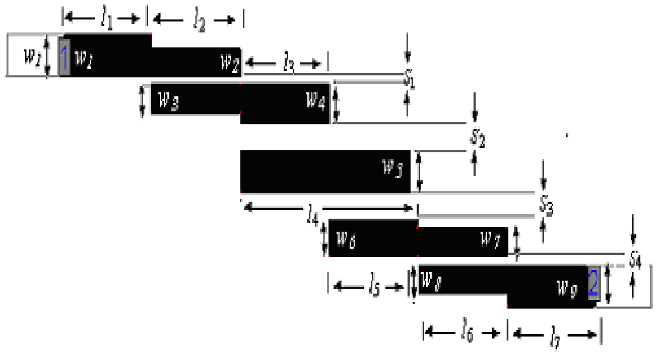


Fig :1 Parallel coupled Microstrip BPF

The circuit model of 3rd order BPF is shown in Fig. 2 (a) and lumped element values [2] are shown in Table 2.

Table 2: L-C lumped element values of 3rd order BPF

$Ls_1 = Ls_3$	Lp_2	$Cs_1 = Cs_3$	Cp_2
10.9512 nH	0.2082 nH	0.0926 pF	4.872 pF

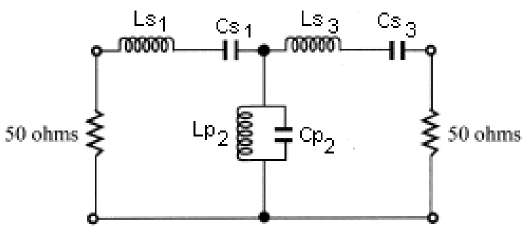
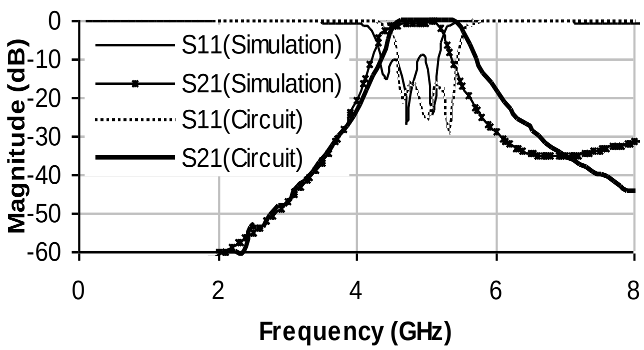


Fig :2 (a) L-C lumped element Circuit Model



2(b) Scattering Parameters of simulated and circuit model

The structure has been simulated with the help of IE3D EM Simulator. The simulated and circuit model S-parameter responses are shown in following figure 2(b). From the circuit model it can be observed that the response provides bandpass filtering characteristics with passband centre frequency, f_0 = 5GHz, Fractional Bandwidth, FBW = 15% and negligible passband insertion loss. It is observed from the above responses there is a good agreement between the simulated and circuit model responses.

3. PERFORMRNCE IMPROVRMENT OF THE PARALLEL COUPLED BPF

The designed structure provides the BPF filtering response with 5GHz centre frequency. But if the response is observed elaborately, there is a tendency of the proposed structure to act as a dual band BPF or tendency of passing the signals around the frequency 13.5 GHz which appearing as unwanted harmonic or spurious of the wanted signal. The elaborate response of the proposed parallel coupled BPF is shown in the following Figure 3.

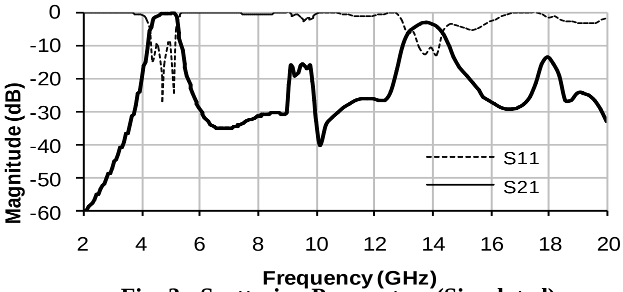


Fig: 3: Scattering Parameters (Simulated)

This tendency of passing the unwanted harmonic can somehow be reduced with little modification of the structure by introducing the Defected Microstrip Structure (DMS). The DMS is nothing but the particular pattern slot etched in the microstrip signal line which is responsible for providing some stopband characteristics.

Here, 'U' shaped DMS with 0.4mm slot width has been introduced for the reduction of harmonics as shown in the following figure 4(a) and the response of the DMS is shown in the figure 4(b).

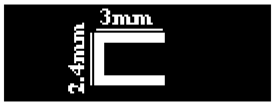


Fig: 4(a): proposed DMS structure

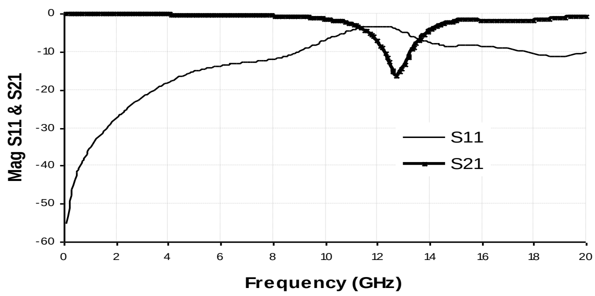


Fig: 4(b): Scattering Parameters

From the above figure it is clear that introducing slot in the microstrip line introduces L-C resonance circuit and provides stop band around 12.5 GHz. With the change of any parameter of the slot keeping other parameters constant resonance frequency can be tuned.

In this paper an array five 'U' shaped DMS units has been introduced in the signal line as following fig. 5(a) and the characteristic response is shown in fig. 5(b).

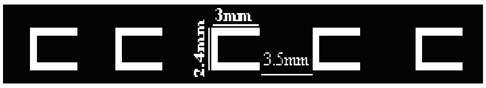


Fig: 5(a): Array of five DMS units

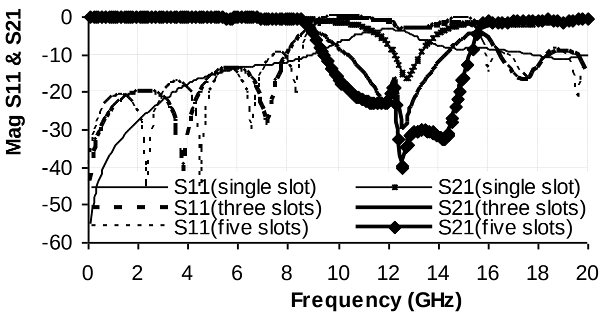


Fig: 5(b): Scattering Parameters

The array of proposed DMS structures improves stop band as shown in the following figure 5(b). This shows that five array structure provides 4.5 GHz attenuation bandwidth at -20 dB.

Thus, the modified structure of the proposed parallel coupled band pass filter is shown in the fig.6(a) and the characteristic response is shown in the fig. 6(b).

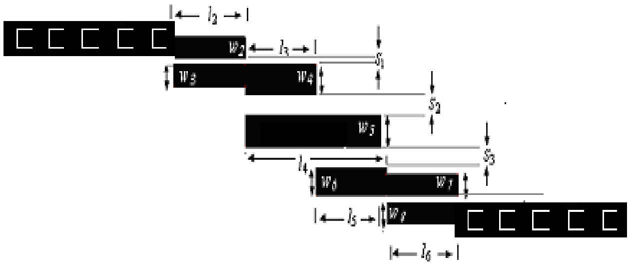


Fig: 6(a) Modified Parallel coupled structured

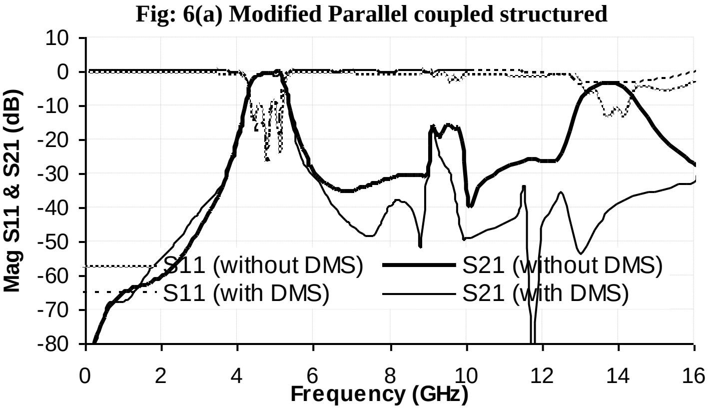


Fig: 6(b): Scattering Parameters with and without DMS

From the above response it is observed that the parallel coupled bandpass filter with modified DMS provides much more acceptable filtering characteristics. It removes the unwanted harmonic as well as increases the selectivity and quality factor of the parallel coupled bandpass filter.

4. MEASUREMENT AND DISCUSSION

The prototype structure is fabricated on FR4 substrate with dielectric constant 4.4, loss tangent $\tan\delta = 0.016$ with substrate height 1.58mm and measured with an Agilent make vector network analyzer of model N5230A. The photonic view of the proposed structure is shown in Fig. 7(a). The simulated and measurement results are shown in Fig. 7(b).

Fig. 7(a) Photographic view of the proposed structure

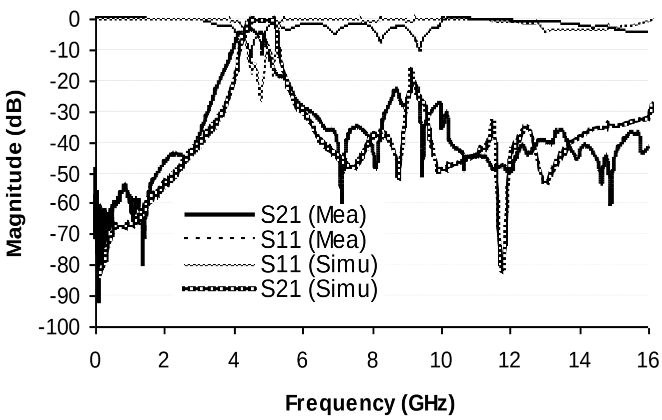


Fig: 7(b): Scattering Parameters

The above response shows that the proposed structure provides good BPF filtering response with passing the signals around centre frequency 5 GHz and removal of higher harmonics. It is obtained from the simulated result that it is a BPF filter of center frequency, f_0, at 4.94 GHz, 20.3 % fractional bandwidth (FBW) at -3dB with high selectivity. Whereas, the measurement results shows center frequency, f_0, at 4.76 GHz with 17.5 % FBW at -3dB. Thus, it is observed that there is a good agreement between simulated and measurement results.

5. CONCLISION

Parallel coupled bandpass filter is one of the important and well-known microstrip filter. Lots of research works have been done on the utilization of Defected Ground Structures (DGS), Split Ring Resonators (SRR) and Complementary Split Ring Resonators (CSRR) for the removal of harmonics appearing around multiple frequencies of central frequency. Defected Microstrip structure (DMS) is one newly adopted research context. Combination of the conventional parallel coupled bandpass filter and DMS structures concept provides excellent filtering response which is too much required in our modern microwave and milimeterwave communication systems such as Rader, Satellite, GPS, Bluetooth etc.

6. ACKNOWLEDGMENTS

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