ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

INVESTIGATION OF SRR PARAMETERS ON MONOPOLE ANTENNA PERFORMANCE

T. K. Ong[1], B. H. Ahmad[1], M. Z. A. Abd. Aziz[1], M. A. Othman[1], M. K. Suaidi[1], H. A. Sulaiman[1] and F. Abd. Malek[2]
[1]Centre for Telecommunication Research and Innovation (CeTRI), Faculty of Electronics and Computer Engineering, Universiti Teknikal Malaysia Melaka (UTeM), Durian Tunggal, Melaka, Malaysia
[2]School of Computer and Communication Engineering, University Malaysia Perlis, Perlis, Malaysia
E-Mail: mohamadzoinol@utem.edu.my

ABSTRACT

This paper presents an investigation of split ring resonator (SRR) parameters on a coaxial-fed monopole antenna. The adding of SRR slot can create a notch in the result of coaxial-fed monopole antenna design. Thus, this paper aims to investigate the effect of changes to the outer ring radius and slit cut width of the SRR slot. All antenna designs and simulations involved are drawn and simulated in Computer Simulation Technology (CST) Studio Suite software in an open space environment to prevent any interference within simualtion range. The antenna design is printed on a FR4 epoxy board with dielectric constant, ε_r of 4.4, tangent loss, *tan* δ of 0.019, and thickness, h of 1.6mm. In the investigation, outer ring radius of SRR slot has been increased from 4mm to 10mm whereas the slit cut width of SRR slot has been increased from 1mm to 8mm. The result shows that the increment of outer ring radius can shift the notch and frequency band to lower frequency. In a contrary, the widening of slit cut width of SRR slot is able to shift the notch and frequency band back to higher frequency. These two characteristics can contribute to wideband or ultrawideband system to provide frequency tunable notch function.

Keywords: split ring resonator, monopole, notch.

INTRODUCTION

The demand on wider bandwidth for higher data rate and the congested allocations on frequency spectrum has brought to a need in designing wideband and ultrawideband (UWB) wireless communication system. At the same time, antenna which is acted as the transmission and reception device of electromagnetic signals must also design to be implemented to the systems. Monopole antenna are commonly used to design wideband and UWB antenna nowadays because of its low cost, simple structure, and low weight characteristics (Sim, *et al.* 2004), (Huang, *et al.* 2008), (Azarmanesh, *et al.* 2011). However, there is a limitation exists in both of these systems. The wide frequency bandwidth might be interfere with the coexistence frequency allocations. In order to avoid this, microwave filters can be added to the system to stop the transmission and reception at that particular frequency region, but this will increase the system cost and complexity. An alternative way to overcome this problem is to create notch function by applying split ring resonator (SRR) structure in antenna design (Lee, *et al.* 2013), (Saha, *et al.* 2014), (Lalj, *et al.* 2014). SRR is one of the metamaterials which is artificially created with special structure to give special electromagnetic properties such as notch function creation. Thus, the SRR parameters is very important to be studied because the electromagnetic properties can be well-controlled by the SRR structure itself.

In this paper, the outer ring radius and slit cut width of SRR slot are investigated on a coaxial-fed monopole antenna. Without adding the SRR slot, the monopole antenna operates for WLAN at 2.4GHz and a wideband covering from 4.62GHz to 10.23GHz. The next section will further discuss the antenna structure, parameters, materials, and also the process of investigation. Further than that, the result of each investigation will be displayed graphically and analyzed. In the last section, a conclusion will be made regarding on the results obtained.

ANTENNA DESIGN

Coaxial-fed monopole antenna design

The basic design of the monopole antenna is contructed by a rectangular patch printed on a FR4 epoxy board, fed by a coaxial probe, and with a flattened ground plane. The FR4 epoxy board has dielectric constant, ε_r of 4.4, tangent loss, *tan* δ of 0.019, and thickness, h of 1.6mm. The dimension of the design is optimized by doing parametric studies on the design parameters to obtain the widest possible bandwidth. The antenna design structure is shown in Figure-1 and the optimized design parameters are tabulated in Table-1.

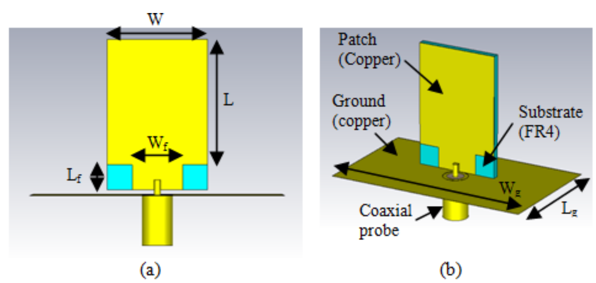


Figure-1. Coaxial-fed monopole antenna structure in (a) front view (b) 3D-view.

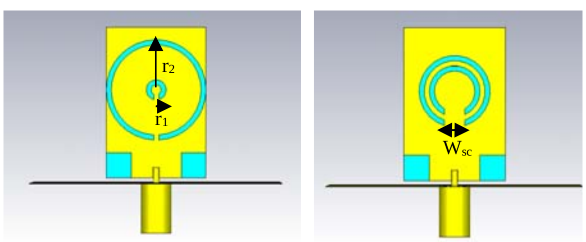
VOL. 10, NO. 2, FEBRUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Table-1. Optimized design parameters and dimension.

Design parameters	Dimension (mm)
Width, W	20
Length, L	25
Length of feed line, L_f	5
Width of feed, W_f	10
Width of ground plane, W_g	50
Length of ground plane, L_g	30
Thickness of Substrate, h	1.6
Thickness of copper layer, t	0.035
Inner ring radius, r_1	2
Outer ring radius, r_2	4
Slit cut width, W_{sc}	1

The investigation is done on a SRR-slotted antenna by varying the outer ring radius and slit cut width of the SRR slot. The SRR slot is located at the center of the antenna patch while the other design parameters remain the same. The structure of SRR-slotted coaxial-fed monopole antenna design is shown in Figure-2 with labelled parameters.



(a) (b)

Figure-2. Investigation of SRR-slotted antenna in varying (a) outer ring radius (b) slit cut width

In the parametric of outer ring radius, the inner ring radius is fixed at 2mm where the outer ring radius is varied from 4mm to 10mm. Next, the inner and outer ring radius of SRR slot has been increased to 5mm and 7mm respectively to allow more samples to be selected for the investigation of slit cut width of SRR slot. In this investigation, slit cut width of SRR slot has been increased from 1mm to 8mm.

RESULTS AND DISCUSSION

This section discuss the parametric study done on varying the outer ring radius and slit cut width of SRR slot on coaxial-fed monopole antenna. Figure-3 shows the effect of the adding of the SRR slot onto coaxial-fed monopole antenna where a notch in the red circle has been created at around 4.09GHz. A notch is formed when the return loss of antenna at certain frequency range increases suddenly or the antenna gain and efficiency decreases unexpectedly at the particular frequency range.

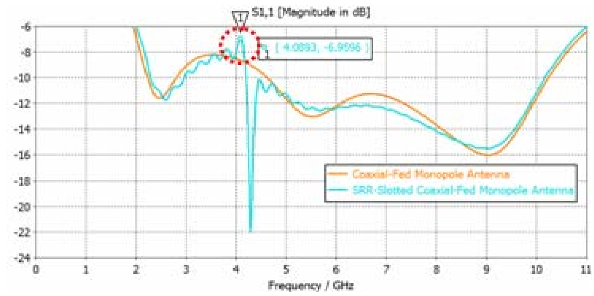


Figure-3. Comparison graph between coaxial-fed monopole antenna design with and without SRR slot.

In the parametric study of outer ring radius of SRR slot, Figure-4 shows that as the outer ring radius increases, the frequency band will shift to the lower frequency together with the notch. The shiftment of frequency band can be seen from marker in the Figure, from 2 to 3, 4, and 6 as well as from 5 to 7, 8, 9, and 1.

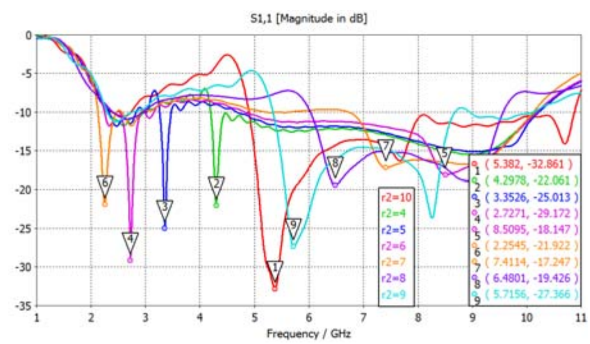


Figure-4. Parametric study of outer ring radius of SRR slot on return loss.

Besides that, the antenna efficiency has also shown that the notch is shifted to lower frequency when the outer ring radius increases. It is shown that the notch moves from marker 2 to 3, 4, 5 and followed by another sequence from 6 to 7, and 1 as shown in Figure-5.

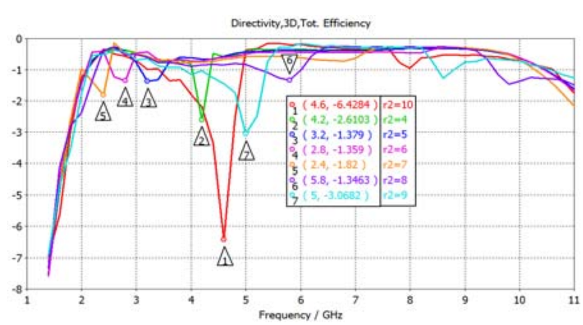


Figure-5. Parametric study of outer ring radius of SRR slot on total efficiency.

In a contrary of shifting frequency band and notch to lower frequency, the widening of slit cut width of SRR slot has brought the frequency band and notch to higher frequency region as shown in Figure-6. Marker 1 to 8 in Figure-6 represents the increment of the dimension of the slit cut width from 1mm to 8mm.

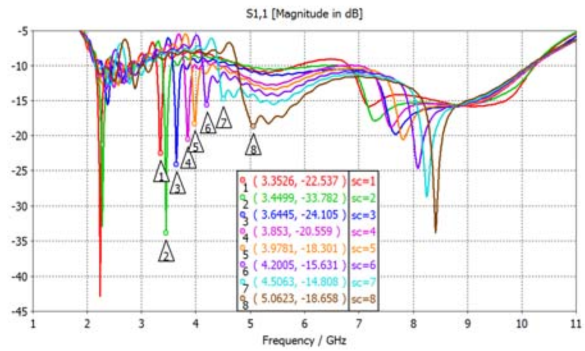


Figure-6. Parametric study of slit cut width of SRR slot on return loss.

In addition, the notch also happens at the simulated total efficiency as shown in Figure-7. The slit cut width increases from marker 1 to 8 represents the increment of width from 1mm to 8mm. Although the increment of slit cut width from 1mm to 2mm does not move the notch to higher frequency, the total efficiency of the antenna has been reduce as much as 37.45 percent?

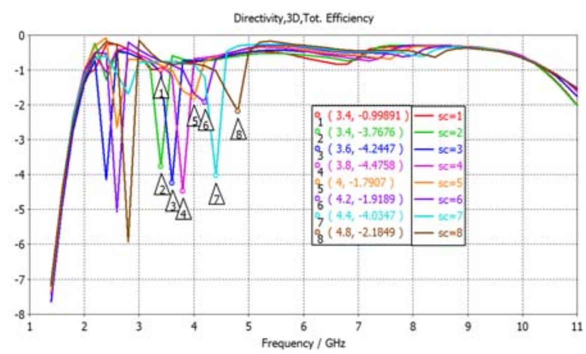


Figure-7. Parametric study of slit cut width of SRR slot on total efficiency.

CONCLUSIONS

This paper has presented an investigation of SRR parameters on monopole antenna performance. The parameters studied were the outer ring radius of SRR slot as well as the slit cut width of SRR slot. The addition of SRR slot onto a coaxial-fed antenna has formed a notch at 4.09GHz. However, with the increment of the outer ring radius, the notch and frequency band has been brought to lower frequency. On the other hand, the increment of slit cut width of SRR slot is able to move the notch and frequency band back to higher frequency. These characteristics are vital for the design of a smart antenna with frequency tunable function. Besides that, this can also be very useful in a wideband or ultrawideband where tunable notch funtion is important to prevent interference with the current allocations.

ACKNOWLEDGEMENTS

The authors would like to present a greatest appreciation to Universiti Teknikal Malaysia Melaka (UTeM) for providing a platform in obtaining the information and materials for the entire research. We would also like to send our gratitude to anonymous referees whose comments led to an improved presentation of our works. Lastly, we would like to thank the Ministry of Education Malaysia (MOE) for PJP/2013/FKEKK (12C)/S01183 research grant.

REFERENCES

Sim, D. U., Moon, J. I. and Park S. O. 2004. A wideband monopole antenna for PCS/IMT-2000/Bluetooth applications. IEEE Antenna and Wireless Propagation Letters. 3: 45-47.

Huang, C. Y., Jeng, B. M. and Yang, C. F. 2008. Wideband monopole antenna for DVB-T applications. Electronic Letters. 44(25): 1448-1450.

Azarmanesh, M., Soltani, S. and Lotfi, P. 2011. Design of an ultra-wideband monopole antenna with WiMAX, C and wireless local area network band notches. IET Microwaves, Antenna & Propagation. 5(6): 728-733.

Lee, J. N., Kwon, H. K., Kang, B. S. and Lee, K. C. 2013. Design of an ultra-wideband antenna using a ring resonator with a notch function. ETRI Journal. 35(6): 1075-1083.

Saha, C., Siddiqui, J. Y. and Antar, Y. M. M. 2014. Multilayered stacked square SRR coupled UWB monopole antenna with dual notch function. IEEE Antennas and Propagation Society International Symposium (APSURSI). pp.787-788.

Lalj. H., Griguer, H. and Drissi, M. 2014. Design of reconfigurable band notches antenna for cognitive radio applications. Wireless Engineering and Technology. 5: 99-105.