Broadside coupled split ring resonator based multiband monopole patch antenna for wireless communication applications

Cite as: AIP Conference Proceedings **2162**, 020068 (2019); https://doi.org/10.1063/1.5130278
Published Online: 29 October 2019

Joe Kizhakooden, Jovia Jose, Nees Paul, Sreedevi P. Chakyar, Anju Sebastian, Sikha K. Simon, K. S. Umadevi, C. Bindu, Jolly Andrews, and V. P. Joseph

Broadside Coupled Split Ring Resonator Based Multiband Monopole Patch Antenna for Wireless Communication Applications

Joe Kizhakooden[1, 2], Jovia Jose[1, 3], Nees Paul[1, 2], Sreedevi P Chakyar[1], Anju Sebastian[1], Sikha K Simon[1], K. S. Umadevi [1, 4], C. Bindu[1, 5], Jolly Andrews[1] and V. P. Joseph[1, a)]

[1]*Christ College (Autonomous), Irinjalakuda, Thrissur, University of Calicut, Kerala, 680125, India*
[2]*St. Thomas' College (Autonomous), Thrissur, University of Calicut, Kerala, 680001, India*
[3]*Vimala College (Autonomous), Cheroor, Thrissur, University of Calicut, Kerala, 680009, India*
[4]*Prajyothi Nikethan College, Pudukad, Thrissur, University of Calicut, Kerala, 680301, India*
[5]*Govt. College, Chittur, Palakkad, University of Calicut, Kerala, 678104, India*

[a)]Corresponding author: vpj@christcollegeijk.edu.in

Abstract: The present work reports the development of a multiband monopole patch antenna by utilizing Broadside Coupled Split Ring Resonator (BCSRR) units. This antenna makes use of the resonant property of metamaterial BCSRR units for multiband frequency designing. Since the magnetic resonant frequency of the BCSRR depends on the effective capacitance and inductance of its rings, the geometrical parameters of the rings like inter planar distance between them, inner and outer radii, split widths and the dielectric material between the rings play important role in designing the radiating frequency bands of the proposed antenna. The desired frequencies for potential applications like Bluetooth, Wi-Fi and Wi-Max are thus achieved by proper designing of the BCSRR units. In this work, it is demonstrated that two additional frequencies can be radiated along with the monopole radiation by coupling two BCSRR units to the monopole. The fabricated antenna exhibits high return loss at 2.45 GHz and 2.75 GHz along with the monopole radiation around 5 GHz. The number of operating frequencies can be increased by adding more BCSRR units at various positions near to the monopole patch. The proposed antenna is compact, light weight and easy to design and fabricate when compared with the recently reported multiband monopole antennas. The good agreement between the experimental and simulated results shows that the proposed antenna is a suitable candidate for potential wireless applications. The different antennas for different applications in a single device can be replaced with the single proposed antenna.

INTRODUCTION

Multiband operation of antennas have lead to tremendous applications in the field of electronic wireless communication due to its properties like light weight, compactness, ease of fabrication and easy integration with other microwave components [1]. Electromagnetic metamaterial based multiband antennas have recently attracted great attention due to their capability of altering the radiation performance owing to their negative values of permittivity and permeability [2]. Frequency reconfigurable antennas using various designs and techniques are also noticeable strides in this field [3]. Recent developments in multiband operation of antennas using a radiating patch with electromagnetic metamaterial components have gained a great attention in the wireless communication field. Various techniques like inducting slots in radiating element [4], re-fashion in ground plane [5], fractal geometry techniques [6] etc. are introduced for further development of antennas using radiating patch. Most of these structures require complex antenna designs and fabrications. In this work, an easy designing and fabricating method based on

Proceedings of the International Conference on Advanced Materials
AIP Conf. Proc. 2162, 020068-1–020068-4; https://doi.org/10.1063/1.5130278
Published by AIP Publishing. 978-0-7354-1907-0/$30.00

Broadside Coupled Split Ring Resonator (BCSRR) loaded monopole patch antenna for multiband operations is presented.

BCSRR is a metamaterial component which exhibits negative permeability. It is a modified form of Split Ring Resonator where the two rings are fabricated on the opposite sides of the dielectric substrate. The proposed monopole patch antenna makes use of the BCSRR properties for multiband frequency designing. The magnetic resonant frequency of the BCSRR structure depends on the effective capacitance and inductance of the rings determined by the geometrical parameters like the inner and the outer radii, the split widths, inter planar distance between the rings and dielectric constant of the substrate. These parameters are designed so as to get desired frequencies for potential applications like Bluetooth, Wi-Fi and Wi-Max. In this work, it is demonstrated that two additional frequencies can be radiated along with the monopole radiation by coupling two BCSRR units to the monopole. The fabricated antenna exhibits high return loss at 2.45 GHz and 2.75 GHz along with the monopole radiation which is designed to get a radiating frequency in the vicinity of 5 GHz. The number of operating frequencies can be increased by adding more BCSRR units at various positions near to the monopole patch. The experimental and simulated results are in good agreement which shows that the proposed antenna is a suitable candidate for potential wireless applications.

BCSRR LOADED MONOPOLE PATCH ANTENNA

The layout of the BCSRR loaded monopole patch antenna is given in Fig.1. Instead of using the conventional double sided PCBs, we have employed thin copper sheets and low loss dielectric substrate for the fabrication. The monopole patch (27.5 mm x 4.5 mm) and the ground plane (40 mm x 15 mm) are made using copper sheet of thickness 20 μm. The dielectric substrate used is a low loss PVC foam sheet of thickness 1.45 mm having relative permittivity 1.2 and dielectric loss tangent 0.001. The surface area of the substrate is 53 mm x 40 mm. The BCSRR unit is constructed distinctly from the conventional manufacturing methods. The two rings are separately etched photo chemically from thin sheets of copper with thickness 20 μm. The outer and inner radii of the rings are designed as 6 mm and 4.5 mm respectively and the slit width is 0.5 mm. Then they are fixed on the opposite sides of a low loss PVC foam substrate of thickness 1.65 mm and the combination is fixed very near (0.3 mm) and side by side to the monopole patch with the slit of the bottom ring facing the patch and the center of the ring coming at a distance of 17 mm from the feed end. Similarly another BCSRR unit of same dimensions but with substrate thickness 1.55 mm is constructed and placed on the other side of the monopole patch such that the center of the ring is at a distance of 11 mm from the feed end.

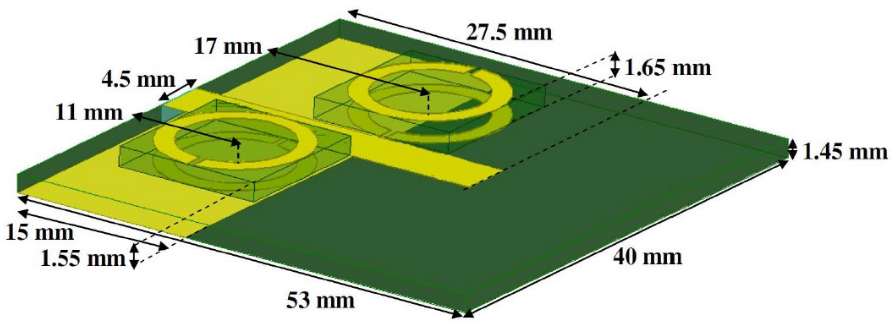

FIGURE 1. The schematic representation of the proposed BCSRR loaded monopole patch antenna.

RESULTS AND DISCUSSIONS

The measured and the simulated S_{11} characteristics of the BCSRR loaded monopole antenna structure versus frequency using Vector Network Analyzer (VNA) and simulation software are depicted in Fig.2. The peaked notch at the vicinity of 5 GHz is due to the monopole patch while the additional notches at 2.45 GHz and at 2.75 GHz are due to the coupling between monopole and BCSRR units. Since the two BCSRR units have different dielectric thicknesses, the values of the effective capacitance and inductance will be different for each unit resulting in the formation of two notches at different frequencies. The geometrical parameters of the rings and thicknesses of the dielectric inserted are so selected that the additional frequencies are at the frequencies for potential applications such as Wi-Fi, Bluetooth, Wi-Max etc. The frequency of 2.45 GHz is internationally selected for Bluetooth and Wi-Fi applications. The frequency 2.75 GHz can be used for lower Wi-Max band applications while 5 GHz frequency can be used for upper Wi-Max band applications. The selected frequencies can be designed to other required values by altering the geometrical dimensions of the rings and the dielectric constant of the substrate. As the size of the rings increases, the notch moves to the lower frequency range as the effective inductance and capacitance increases whereas the thickness of the dielectric substrate increases, the notch moves to the higher frequency side.

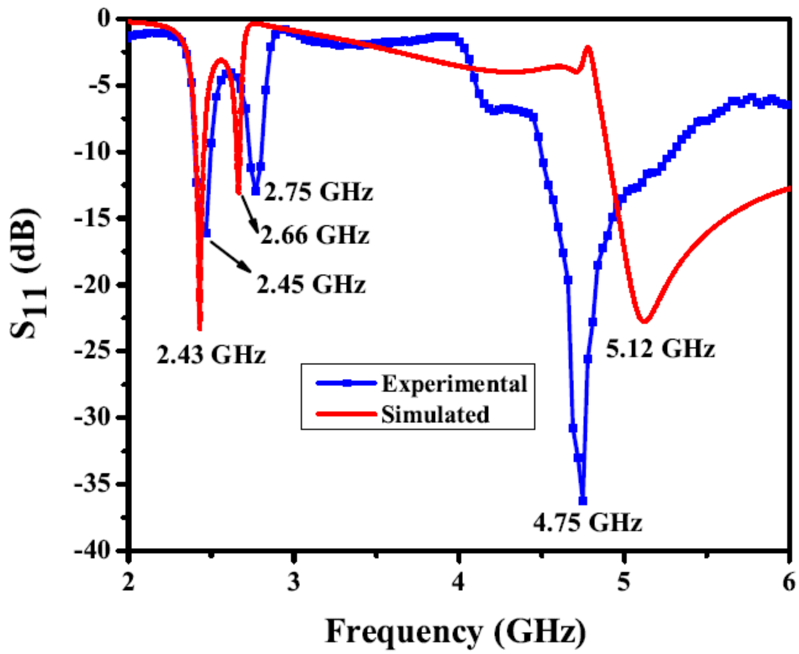

FIGURE 2. The experimental and simulated S_{11} characteristics versus frequency of the proposed BCSRR loaded monopole patch antenna.

In fact, the magnetic resonant frequency of the BCSRR depends on the self inductance of the rings, mutual inductance between the two rings, mutual capacitance between the rings and the capacitance of the two splits. The mutual inductance between the two rings is relatively small compared to the self inductance of the two rings and the capacitance of the splits is also small compared to the mutual capacitance between the rings. So the notch due to the BCSRR coupling is mainly due to the changes in the ring dimensions, which in turn changes its self inductance, as well as the mutual capacitance between the rings. Thus multiband operation is achieved by coupling two BCSRR units having selected parameters with the monopole patch. More notches at different frequencies can be procured by inserting more number of BCSRR units corresponding to the maximum field positions of the monopole patch. Thus different antennas for different applications in a single device can be replaced with the single proposed antenna.

CONCLUSION

It has been demonstrated that multiband frequency operation in monopole patch antenna is possible by coupling BCSRR units to the monopole. The fabricated prototype of the proposed antenna exhibits high return loss at 2.45 GHz and 2.75 GHz along with the monopole radiation around 5 GHz. The radiating frequencies can be designed to other desired values by making changes in dielectric thicknesses and in ring parameters. The multiband frequency operation in antenna based on BCSRR is manifested for the first time and the experimental results are validated by simulation. Owing to small dimensions and easy integration with other antenna components, the potential communication applications like Bluetooth, Wi-Fi and Wi-Max can be achieved easily by the single proposed antenna. Thus compared with the reported multiband monopole antennas, the proposed BCSRR based multiband monopole patch antenna is quite easy to design and fabricate.

ACKNOWLEDGMENTS

Jovia Jose would like to thank University Grants Commission (UGC), Government of India for the financial support given under Faculty Development Program (FDP). Sreedevi P. Chakyar acknowledges UGC, Govt. of India for the financial support given under UGC Junior Research Fellowship (UGC JRF). Sikha K Simon also gratefully acknowledges UGC, Govt. of India for the financial support under Moulana Azad National Fellowship (MANF JRF).

REFERENCES

1. R. S. Daniel, R. Pandeeswari, and S. Raghavan, AEU-International Journal of Electronics and Communications **75**, 8–14 (2017).
2. J. Wang, S. Qu, J. Zhang, H. Ma, Y. Yang, C. Gu, X. Wu, and Z. Xu, Progress In Electromagnetics Research **6**, 35–45 (2009).
3. H. Cheribi, F. Ghanem, and H. Kimouche, Electronics Letters **49**, 315–316 (2013).
4. P. N. Shinde and J. P. Shinde, AEU-International Journal of Electronics and Communications **69**, 1489–1494 (2015).
5. R. Pandeeswari and S. Raghavan, Microwave and Optical Technology Letters **57**, 2413–2418 (2015).
6. P. Beigi and P. Mohammadi, AEU-International Journal of Electronics and Communications 70, 1382–1387 (2016).