MICROSTRIP BAND REJECTION FILTER USING OPEN LOOP RESONATOR

B. Jitha, P. C. Bybi, C. K. Aanandan, and P. Mohanan
Centre for Research in Electromagnetics and Antennas, Department of Electronics, Cochin University of Science and Technology, Cochin 682022, India; Corresponding author: anand@cusat.ac.in

Received 31 October 2007

ABSTRACT: *Design of a compact microstrip band reject filter is proposed. The device consists of an Open Loop Rectangular Resonator (OLRR) coupled to a microstrip line. The transmission line has a U-bend which enhances the coupling with the OLRR element and reduces the size of the filter. The filter can be made tunable by mounting variable capacitance to the system. Simulated and experimental results are presented.* © 2008 Wiley Periodicals, Inc. Microwave Opt Technol Lett 50: 1550–1551, 2008; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.23415

Key words: *open loop rectangular resonator (OLRR); microstrip band reject filter; tunable filter*

1. INTRODUCTION

Narrow band rejection filters are used in communication systems such as satellite location systems, mobile phones, cable televisions, radar systems, and numerous other applications for noise reduction and rejection of unwanted signals. Applications of microstrip ring resonators in filters [1] have tiled the base for researchers to design compact filters using resonators of different shapes like triangular resonators [2], spurline [3], and SRRs [4].The advantage of SRRs over the EBG based filter is studied in [5]. A conventional rectangular ring resonator is simple to design but is too large to be used in modern communication devices. Filter using square ring resonator of dimension of the order of λg/4 provides good notching [6]. The size of the filter can be further reduced by introducing a split in one of its arms forming an open loop rectangular resonator.

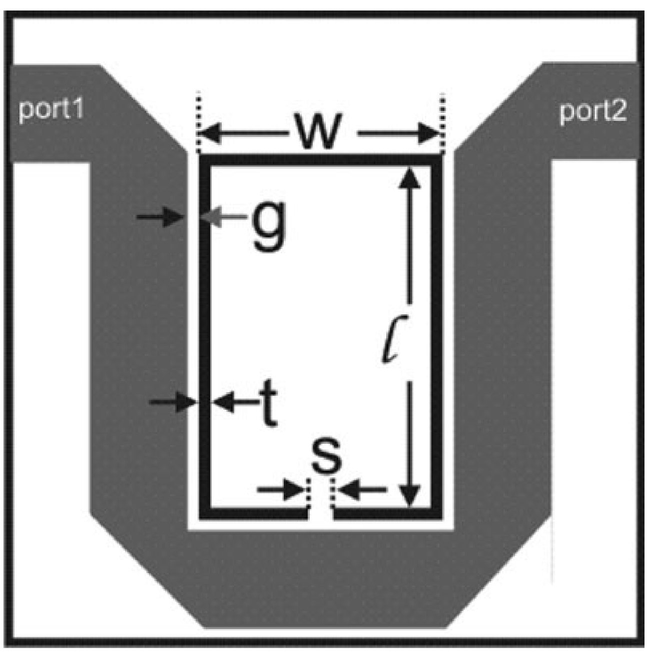

Figure 1 Geometry of the proposed OLRR narrow band reject filter (l = 17 mm, w = 12 mm, s = 1 mm, t = 0.5 mm)

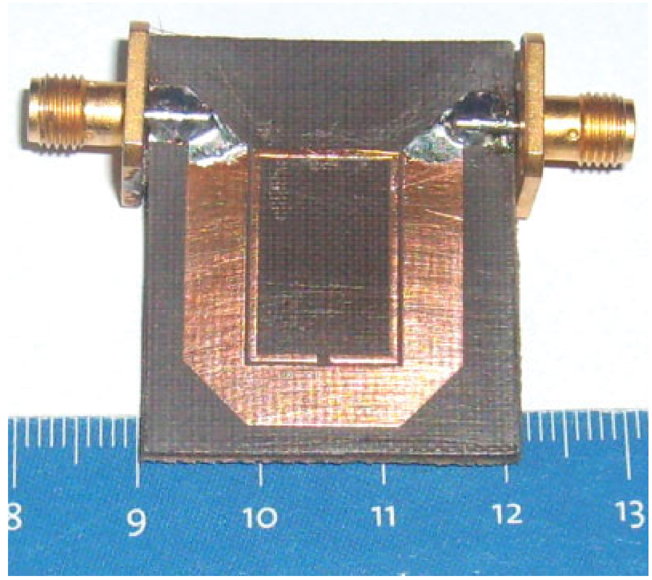

Figure 2 Photograph of OLRR filter. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

In the design reported here, an open loop rectangular resonator (OLRR) is introduced inside a U-bend of a microstrip transmission line to achieve band rejection. This structure is more compact and the configuration ensures better coupling between the resonator and the transmission line.

2. OLRR FILTER DESIGN

Figure 1 shows the geometry of the OLRR filter. A rectangular loop of length l, width w, thickness t is fabricated on an RT Duroid substrate of $\varepsilon_r = 3.2$ and thickness 1.6 mm. The mitred 50Ω transmission line is bend around the resonating element with a gap distance g. The approximate value of the resonant frequency of the nth mode is given by,

$$f_0 \approx \frac{\mathrm{nc}}{2(p-s)\sqrt{\varepsilon_{\mathrm{eff}}}}$$

Where p is the average perimeter, s is the split width, and c is the speed of light in free space and $\varepsilon_{\mathrm{eff}}$ is the effective dielectric constant calculated for the microstrip line.

3. SIMULATED AND MEASURED RESULTS

Based on the design shown in Figure 1, the structure is simulated in Zeland IE3D to study the reflection and transmission characteristics. The prototype was fabricated as shown in Figure 2.

The performance of the filter was experimentally verified using RS ZVB 20 Network analyzer. Simulated and measured results are given in Figure 3. A stop bandwidth of about 70 MHz (−10dB) is observed for the filter.

The rejection frequency of the OLRR filter can be tuned by connecting a variable capacitance across the split. This is verified by simulation using different capacitance values across the split and the results are shown in Figure 4(a). It is seen that the resonant frequency can be controlled in a wide range by varying the capacitance. Electronic tuning can be achieved by integrating a varactor diode across the split as shown in Figure 4(b) with an isolation circuit employing a 100 pF capacitance as an RF short and RF chokes for protecting the DC voltage source.

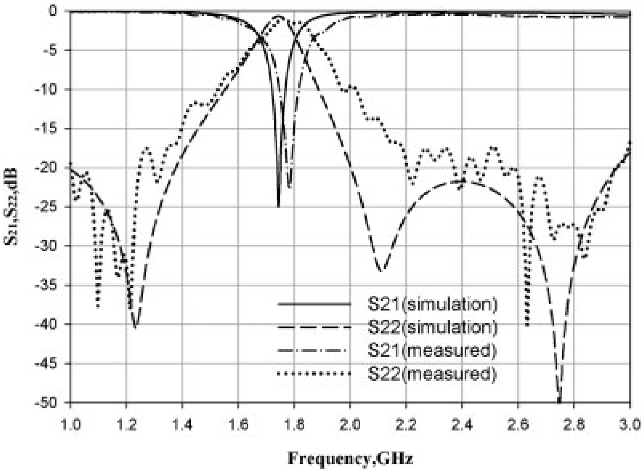

Figure 3 Transmission characteristics of the OLRR filter

The band stop attenuation can be further increased by using two resonating elements as shown in Figure 5. Here the distance between the OLRR elements is taken as 15 mm (∼;*g*/8) to minimize losses in the pass band. The simulated response shown in Figure 5 indicates a sharp roll-off which is an important consideration in wireless communication system.

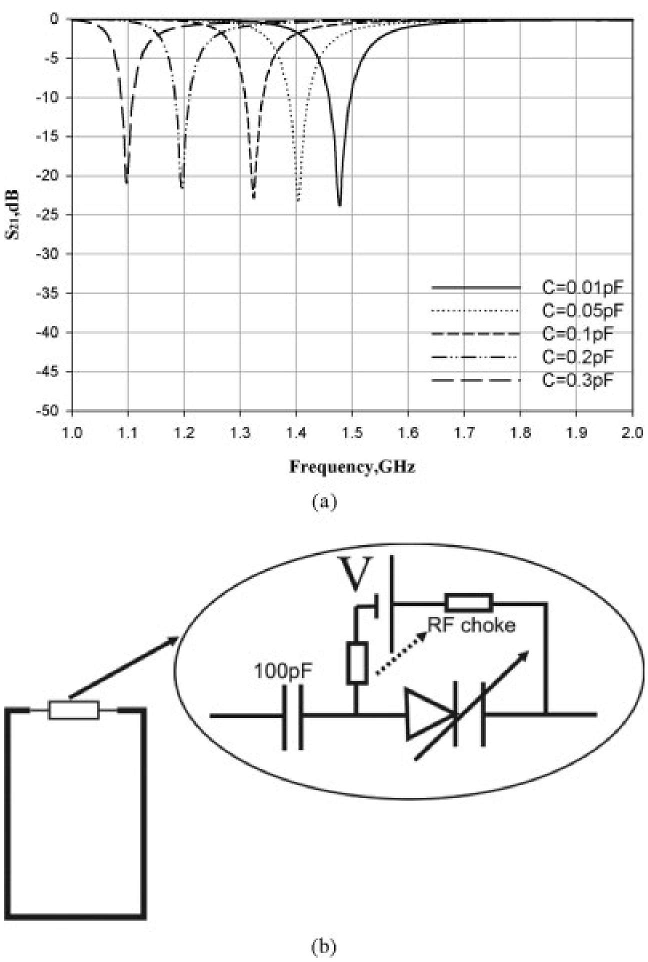

Figure 4 (a) Simulated results of notch frequency tuning of the OLRR filter (b) DC isolation circuit for connecting the varactor

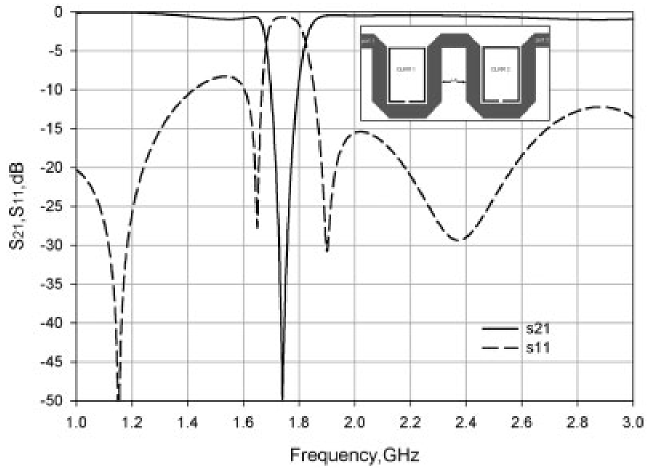

Figure 5 Simulated response of notch filter with two OLRR elements (inset: layout)

4. CONCLUSION

A simple and compact microstrip band reject filter is designed and implemented. It is demonstrated that the notched frequency can be tuned electronically by embedding varactor diode in the split. The fabricated prototype is very small and can be further miniaturized using a higher permittivity substrate. The compactness and tunability make this design attractive for applications in modern communication systems.

ACKNOWLEDGMENT

Authors acknowledges the FIST programme of Department of Science and Technology, Government of India, for financial assistance.

REFERENCES

1. K. Chang and L.-H. Hsieh, Microwave ring circuits and related structures, 2nd ed., Wiley, 2004.
2. W.-N. Chen, M.-H. Weng, I.-T. Tang, C.-Y. Hung, T.-C. Cheng, and M.-P. Houng, Notch filters with novel microstrip, triangle-type resonators, IEEE Trans Ultrasonics Ferroelectrics Frequency Control 51 (2004), 1018–1021.
3. C. Nguyen and K. Chang, On the analysis and design of spurline bandstop filters, IEEE Trans Microwave Theory Tech 33 (1985), 1416–1421.
4. C.K. Anandan, C.S. Nimisha, B. Jitha, P. Mohanan, and K. Vasudevan, Transmission properties of Microstrip lines loaded with split ring resonators as superstrate, Microwave Opt Technol Lett 11 (2006), 2280–2282.
5. J. Garcia-Garcia, J. Bonache, I. Gill, F. Martin, R. Marques, F. Falcone, T. Lopetegi, M.A.G. Laso, and M. Sorolla, Comparison of electromagnetic band gap and split ring resonator microstrip lines as stop band structures, Microwave and Opt Technol Lett 4 (2005), 376–379.
6. J.V.S. Harikrishna, R.N. Karekar, and R.C. Aiyer, Improved high rejection notch filter using square ring resonator with flexible electromagnetic coupling, Microwave Opt Technol Lett 5 (2007), 1201–1203.