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LOW COST COMPACT COUPLED LINE BAND SELECTED DUAL BAND-PASS FILTER WITH WIDE TUNING RANGE

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Abstract

A low cost dual band, band selected band-pass filter realized with simple coupled line structure is proposed in this letter. The proposed filter employs low cost diodes and capacitors for the band selection. The designed filter has a miniature circuit size of 8.4 cm x 1.5 cm and has a measured pass band insertion loss not more than 1.8 dB at its pass bands while fabricated in FR4 substrate. The filter presents wide tunable band selection in the range of 1.5-4.3 GHz and 5-8.2 GHz for the first and second bands utilizing the biasing dc voltage of 1-5 V.

1 INTRODUCTION

The demand for multi-band filters which are the key components to control the spectrum of RF signals and tracking interference issues in the multiband transceivers are increased recently . The RF transceiver has challengeable characteristics such as small size, high performance, low cost, multi-band reconfigurable and multi-functions .Therefore, the band-selected band pass filter (BPF) with wide tenability is essential for the RF front end [1]. These filters are normally accomplished with different tuning elements such as RF micro-electro-mechanical system (RF-MEMS) devices [2], PIN diodes [3], and barium-strontium-titanate varactors and silicon/GaAs varactor diodes [4]. Several tunable filters have been reported in [5-7].

In this letter, a compact size single reconfigurable and pass filter capable of operating in the range of 2-11.5 GHz while maintaining 6-7.5 GHz as stop band is reported. Coupled line filter configuration is used along with varactor diodes to achieve discrete tuning since PIN diodes allow wide range tuning of both the resonant frequency and bandwidth, limited only by the electrical size of transmission lines. Filter using diodes are attractive below 12 GHz where diodes can still show quality factors above 50 with low bias voltages. The schematic and the layout of the proposed design are shown in Fig 1 and Fig 2. Fig 3 shows the photograph of the designed filter.

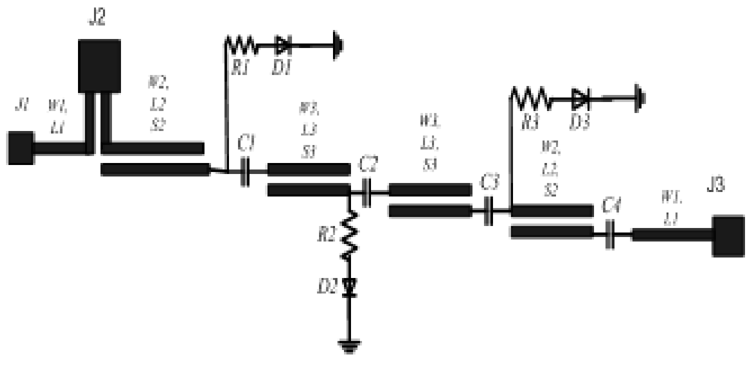

Figure 1 Fig 1.Schematic of the proposed filter where W1=1.2763

mm, W2=0.22 mm, W3=0.241 mm, L1=7.5 mm, L2=23.033 mm, L3=12.749 mm, S2=0.23 mm, S3=0.471 mm.

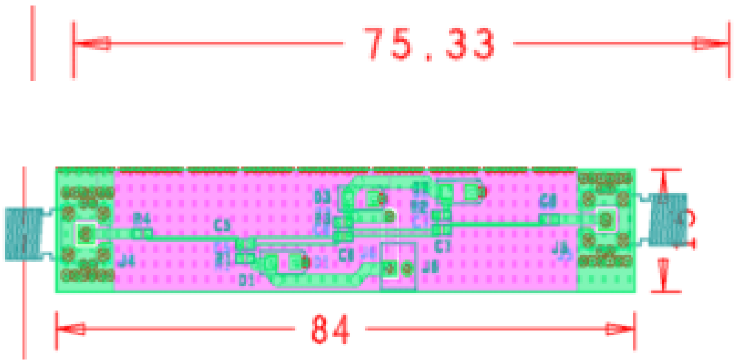

Figure 2 Layout of the proposed filter showing component fixtures.

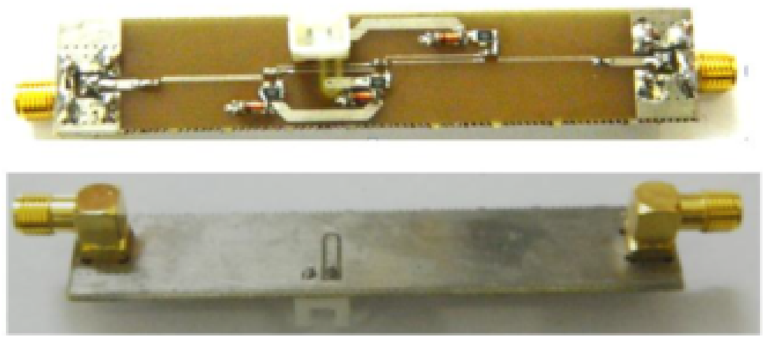

Figure 3 Photograph of the fabricated filter showing its front and back views.

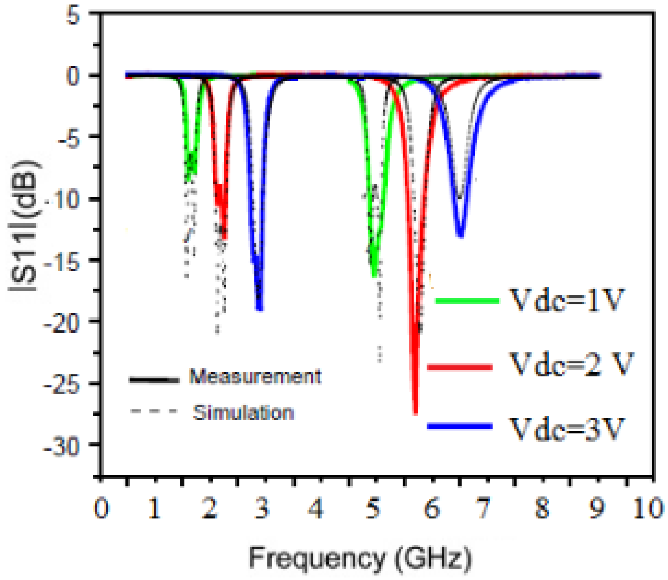
|S11|(dB)
5
0
-5
-10
-15
-20
-25
-30
0 1 2 3 4 5 6 7 8 9 10
Frequency (GHz)
Measurement
Simulation
Vdc=1V
Vdc=2 V
Vdc=3V

Figure 4(a)

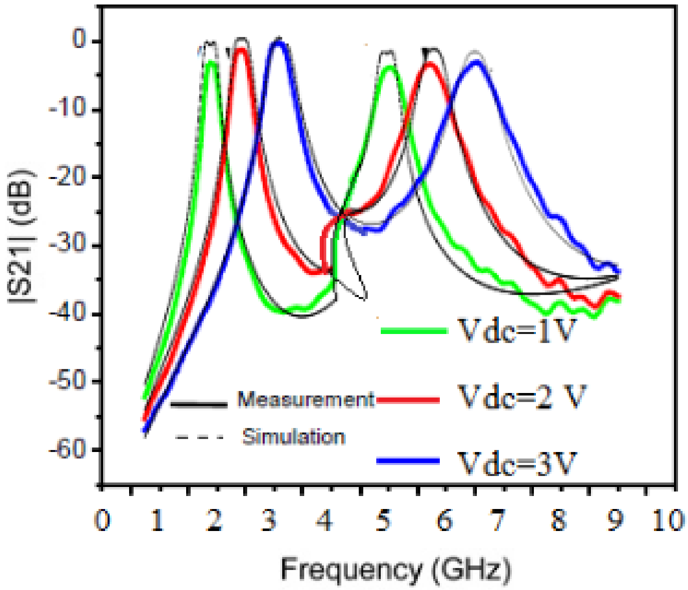

Figure 4(b)

Figure 4 Simulated and Measured S parameters of the proposed filter for biasing dc voltage variation from 1-3 V
(a) Magnitude of S11
(b) Magnitude of S22

Filter Design and Measurements: The proposed filter is designed on the low cost FR4 substrate with ξ_r= 4.3, substrate thickness h=1.6 mm and tan δ =0.0021. The detailed design procedure of the dual band pass filter is started by determining the third order filter coefficients of the conventional coupled line filter and then converting the parameters to micro striplines. The center of each pass band is derived correspondingly based on the desired frequency response centering at the high edge of a given frequency tuning range. As such, the required Q_exo (even mode impedance) and Q_exe (Odd mode impedance)and coupling coefficient and for the ideal tunable filter were determined. The tuning range and the rate at which the tuning should be done is also determined by properly selecting W, L, S (width, space, length) with respect to the first and second pass bands. The coupled-line length and gap width are then designed to maintain the frequency-response configuration and operating bandwidth of the first and second pass bands. The detailed dimensions of the filter are W1=1.2763 mm, W2=0.22 mm, W3=0.241 mm, L1=7.5 mm, L2=23.033 mm, L3=12.749 mm, S2=0.23 mm, S3=0.471 mm with the component values of R1=R2=R3=80, C1=C2=C3=C4=10 pF, C5= 1.1, pF, C6= 1.3 pF, C7= 1.4 pF andC8= 1.5 pF. The varactor diodes used from MACOM (D1-MA46H202, D2-MA46H203, D3-MA46H204 and D4-MA46H201) with different capacitive tuning ranges.Diode D1 has tuning range between 2.7-3.3 pF where D2,D3 and D4 has tuning ranges 4.5-5.5 pF,9-11 pF and 0.9-1.1 pF respectively. Resistors, Capacitors and varactor diodes are placed in the circuit in such a way that there is a desired transmission zero between the two pass bands as shown in Fig 1 to enhance the tunability of the filter. The designed circuit is optimized using S parameter simulation tool in Advanced Design System. These obtained dimensions which are mathematically derived from the above steps are constructed correspondingly on the layout and filter characterization is checked for verifying the proper functionality of the filter. Fig 4 shows the measured and simulated frequency responses of the proposed filter for biasing voltage varying from 1-3 V. A good agreement is shown between the simulation and measurements. The first pass band with a center frequencies 1.52, 2.25 and 2.9 GHz has approximately 1.6,1.7 and 1.8 dB of insertion loss and 8.2, 14.1 and 18.8 dB of return loss respectively. The second pass band with a center frequencies 5,5.6 and 6.5 GHz has 1.6,1.75 and 1.85 dB of insertion loss and approximately 15.5, 27.5, 12.2 dB of return loss. Upon practical measurements the filter presents wide tunable band selection in the range of 1.5-4.3 GHz and 5-8.2 GHz for the first and second bands utilizing the biasing dc voltage of 1-5 V.

2 CONCLUSION

A low cost tunable dual band filter with wide tuning range has been investigated and reported with its simulated and measured return loss and insertion loss characteristics. The proposed filter finds its applications in wireless communications and C band applications.

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