Improvement of Stopband Performance OF Microstrip Reconfigurable Band Pass Filter By Defected Ground Structure

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Abstract

A scheme for designing reconfigurable parallel-coupled-line bandpass filters using a SPDT MEMS switch, capable of operating at two different passband is presented. The spurious resonance of the filter has been removed by using defected ground structures to obtain better stopband performance. A proto-type filter with passband center frequency around 3.5 GHz and 5.0 GHz has been designed. The simulation has been done by MOM based IE3D software. Applying defected ground structures under output feed lines, we have achieved stopband with minimum attenuation of -25 dB upto 12 GHz.

1. INTRODUCTION

Modern microwave communication systems especially broad-band and multiband applications in satellite and mobile communications, require high performance bandpass filters having low insertion loss and high selectivity together with linear phase or flat group delay in the passband. The microstrip parallel-coupled half-wavelength resonator filter, proposed by Cohn in 1958 [1] has been one of the most commonly used Bandpass filter. Recently Chang and Itoh introduced a modified parallel-coupled filter structure to improve the upper stopband rejection and the response symmetry [2].

With the arrival of RF MEMS technology in the last decade, there has been a significant amount of activity in trying to develop a wide variety of components that can be reconfigurable and/or electronically tunable in order to allow for transceiver re-use at different frequency bands [3]. Examples of such components include antennas, phase shifters, and different type of filters. In the frequency-tunable filters, the passband of the filter changes with an applied DC voltage.

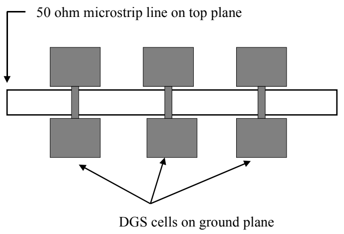
Recently, defected ground structure (DGS) for planar transmission lines has drawn a wide interest because of their extensive applicability in antenna and microwave circuits [4-5]. DGS etched in the metallic ground plane of microstrip lines, are attractive to obtain unwanted frequency rejection and circuit size reduction.

In this paper, we have design a microstrip parallel-coupled-line bandpass filter with pass band center frequency of 3.5 GHz and 3dB bandwidth of 400 MHz. The reconfigurable filter circuit consists of two same type of parallel-coupled bandpass filters and a single-pole double throw MEMS switch. The incident signal enters through a three-conductor set of coupled lines, which feeds the two bandpass filter section. The switch selects between the outputs of the two filter section and thus a reconfigurable system is obtained.

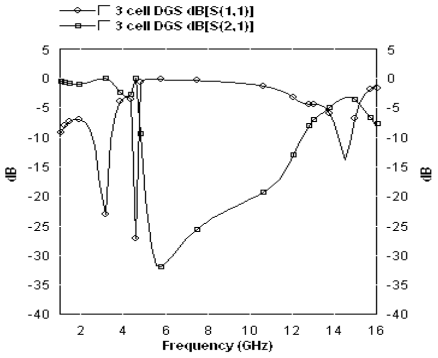
We have applied DGS to enhance the stopband performance of the filter. The proposed DGS cell consists of two rectangular slots connected by a thin transverse slot symmetrically under the microstrip line. The stop band performance affects by generation of unwanted spurious frequencies. We remove the spurious frequencies by putting sets of three DGS cells under output feed lines. So finally we are able to achieve good stop-band performances. DGS under feedlines have a very little effect on passband frequency of the filter and that is due to insertion loss of the lowpass characteristics of DGS.

2. DESIGN OF DEFECTED GROUND STRUCTURE UNDER MICROSTRIP LINE

DGS cell consist of two rectangular slots of length 4.4 mm and width 4 mm are connected by a thin transverse rectangular slot of width 0.4 mm and length 2.0 mm symmetrically under 50 ohm microstrip line, assuming the substrate with thickness 0.792 mm and dielectric constant of 3.2. Here an array of three DGS cells is placed with separation of 5.5 mm to study lowpass filtering characteristics. By cascading three cells under microstrip line as shown in Fig. 1, we are able to achieve sharp and wide stopband characteristics. The resonant frequency can be tuned by adjusting the width of transverse connecting slot or by changing dimension of rectangular slots.



(a)



(b)

Fig. 1: Microstrip line with 3 numbers of DGS cells (a) Layout & (b) S-parameter characteristics

The above structure is simulated with MOM based IE3D commercial software. S-parameters are plotted in Fig. 1(b) and observe the cutoff frequency at 4.7 GHz and stopband center frequency at 5.7 GHz respectively. The 20 dB rejection bandwidth is 5.0 GHz and the sharpness factor at lower cutoff edge is 30 dB/ GHz which shows good filter characteristics. The stopband of the DGS is utilized to design the stopband of the proposed bandpass filter.

3. DESIGN OF MICROSTRIP PARALLEL-COUPLED-LINE BANDPASS FILTER

We have design a microstrip parallel-coupled-line bandpass filter. The layout of the filter is shown in Fig. 2. It shows input and output feed lines has length of 12 mm. We provide higher length of feed line for incorporating DGS cells. The width of feed line is made 1.92 mm towards port and 0.5 mm towards couple line for proper matching of impedance. The couple lines have width of 2 mm and they are separated by a gap of 0.4 mm. The gap between feed line and couple line are made of 0.2 mm.

The length of the parallel coupled lines is half of the guided wavelength and we have designed the value of 26 mm, taking center frequency at 3.5 GHz for substrate having dielectric constant 3.2 and thickness 0.79 mm.

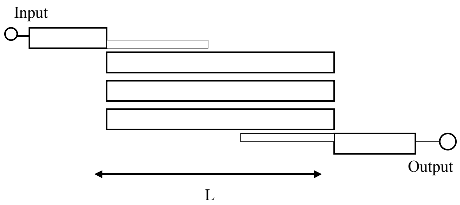
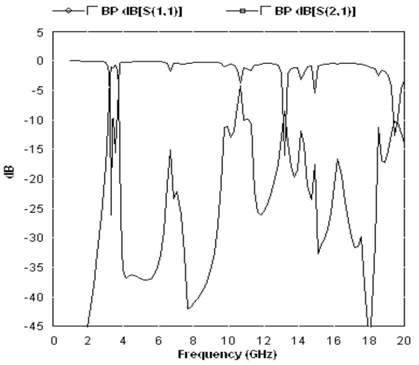
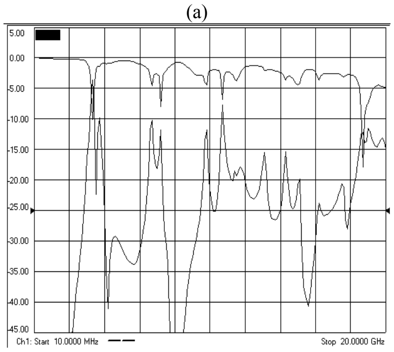


Fig. 2: Layout of typical microstrip parallel-coupled-line bandpass filter

The simulated S-parameters are plotted in Fig. 3(a) and observe the pass-band (3 dB) width of 0.41 GHz at centre frequency of 3.5 GHz. The 20 dB-Rejection bandwidth is 0.8 GHz. It shows higher harmonics centered at 7 GHz, 10.5 GHz etc. The fabrication is done in Arlon make PTFE substrate with dielectric constant 3.2 and thickness of 0.79 mm. The measured result by vector network analyzer has been shown in Fig. 3(b), which almost comply the simulated result.



(a)

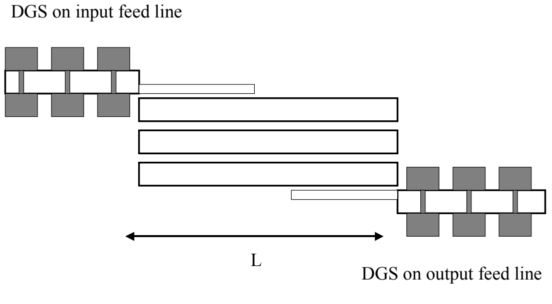


(b)

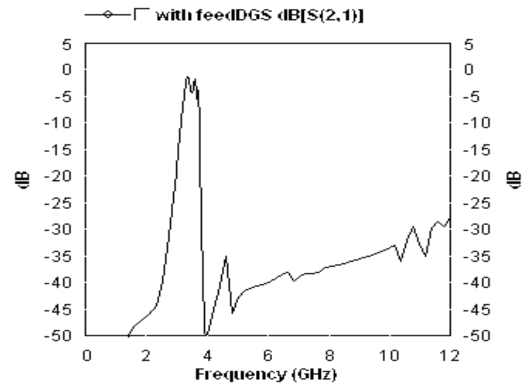
Fig. 3: S-parameter of Bandpass filter (a) Simulated and (b) Measured

4. REJECTION OF SPURIOUS COMPONENT OF BANDPASS FILTER USING DGS

DGS etched in the metallic ground plane under both input and output feed lines, are attractive option to reject unwanted harmonic frequency components. The frequency of operation is accurately tuned by adjusting the dimension of rectangular slot. We put 3 numbers of DGS cells under input lines and output lines.



(a)



(b)

Figure 4: BPF with DGS under input and output feed line: (a) layout & (b)Simulated S-parameter

The input and output DGSs behave like lowpass filter with cutoff frequency 4.7 GHz and roll of 30 dB/GHz. So they allow the fundamental frequency at 3.5 GHz to pass but attenuate other harmonics at 7 GHz and 10.5 GHz. Finally we are able to achieve wide stopband with minimum attenuation –25 dB up to 12 GHz as shown in Fig. 4(b).

5. REJECTION OF SPURIOUS COMPONENT OF RECONFIGURABLE FILTER USING DGS

A layout of reconfigurable dual band filter has been shown in Fig.5, which consists of two parallel-coupled bandpass filters placed in both side of input feed line. The incident signal enters a three-conductor set of coupled lines to either the top or bottom depending on the frequency of the signal. A single-pole double throw (SPDT) MEMS switch is used to select between the outputs of top or bottom filters and thus passband frequency selection is achieved. The upper bandpass filter section was designed to have a center passband frequency of 5 GHz by using a resonant length, L1=18 mm and the lower bandpass filter section has a center passband frequency of 3.5 GHz using L2 = 26 mm. For the both filters, the gap between the feed line and coupled line was 0.2 mm and gap between coupled lines was 0.4 mm. The MEMS switch is magnetically actuated device and requires a voltage pulse for switching operation.

The simulated S21 of the reconfigurable BPF shows the passband at 5 GHz when output is connected to port 2 and passband at 3. 5 GHz when output is connected to port 3.

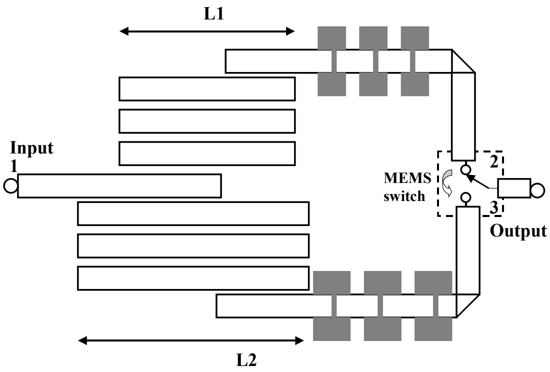
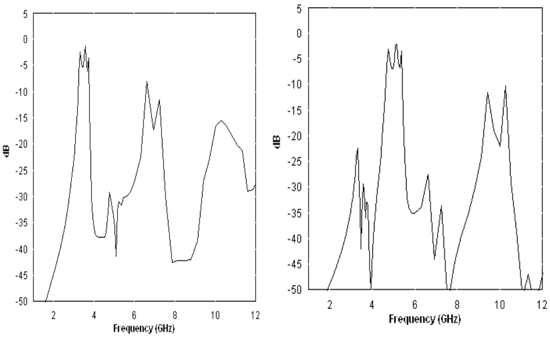


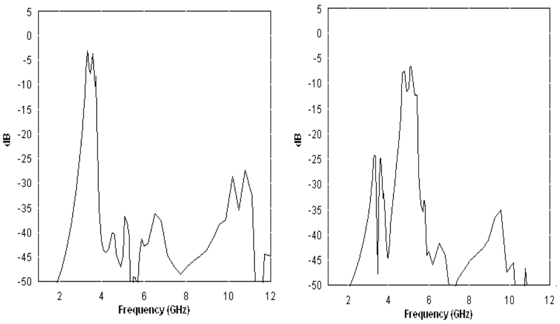
Fig. 5::Layout of Reconfigurable BPF (a) with DGS under output lines.



(a) (b)

Fig. 6: S_{21} of Reconfigurable BPF, when output (a) connected at port 3; (b) connected at port 2

We have etched DGS under output feed lines of both filter section to remove the spurious signals. As the passband frequency of two filters is different, we took different dimension of DGS. DGS cell for upper filter have patch dimension 3.4 mm x 3 mm, transverse connecting slot have dimension 0.4mm X 2mm and separation between two cells is 4.5 mm. DGS cell for lower filter have patch dimension 4.4 mm x 3 mm and separation between two cells is 5.5 mm respectively. The spurious signals for both filter configurations have been removed by DGS under output feed lines as shown in Fig. 7. DGS under feedline have a little effect on passband frequency due to finite insertion loss of the lowpass characteristics of DGS.



(a) (b)

Fig. 7: S_{21} of Reconfigurable BPF without DGS, when output (a) connected at port3 ; (b) connected at port2.

CONCLUSION

We design a microstrip parallel-coupled bandpass filter and etched DGS under both input and output feed lines to reject unwanted harmonic frequency components. A reconfigurable filter structure using SPDT MEMS switch, which operates at two different passbands is presented. We incorporate DGS under output lines of both section of the filter to remove the unwanted spurious signals. Such reconfigurable filters may find lots of application in a variety of transceiver system that required channel selection.

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