KIET IJCE KIET International Journal of Communications & Electronics
Volume. No. 7, Issue No. 1, Jan-June 2019, ISSN: 2320 – 8996

Metamaterial based Band Pass Filter for Wireless Communication

Navita Singh[#1], , R.N. Baral[*2], Arun Kumar[$3]
[1] Department of Electronics and Communication Engineering,I.F.T.M. University, Moradabad.
[2]Department of Electronics and Communication Engineering, IMS Engineeering College, Ghaziabad,
[1]singh.navita@rediffmail.com,
[2]r.n.baral@gmail.com,
[3]drarunkumargkp@gmail.com

Abstract. A new approach for the development of planar metamaterial structures is developed. With the development of metamaterials in recent years, more and more interests have been attracted in the potential applications of these novel materials. For this purpose, split-ring resonators (SRRs) coupled to planar transmission lines are investigated. The electromagnetic behavior of these elements, as well as their coupling to the host transmission line, are studied. The proposed analysis is of interest in the design of compact microwave devices based on the metamaterial concept. This paper first provides left-handed metamaterials and introduces technologies that are nearing practical use, focusing on such applications as telecommunication devices.

Keywords: Metamaterial, Conventional Filter, Computational electromagnetic, Q- factor

Periodically arranged at intervals shorter than the specified wavelength of an electromagnetic wave, small pieces of metal and the like can constitute an artificial medium that has characteristics not found in nature . Such a medium is called metamaterial. Metamaterials refer to artificial structures that consist of a periodic array of metal pieces or the like. Technologies called “left-handed Metamaterials” in particular can even produce phenomena that are not available in natural substances and thus it is expected that this will enable the fabrication of electronic devices with functions heretofore unimaginable. Metamaterials can also be made of dielectrics, magnetic substances, semiconductors, and the like, and even electric circuits instead of metal pieces.The word “meta” derives from the Greek word that means “beyond”. While conventional materials provide their intended physics properties in terms of design on the atomic or molecular level, metamaterials realize their specified physical properties through the design of an artificial structure that can be regarded as a quasi-uniform medium in a macroscopic view.

In recent years, there has been a growing interest for the design of one, two and three-dimensional artificial structure (also called metamaterials) with electromagnetic properties generally not found in nature. Among them, special attention has been devoted to double-negative media. These are artificial periodic structures composed of sub-wavelength constituent elements that make the structure behave as an effective medium with negative values of permittivity and permeability at the frequencies of interest. The properties of such media were already studied by Veselago over 30 years ago.Russian scientist V.G.Veslago published about 30 years ago that examined the effects of a “left-handed” material with the simultaneously negative-permittivity and permeability along with a negative refractive index. Having originated from a purely theoretical interest, the study predicted some new

KIET IJCE KIET International Journal of Communications & Electronics
Volume. No. 7, Issue No. 1, Jan-June 2019, ISSN: 2320 – 8996

phenomena that had never been conceived of. Left-handed materials were supposed to have a negative refractive index and optical applications of their characteristics attracted interest. Since there was no actual material to validate the theory at that time, no further attention was given to left-handed materials.

2 Filter Design Methodology

In this paper presents a low cost and low insertion loss split ring resonator band pass filter(BPF) based on inexpensive commercial FR4(εr = 4.4) substrate. Microstrip technology is used for simplicity and ease of fabrication. The design and simulation are performed using 3D full wave electromagnetic simulator HFSS. The maximum return loss of 19 dB throughout the operation frequency of 1.5 GHz. This filter is widely used today for the telecommunication and satellite. This three pole finite frequency filter structure is able to produce two finite frequency attenuation poles one on the lower side and other on the higher side of pass band. The element values of low pass prototype filter of this design are

$g_1 =$, $g_3 = 0.695$, $g_2 = 1.245$

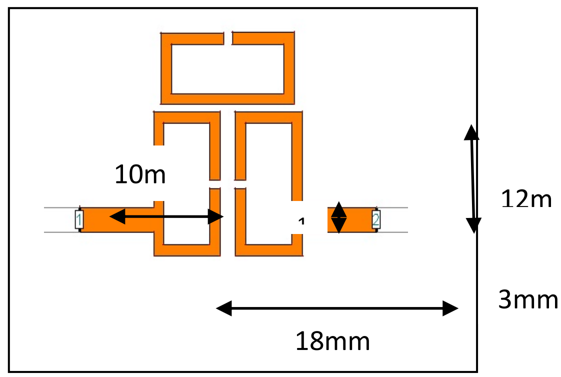
$M_{1,2} = M_{2,3} = 0.4752$, $M_{1,3} = -0.0288$

$J_{12} = J_{23} = 1.0$, $J_{13} = -0.457$

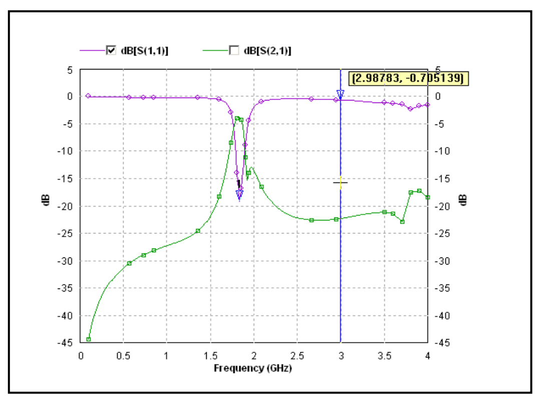
$B_1 = B_3 = 0.185$, $B_2 = -0.615$

$Q_{e1} = Q_{e3} = 15.7203$

In microwave wireless systems, different filters are available for different applications. The miniaturizations of microwave filters have been one of the challenges for microwave communication devices. Limitation can be improved by increasing the pass-band insertion loss (*IL*) by adding new sections. However, this increasing does increase the size of overall structure. In orderto overcome these problems there has been an increasing interest for the use of metamaterial structures such as SRRs or other structures [4] in the development of compact microwave components using printed circuit boards and MMIC technologies [5]-[9]. So, Metamaterial filters at high frequencies are the best studied for microwave wireless where miniaturization of filters provides reduction in size, light weight and low cost.



(a)



(b)

Fig. 1. Band pass Filter contains rectangular SRR (a) Layout, (b) S21 and S11 frequency response using HFSS simulator.

3 Result and Discussion

In the field of information and communications, advanced technologies have been sophiscated, as a result of fusion of wide range of technologies including materials, devices, signal processing and systemization. New types of applications of the technologies surrounding left-handed metamaterials are being openedup fromdifferent technical approaches, making use of their novel characteristics. Fig. 1. (a) shows the final layout of the design split ring resonator band pass filter. The simulated result of fig.1. (a) are shown in fig.1 (b) . The filter having return loss of – 19 dB at 1.5GHz. The filter having split ring resonator have large fractional bandwidth (FBW) = 4.42%. The filter is design on the top of FR/4 'Glass/Epoxy' substrate having the dielectric permittivity of 4.4 with the thickness 1.6mm the loss tangent of the substrate is 0.02.The simulated result shows that by using rectangular split ring resonator attenuation pole of finite frequency on the upper side of the pass band leads to a higher selectivity on this side of the pass band.

4 Conclusion

We have presented both the theory and simulation of a new class of filter. We have performed the HFSS simulation to confirm the circuit theory. The design parameters can be obtained based on the prototype circuits and the coupling coefficients and quality factor can be characterized by using full-wave simulation. The proposed filter have great reduction in size and cost and improved performance compared to the conventional band pass filters, presently are in use for transreceive communication systems for ground and space applications.

References

1. AhnD,KimS.J,KimS.C,Qian J, and Itoh T. A . : Design of the Lowpass Filter Using the Novel Microstrip Defected Ground Structure: IEEE Transactions on Microwave Theory and Techniques. 49(1), 86-91 (2001)
2. Garcia-Garcia J,MartinF.F,Bonache J, Baena,GilJ,LopetegiI,LasoT,Marcotegui M, Marques A,Sorolla R. :Stepped impedance Lowpass Filter with Spurious Pass-band Suppression: Electronic Letter. 40(14): 881-883 (2004)
3. Pendry B.J, Holden A,RobbinsD,MarquesR,MartinF,Sorolla M.: Effective Negative-ε Stop-Band Microstrip Lines Based on Complementary Split ring Resonators. IEEE Microwave Wireless Component Letter: 14(6): 280- 282 (2004)
4. Tu W, Chang K. Compact Microstrip Lowpass Filter with Sharp-Rejection. *IEEE Microwave Wireless Component Letter.*15(6): 04-406 (2005)
5. Garcia-Garcia J,MartinF,BonacheJ,FalconeF,Baena J, Gil I, AmatE,LapetegiT,Laso M, IturmendiJ,SorollaM,Marques R. Microwave Filters with Improved Stopband Based onSub-Wavelength Resonators. *Microwave and Optical Technology Letter* 46(3):283-285.(2005)
6. BaenaJ,BonacheJ,MartinF,Marques R, Falcone F,LopetegiT,LasoM,Garcia-Garcia J, Gil I,PortilloM,Sorolla M. Equivalent–Circuit Models for Split Ring Resonators Coupled to Planar Transmission Lines. IEEE Transaction on Microwave Theory and Techniques. 53(4):1451-1461(2005)
7. Manda M, Mondal P, Sanyal S, Chakrabarty S.Low insertion-loss, sharp rejection and compact microstrip lowpass filters. IEEE Microwave and Wireless Components Letters.16(11): pp.600-602 (2006)
8. BonacheJ,Gil M, Gil I,Garcia-Garcia J, Martin F.: On the Electrical Characteristics of Complementary Metamaterial Resonators. IEEE Microwave and Wireless Components Letters 6(10):543- 545 (2006)

9. Engheta N, ZiolkowskyR. : Metamaterial: Physics and Engineering Explorations.*Wiley*, *Hoboken*.(2006).
10. Xu He-Xiu, Wang Guang-Ming,Zhang Chen-Xin,Liang Jian-Gang : Hilbert-shaped complementary ring resonator and application to enhanced-performance lowpass filter with high selectivity. International Journal of RF and Microwave Computer-Aided Engineering : 21 (4): 399-406 (2011