International Journal of the Physical Sciences Vol. 6(18), pp. 4378-4381, 9 September, 2011
Available online at http://www.academicjournals.org/IJPS
DOI: 10.5897/IJPS11.144
ISSN 1992-1950 ©2011 Academic Journals

Full Length Research Paper

A metamaterials inspired miniaturized phi-shaped antenna

Vipul Sharma[1]*, S. S. Pattnaik[2], Nitin[3], Tanuj Garg[1] and S. Devi[2]

[1]Department of Electronics and Communication Engineering, Gurukul Kangri University, Haridwar, India.
[2]Department of ETV, NITTTR, Chandigarh, India.
[3]Department of Electronics and Communication Engineering, UIT, Dehradun, India.

Accepted 22 March, 2011

This paper introduces a new low cost, robust miniaturized microstrip antenna inspired with metamaterial split ring resonator structure (SRR). Because of metamaterials property there has been considerable reduction in size. The overall antenna structure is phi shaped which is equivalent to two SRRs placed back to back. This phi shaped antenna (PSA) thus obtained has been simulated on EM solver Ansoft HFSS and scattering matrix parameters are analysed. Excellent performance in terms of size and radiation pattern is achieved. These types of antennas are very useful for applications where space of equipment is a constraint.

Key words: Metamaterial, split ring resonator, microwave, microstrip structures, miniaturized antennas.

INTRODUCTION

There has been extensive research regarding innovative structures and applications of metamaterials in microwave engineering since inception of its concept (Peng et al., 2009; Ali et al., 2008; Hao et al., 2009; Jun et al., 2010). These include split ring resonators (Sabah, 2010; Sharma et al., 2011), tunable microwave filters (Peng et al., 2009; Ali et al., 2008), phase shifters etc. In this series of experimentation and research, some antennas inspired by metamaterials structures have been reported (Ziolkowski et al., 2009; Erentok et al., 2008; Sulaiman et al., 2010; Mahmood, 2004; Si et al., 2008). Most of these papers claim achievement either in terms of wider bandwidth or in terms of miniaturization (Palandoken et al., 2009; Ziolkowski et al., 2009). This paper reports an ever new small sized antenna structure inspired with metamaterial property. These types of small sized antenna are very useful for applications where space is a constraint. The antenna is physically phi shaped with two split rings (SRRs) back to back giving magnetic resonance and the metal strip interfacing the two leading to electrical resonance. Simulation of the antenna has been performed on Ansoft HFSS platform and the scattering parameters (s-parameters) obtained from this simulation are analysed. Further, it is seen that the three dimensional radiation pattern of the antenna is dough nut shaped quite similar to that of a half wave dipole with more than three fold reduction in size.

*Corresponding author. E-mail: vipul.s@rediffmail.com.

THE ANTENNA STRUCTURE

Structure of the phi shaped antenna (PSA) is shown in Figure 1. The RF signal ranging from 0.5 to 10 GHz is fed at metal strip parallel to slots at other side of substrate through 50 ohm coaxial cables as shown in Figure 1. Physical parameters of the PSA antenna are as follows:

i) Substrate dielectric constant = 5.7 (mica); substrate thickness = 0.785 mm diameter of inner circle = 9.4 mm diameter of outer circle = 10.0 mm.
ii) Length and width of "central rectangular strip" are taken as 9.4 and 0.18 mm respectively. The structure is fed by coaxial cable (PEC). Further two PSA placed at far field distance as shown in Figure 2, were simulated to analyse transmission properties and to obtain transmission coefficient S_{21}.

RESULTS

Simulation of the antenna was performed on EM solver Ansoft HFSS. The simulation results are shown in Figure

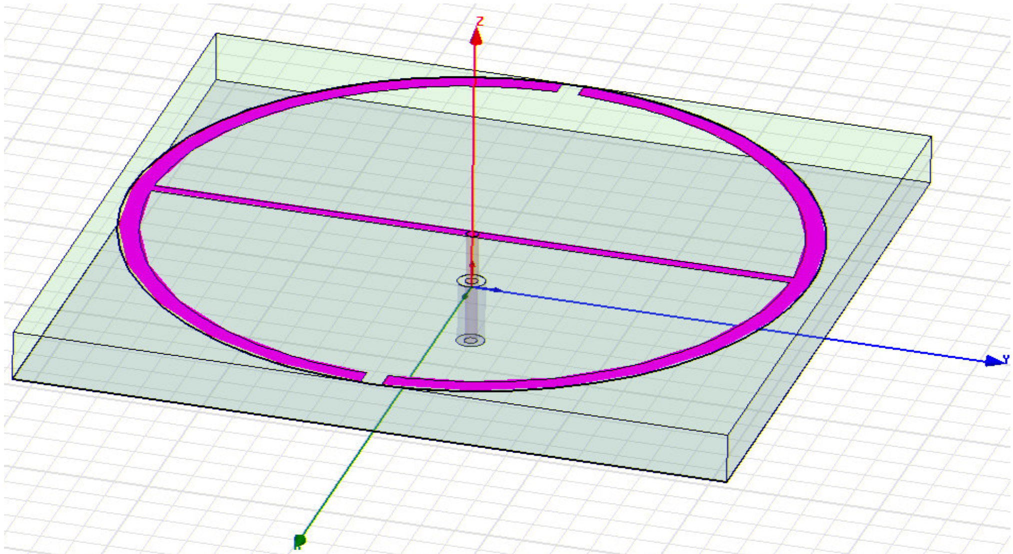


Figure 1. Structure of the phi shaped antenna.

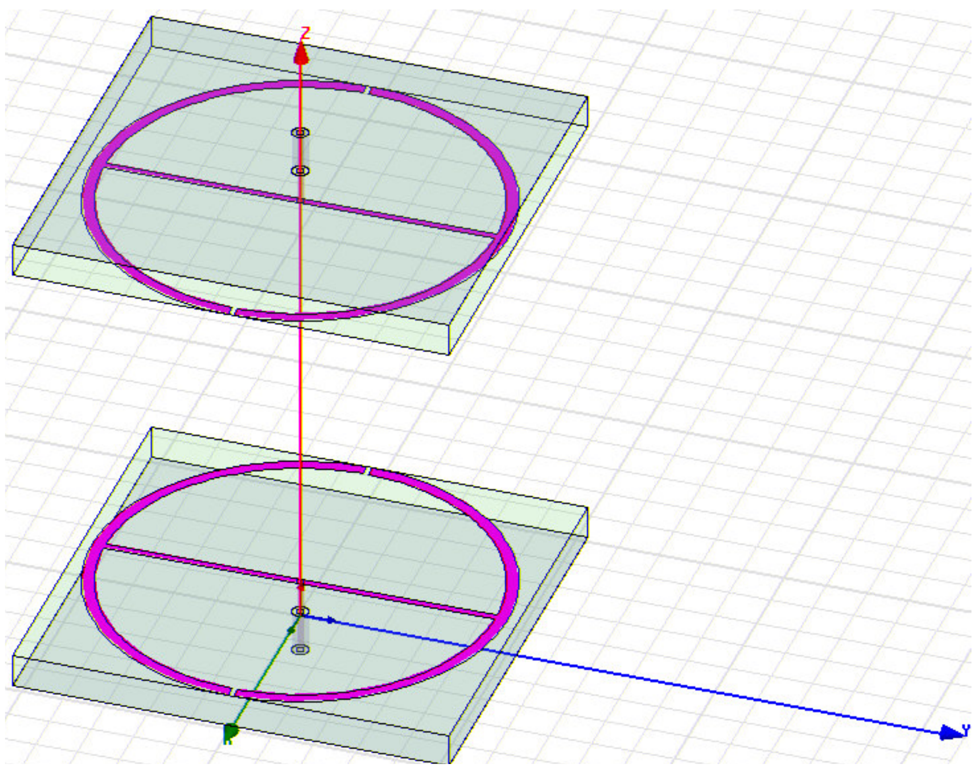
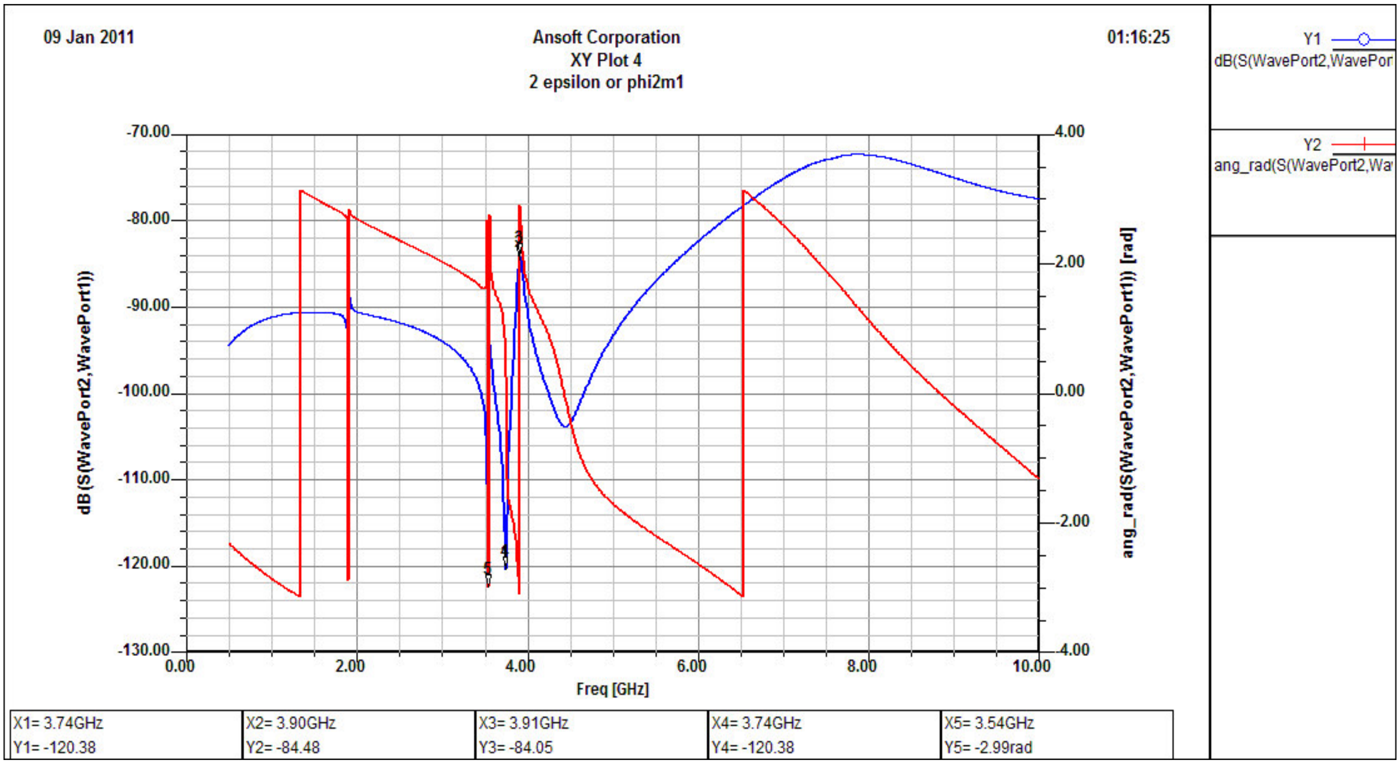
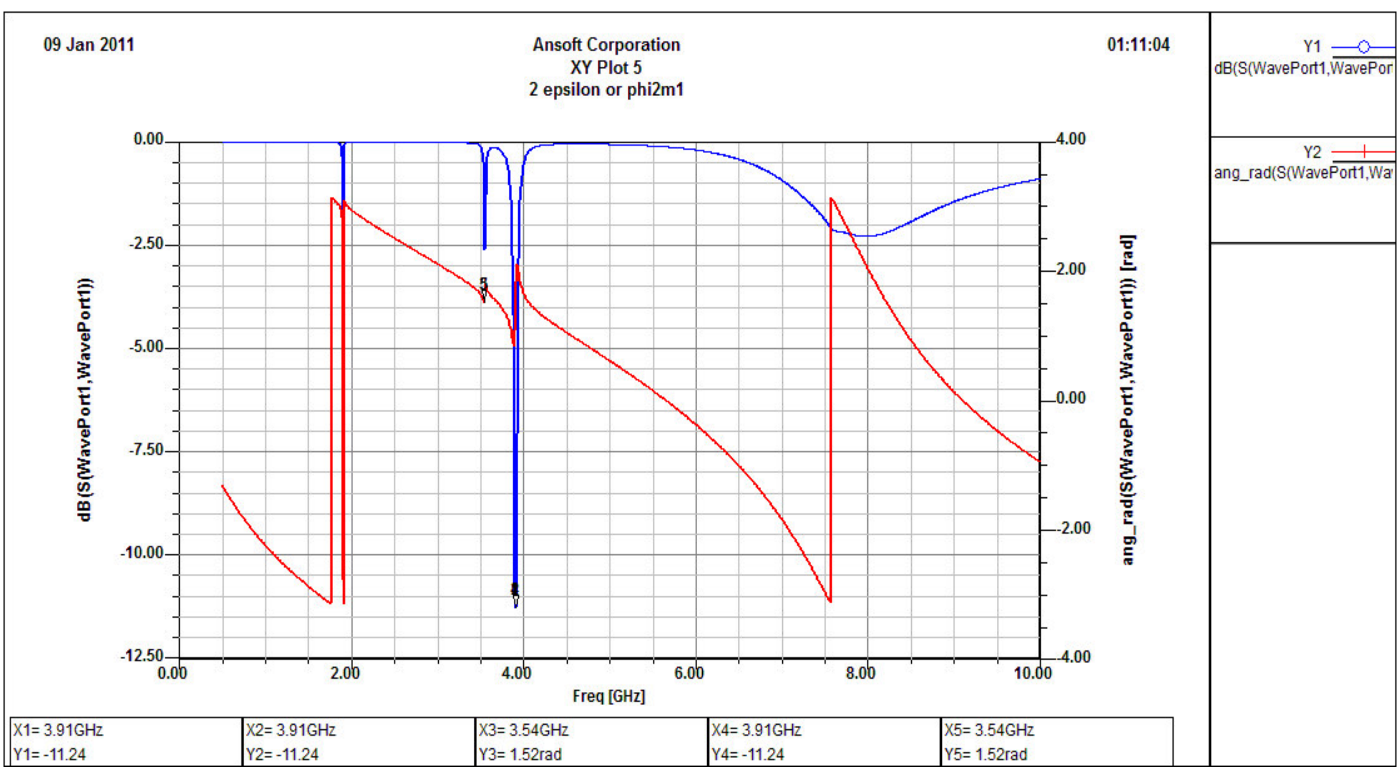


Figure 2. Two PSA antennas place face to face at far-field distance.

3. In Figure 3a, this can be observed that reflection coefficient S_{11} is showing phase reversal at four different frequencies hence indicating existence of metamaterial property. Out of these four resonant frequencies, at 3.91 GHz, the value of reflection coefficient is quite supportive for antenna application. Further to confirm the existence of metamaterials property, two antennas were taken together at far filed distance and simulation was performed. The transmission coefficient S_{21} thus obtained was analysed which is shown in Figure 3b. It can be seen that S_{21} also has phase reversal (zero crossing) at 3.91 GHz which confirms the existence of metamaterial



(a)



(b)

Figure 3. (a) Reflection coefficient S_{11} (blue-magnitude and red-phase); (b) Transmission coefficient S_{21}(blue-magnitude and red-phase).

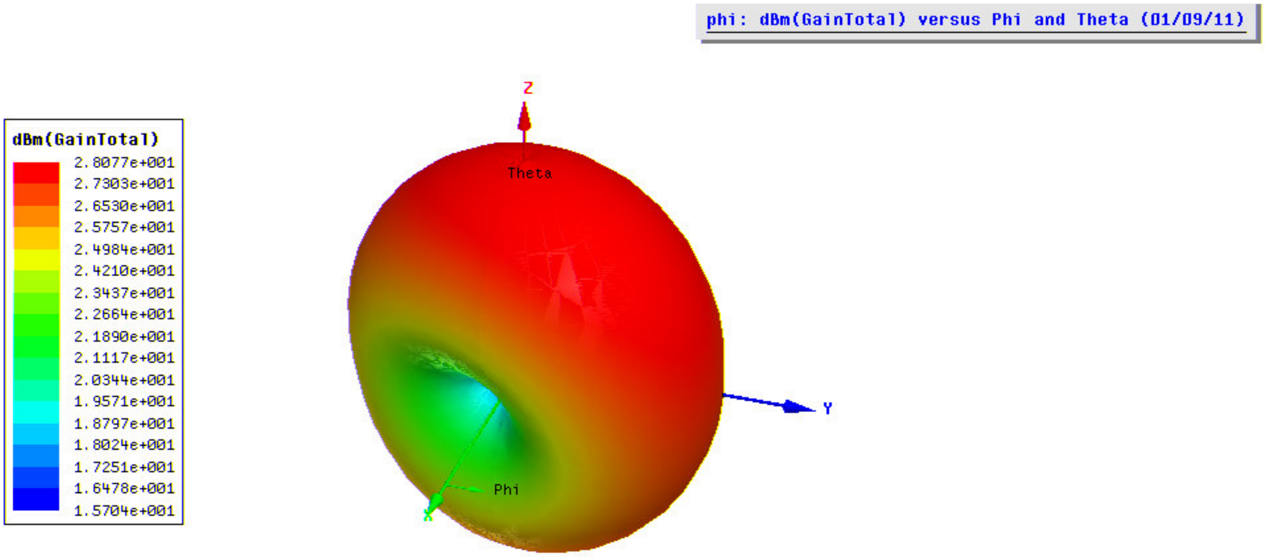


Figure 4. Radiation pattern of PSA.

property at this frequency (Sabah, 2010; Erentok et al., 2008). The radiation pattern has been plotted in Figure 4. The radiation pattern is dough nut shaped quite similar to that of half was dipole but with more than three fold reduction in size.

CONCLUSION

This paper successfully demonstrates behaviour of a miniaturized microstrip antenna inspired with metamaterial split ring structures. More than three fold reduction in size has been obtained as compared to standard requirement of half size of wavelength. Radiation pattern of the antenna is dough nut shaped, nearly omni-directional. This type of antenna is useful for the applications like sensors for ground penetration radar, sensors for detection of malignant tissues in skin cancer patients and other handheld portable wireless equipments.

ACKNOWLEDGMENT

The authors are thankful to DEAL, Dehradun, for extending their laboratory to use HFSS.

REFERENCES

Ali A, Hu Z (2008). Negative permittivity meta-material microstrip binomial low-pass filter with sharper cut-off and reduced size. IET Microw. Antennas Propag., 2(1): 15-18.

Erentok A, Ziolkowski RW (2008). Metamaterial inspired efficient electrically small antennas. IEEE Trans. Ant. Prop. 56(3): 691-707.

Hao Y, Mitra R (2009). FDTD Modeling of Metamaterials. Artech House. Norwood. 103: 110-114.

Jun CT, Smith DR, Liu R (2010). Metamaterials: Theory, Design, and Applications. Springer. New York. pp. 3-10.

Mahmood SF (2004). A new miniaturized annular ring patch resonator partially loaded by a metamaterial ring with negative permeability and permittivity. IEEE Antenna Wirel. Propag. Lett., 3: 19-22.

Peng Y, Zhang WX (2009). Microstrip band reject filter based on Inter-digital capacitance loaded loop resonator, 8: 93-103.

Palandoken M, Grede A, Henke H (2009). Broadband microstrip antenna with left handed metamaterials. IEEE Trans. Ant. Prop., 57(2): 331-338.

Sabah C (2010). Tunable metamaterial design composed of triangular split ring resonator and wire strip for S- and C- microwave bands. Prog. Electromagn. Res. B., 22: 341-357.

Si LM, Lv X (2008). Cpw-fed Multi-band Omni-directional Planar Microstrip Antenna Using Composite Metamaterial Resonators for Wireless Communications. Prog. Electromagn. Res. PIER, 83: 133-146.

Sulaiman AA, Othman A, Jusoh M H, Baba NH, Awang RA, Ain MF (2010). Small Patch Antenna on Omega structure metamaterials. Eur. J. Sci. Res., 43(4): 527-537.

Ziolkowski RW, Jin P, Nielsen JA, Tanieliam MH, Holloway CL (2009). Experimental verification of Z antennas at UHF frequencies. IEEE Antenna Wirel. Propag. Lett., 8: 1329-1333.