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Design of Rectangular Microstrip Antenna with Metamaterial for Increased Bandwidth

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ABSTRACT: In this paper a Rectangular Patch Antenna is specifically designed and analysed using metamaterial concepts. Based on an ordinary patch antenna, it has a double C shaped resonant structure embedded in the centre of the substrate of the Rectangular Patch Antenna. The resonant structure has a strong electric response in a certain frequency of interest, and can be used to construct metamaterials with negative permittivity. It is found the great impact on the antenna performance to modify the dimension to 57% of a conventional patch antenna. This antenna has strong radiation in the 45° to the horizontal direction for some specific Broadcast applications within the sub-resonant band, and can construct a dual frequencies antenna under certain conditions. Numerical results verify that the novel antenna performance is satisfactory.

KEYWORDS: Patch Antenna, Metamaterial, Double C-Shaped Structure, Feeding Point, Return Loss.

1 INTRODUCTION

Rectangular microstrip patch antennas, due to their inherent capabilities such as low cost, low weight, and low profile, are widely used in the applications of the wireless communication. However, their transverse dimensions cannot be made arbitrarily small, since the resonance frequency of the rectangular microstrip antennas at a given frequency when its linear transverse dimension is of the order of half wavelength [1]. Over the years, indeed, several techniques have been proposed in order to squeeze the resonant dimensions of patch radiators and enhancement in gain of the antenna, while maintaining their other radiation features [2]. The conventional approach to miniaturizing an antenna is to set the radiator on a high dielectric substrate. Obviously, there are two drawbacks to this [3]. one problems are the electromagnetic field remains highly concentrated around the high permittivity region, and another one is the characteristic impedance in a high permittivity medium is rather low, which creates difficulties in the impedance matching. The use of the metamaterials is properly to improve some basic antenna features (impedance matching, gain, bandwidth, efficiency, front-to-back ratio, etc.), which has represented a novel way of overcoming the limitations shown by some of the well-known techniques for reducing the antenna size [4]. Several examples of compact radiators have been recently proposed.

The metamaterials are artificially structures, and the electromagnetic properties of the materials provided are not encountered in nature [5]. Double negative metamaterials (dng) and single negative metamaterials (sng) have been designed and fabricated [6-7].

In this paper novel rectangular resonator structures with the metamaterials are first analysed and the modes for the sub-wavelength resonance of the rectangular microstrip antenna are excited. Then, a subwavelength structure of the rectangular microstrip patch antenna loaded with the rectangular double c shaped resonator is considered and analysed. Numerical results are shown that the novel antenna has a subwavelength resonance, and reduce the geometry size efficiently. Also the enhancement in gain and bandwidth of an antenna is also observed.

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2 REACTANGULAR MICROSTRIP ANTENNA

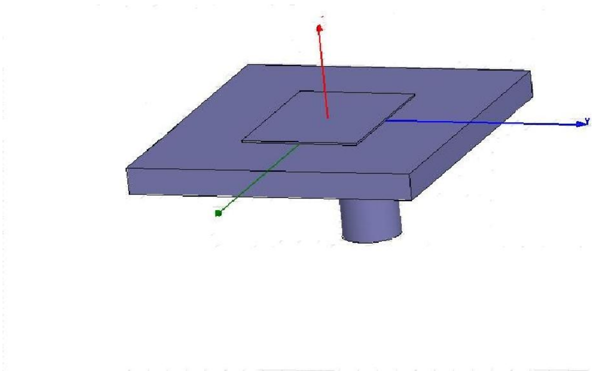


Fig. 1. Rectangular Patch Antenna

The Rectangular patch antenna is having a dimension of 8.49 X 6.171 X 0.1 mm (Fig.1) The dielectric substrate used is FR4 of thickness 1.5 mm, with dielectric constant 4.4. The resonating frequency considered is 10.2 GHz. The Co-axial feeding is applied to an antenna.

3 METAMATERIAL STRUCTURE

After the first metamaterials were fabricated in 2000 by Smith D.R. and his group [5], scientists have proposed many structures to form metamaterials. But most of the structures are based on the split ring resonators (SRRs) and the PEC bars or their transfigurations. In Ref. [8], a substrate with embedded capacitive loaded strips (CLSs) and SRRs has been proposed. Moreover, a double H-shaped resonator for an isotropic ENG metamaterial and a rectangular ELC resonator structure have presented and discussed [9-17].

In our model, a new rectangular double C shaped structure resonator (DCR) with the ENG metamaterial has been formed a SRRs shown in Fig.1. The parameters in the structure are chosen the FR-4 substrate thickness as 0.203 mm with 4.8 dielectric constant, and a metal clad 0.017 mm. Finally, the length and width are chosen as 5mm and 2mm, respectively for the rectangular substrate, and the gap between the PEC strips and the width of the PEC strips are all chosen as 0.1mm shown in Fig.1.

The patch is printed on centre of a thin substrate of FR4 with dielectric constant 4.4 with dimensions of 20 X 10 X 2 mm3, and the patch has dimensions of 8 X 5mm2. A coaxial probe is fed to the patch antenna with characteristic impedance Z0=50Ω, the feed point is at (-1.2, 0.8) as shown in Fig.3 and Fig. 4.

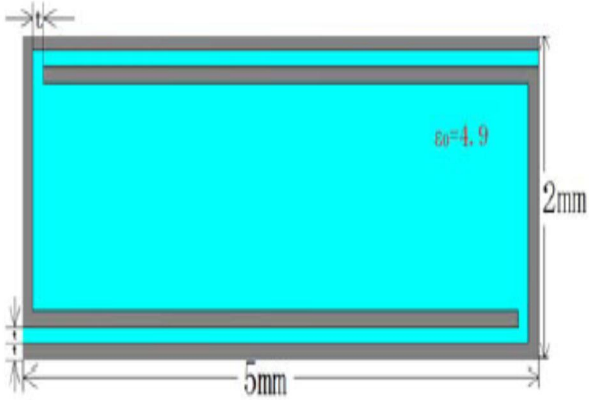
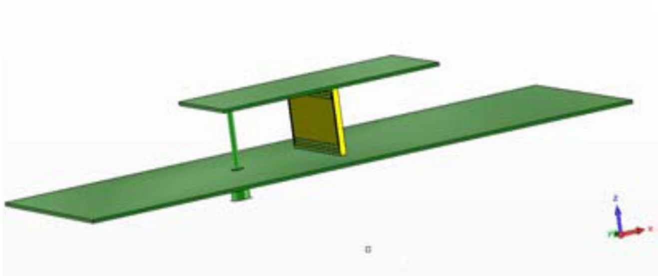
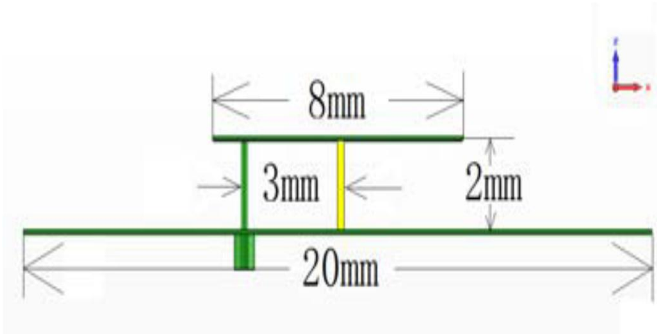


Fig. 2. Geometry of the rectangular double C shaped structure resonator (DCR)

The DCR is loaded in the centre of structure with its strip against the probe. Fig.5 is the distribution of the S parameters of the new patch antenna. It is found that the microstrip patch antenna loaded with DCR structure has two resonant frequencies with f1 = 5.1800 GHz and f2 = 10.2625 GHz because of the insertion of the DCR structure into the substrate of the antenna, with a return loss of -16.6074 dB and -30.3188 dB Respectively (Fig.5). The designed antenna satisfies the required VSWR over these frequency ranges (Fig.7).



(a)



(b)

Fig. 3. Sketch of the rectangular patch antenna with the DCR resonator structure, (a) 3D view; (b) xz-plane view

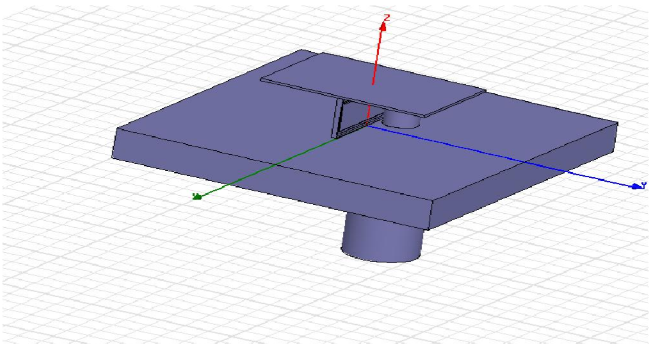


Fig. 4. Rectangular Microstrip antenna with Metamaterial structure

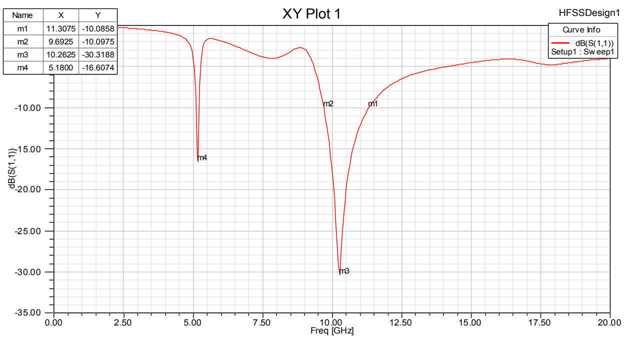


Fig. 5. Return loss of an antenna with Metamaterial structure

The higher resonant frequency is excited by the patch, and the subwavelength resonant is considered as exciting by the DCR structure. Under the subwavelength resonance, the effective permittivity of the DCR medium is expected to be negative value. The -10dB bandwidth, which is defined standard for engineering applications, is 615.5MHz and 1180MHz respectively. Further, the linear gain of first resonant frequency is 4.89 dB, and the antenna efficiency is 89 percent, which is better than a traditional patch antenna. It is also found from the pattern that this antenna has strong radiation in the 45° to the horizontal direction at the sub-wavelength frequency because the wave propagation along the patch has been effected by the left-hand transmission characteristics of the DCR structure. The new patch character has potential in the antenna designs and applications.

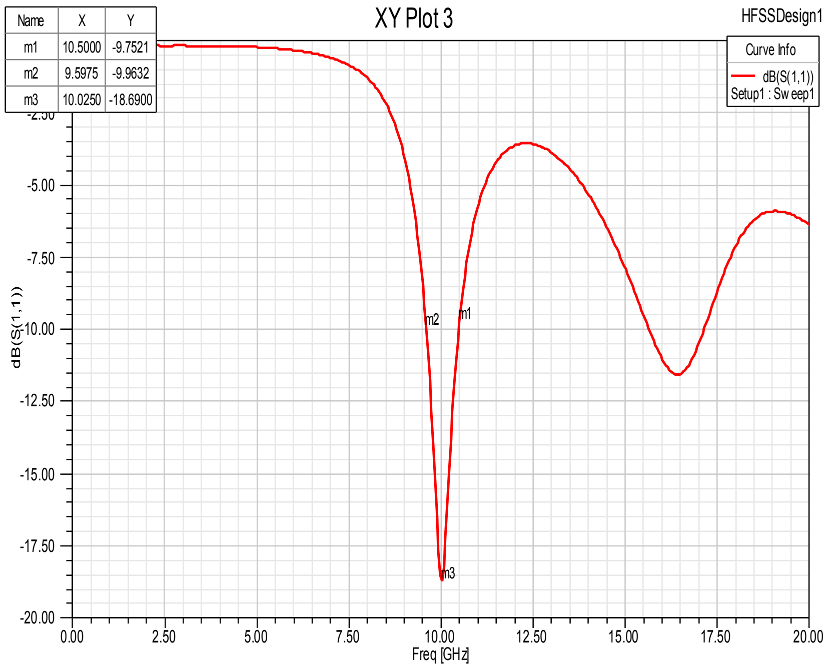


Fig. 6. Return loss of an antenna without metamaterial structure

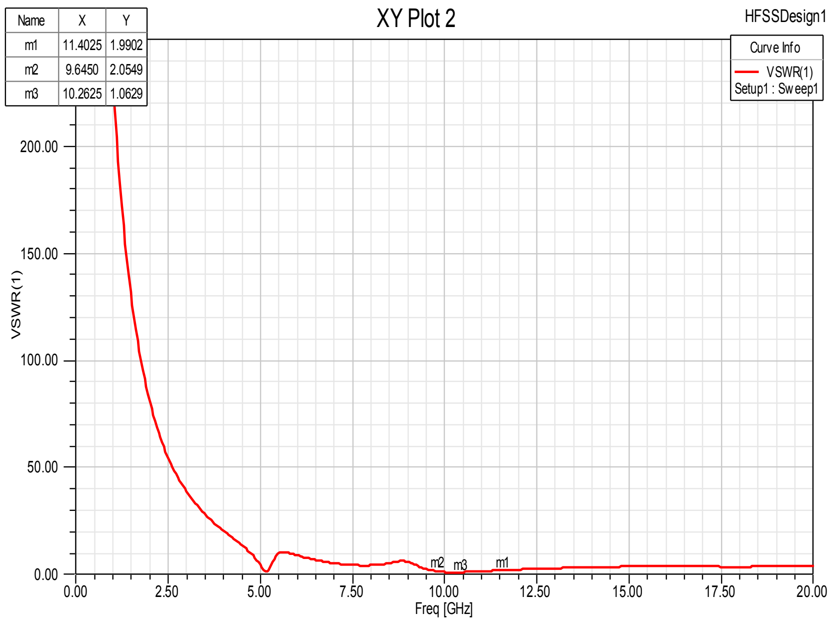


Fig. 7. VSWR of an antenna with Metamaterial structure

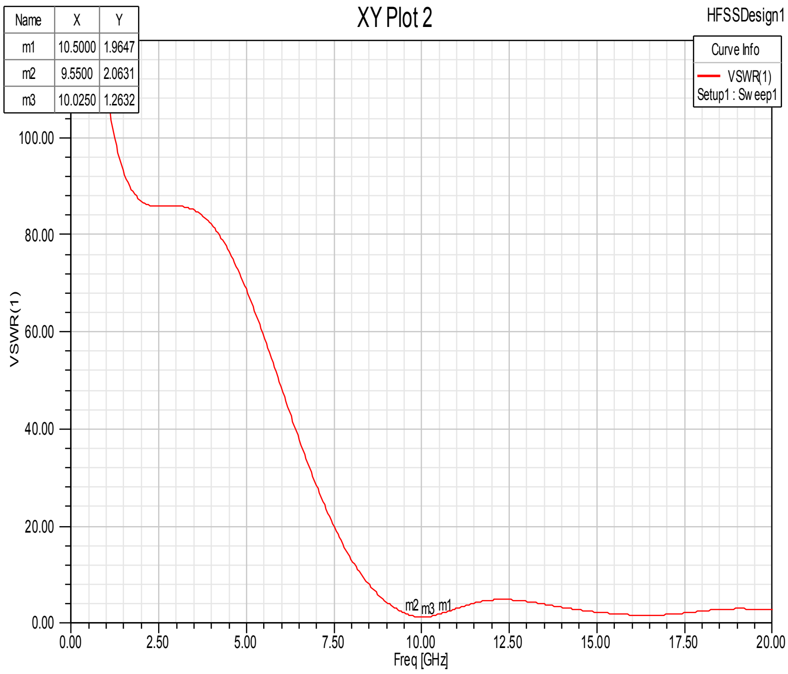


Fig. 8. VSWR of an antenna without Metamaterial structure

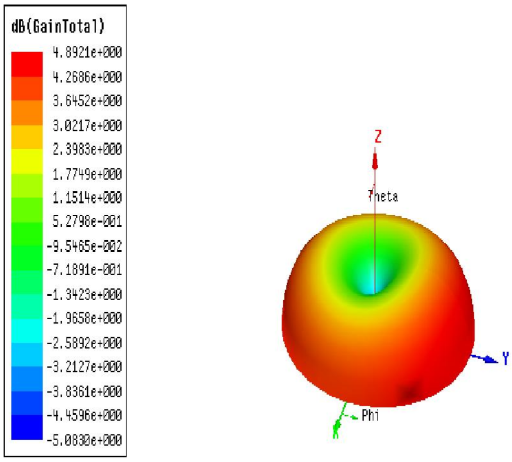


Fig. 9. Gain of an antenna with Metamaterial structure

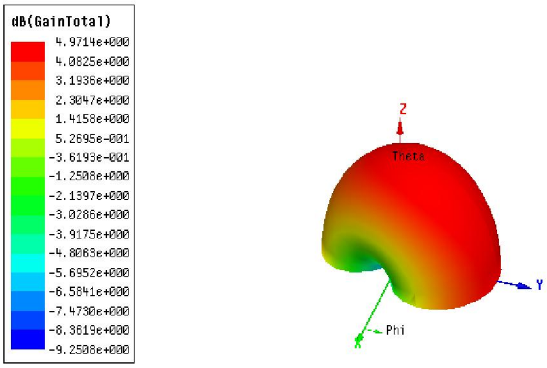


Fig. 10. Gain of an antenna without Metamaterial structure

4 CONCLUSION

A miniature metamaterial microstrip patch antenna has been designed and analyzed in this paper. The working frequency of the rectangular microstrip antenna has significantly descended 57% and increased bandwidth of 0.6 GHz to that of the conventional microstrip antenna, and this antenna has strong radiation near the horizontal direction at the subwavelength frequency. The antenna can be used for dual resonant frequencies and Broadcast communication.

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REFERENCES

[1] Andrea Alù, Filiberto Bilotto, N. Engheta, and Lucio Vegni, "Subwavelength, compact, resonant patch antennas loaded with metamaterials," *IEEE Trans. Antennas Propag*., vol. 55, pp. 13–25, 2007.

[2] S.S. Zhong and J.H. Cui, "Compact circularly polarized microstrip antenna with magnetic substrate," in *Proc. IEEE AP-S Int. Symp., San Antonio, TX,* vol. 1, pp. 793–796, Jun. 2002.

[3] D. Psychoudakis, Y.H. Koh, J.L. Volakis, and J.H. Halloran, "Design method for aperture-coupled microstrip patch antennas on textured dielectric substrates," *IEEE Trans. Antennas Propag*., vol. 52, no. 10, pp. 2763 – 2766, Oct. 2004.

[4] J.S Lim, C.B. Kim, J.S. Jang etc "Design of a subwavelength patch antenna using metamaterials," *Microwave Conference, EuMC 2008, 38th European*, pp. 547-550, Amsterdam, 2008.

[5] V.G. Veselago, "The electrodynamics of substances with simultaneously negative values of ε and μ," *Sov. Phys. Uspekhi,* vol. 10, no. 4, pp. 509-514, Jan-Feb. 1968.

[6] D.R. Smith, W. J. Padilla, D.C. Vier, S.C. Nemat-Nasser and S. Schultz, "Composite Medium with Simultaneously Negative Permeability and Permittivity," *Physical Review Letters*, vol. 84, no. 18, pp.4184-4187, May 2000.

[7] J.B. Pendry, A. J. Holden, D.J. Robbins and W.J. Stewart, "Magnetism from Conductors and Enhanced Nonlinear Phenomena*," IEEE Trans. on MTT*, vol. 47, pp. 2075-2084, 1999.

[8] R. W. Ziolkowski, "Design, fabrication, and testing of double negative metamaterials," *IEEE Trans. on Antennas and Propag*., vol. 51, no. 7, pp. 1516-1529, July 2003.

[9] J. Machac, M. Rytir, P. Protiva, and J. Zehetner, "A double H-shaped resonator for an isotropic ENG metamaterial," *Microwave Conference, EuMC 2008, 38th European*, pp. 547-550, Amsterdam, 2008.

[10] D. Schuring, J.J. Mock, and D.R. Smith, "Electric-field coupled resonators for negative permittivity metamaterials," *Applied physics letters*, vol. 88, Issue: 4, pp. 041109-041109 -3, 2006.

[11] Rabih Rahaoui and Mohammed Essaaidi, "Compact Cylindrical Dielectric Resonator Antenna excited by a Microstrip Feed Line," *International Journal of Innovation and Applied Studies*, vol. 2, no. 1, pp. 1–5, January 2013.

[12] Mohammed Younssi, Achraf Jaoujal, Yacoub Diallo, Ahmed El-Moussaoui, and Noura Aknin, "Study of a Microstrip Antenna with and Without Superstrate for Terahertz Frequency," *International Journal of Innovation and Applied Studies*, vol. 2, no. 4, pp. 369–371, April 2013.

[13] M. I. Hasan and M. A. Motin, "New slotting technique of making compact octagonal patch for four band applications," *International Journal of Innovation and Applied Studies*, vol. 3, no. 1, pp. 221–227, May 2013.

[14] Tajeswita Gupta and P. K. Singhal, "Ultra Wideband Slotted Microstrip Patch Antenna for Downlink and Uplink Satellite Application in C band," *International Journal of Innovation and Applied Studies*, vol. 3, no. 3, pp. 680–684, July 2013.

[15] Sonali Kushwah, P. K. Singhal, Manali Dongre, and Tajeswita Gupta, "A Minimized Triangular – Meander Line PIFA Antenna for DCS1800/WIMAX Applications," *International Journal of Innovation and Applied Studies*, vol. 3, no. 3, pp. 714–718, July 2013.

[16] Tajeswita Gupta, P. K. Singhal, and Vandana Vikas Thakre, "Modification in Formula of Resonating Frequency of Equilateral TMPA for Improved Accuracy and Analysis," *International Journal of Innovation and Applied Studies*, vol. 3, no. 3, pp. 727–731, July 2013.

[17] Anshul Agarwal, P. K. Singhal, Shailendra Singh Ojha, and Akhilesh Kumar Gupta, "Design of CPW-fed Printed Rectangular Monopole Antenna for Wideband Dual-Frequency Applications," *International Journal of Innovation and Applied Studies*, vol. 3, no. 3, pp. 758–764, July 2013.