ISSN 0735-2727, Radioelectronics and Communications Systems, 2016, Vol. 59, No. 11, pp. 496–501. © Allerton Press, Inc., 2016.
Original Russian Text © P. Kaur, S.K. Aggarwal, A. De, 2016, published in Izvestiya Vysshikh Uchebnykh Zavedenii, Radioelektronika, 2016, Vol. 59, No. 11, pp. 29–36.

Performance Enhancement of Rectangular Microstrip Patch Antenna Using Double H Shaped Metamaterial

Preet Kaur[1*], S. K. Aggarwal[1], and Asok De[2***]**
[1]YMCA University of Science and Technology, Faridabad, India
[2]National Institute of Technology, Patna, India
*e-mail: preetmoar@gmail.com
**e-mail: sa_3264@yahoo.co.in
***e-mail: asok.de@gmail.com
Received in final form June 6, 2016

Abstract—In this paper a high performance rectangular microstrip patch antenna (RMPA) has been designed using double H shaped metamaterial. First, the double H shaped metamaterial has been designed and optimized at 5.2 GHz resonant frequency of patch antenna. It has been found that embedding of this metamaterial into the substrate beneath the reference patch antenna improves its return loss and bandwidth without changing the resonant frequency and gain. To further enhance the gain and efficiency of the metamaterial embedded RMPA a superstrate of double H shaped metamaterial has been applied at the distance of $\lambda/3$ over it. Finally, a high gain, broadband and good impedance matched metamaterial inspired RMPA has been obtained. The proposed antenna was simulated and optimized using HFSS software. The prototype antenna has been fabricated and measured results of the proposed antenna are found to be in good agreement with the simulated results.

DOI: 10.3103/S0735272716110030

1. INTRODUCTION

In modern wireless and electronics systems the demand for compact, high gain, broad-band, low-cost and light weight radiator with single feeding system has been increased substantially [1, 2]. Conventional rectangular microstrip patch antenna (RMPA) compatible for wireless application has low profile, simple structure, low cost, ease of fabrication and has simple feeding system, but this antenna has low gain and narrow bandwidth because of the influence of surface wave on its radiation pattern [3]. In order to solve this problem a microstrip patch array antenna can be used, but the complex feeding system and lower radiation efficiency limit its application.

Recently, the researchers have proposed the utilization of metamaterial to design antennas with enhanced performance and reduced profile [1]. Metamaterials are artificial materials formed by embedding specific inclusion in host media and can be engineered to have desired electromagnetic properties.

Some of these materials have negative permittivity or permeability. If both permittivity and permeability are negative at the same frequency, then these materials are called left handed materials and exhibit negative index of refraction [4]. Several works have been dedicated to the improvement of the performance of antennas using metamaterials [5–13].

Double H shaped metamaterial is a double negative (DNG) resonant material [14]. In [15] we have presented a design of compact antenna using this resonant material, but the antenna has low gain. In this paper double H shaped resonator is embedded underneath the patch antenna to improve the impedance matching and to increase bandwidth without reducing the gain. To further improve the gain of the developed antenna a superstrate of double H shaped metamaterial has been added into the structure at the distance of $\lambda/3$. The gain of 6.58 dB has been achieved, which is good result for a patch antenna.

REFERENCES

1. Huiliang Xu, Zeyu Zhao, Yueguang Lv, Chunlei Du, Xiangang Luo, "Metamaterial superstrate and electromagnetic band-gap substrate for high directive antenna," *Int. J. Infrared Millimeter Waves* **29**, No. 5, 493 (2008), DOI: 10.1007/s10762-008-9344-y.
2. A. Chauraya, J. Kelly, G. K. Palikaras, C. B. Mulenga, J. A. Flint, A. P. Feresidis, J. C. Vardaxoglou, "Planar and cylindrical metamaterial structures for antenna applications," *Proc. of EMTS Int. URSI Commision B-Electromagnetic Theory Symp.*, July 2007 (2007).
3. Jing Liang, Hung-Yu David Yang, "Radiation characteristics of a microstrip patch over an electromagnetic bandgap surface," *IEEE Trans. Antenna Propag.* **55**, No. 6, 1691 (Jun. 2007), DOI: 10.1109/TAP.2007.898633.
4. W. P. Kock, "Metal-lens antennas," *Proc. IRE* **34**, No. 11, 828 (Nov. 1946), DOI: 10.1109/JRPROC.1946.232264.
5. B.-I. Wu, W. Wang, J. Pacheco, X. Chen, T. M. Grzegorczyk, J. A. Kong, "A study of using metamaterials as antenna substrate to enhance gain," *PIER* **51**, 295 (2005), DOI: 10.2528/PIER04070701.
6. Y. G. Ma, P. Wang, X. Chen, C. K. Ong, "Near-field plane-wave-like beam emitting antenna fabricated by anisotropic metamaterial," *Appl. Phys. Lett.* **94**, 044107 (2009), DOI: 10.1063/1.3077128.
7. Bimal Garg, Nitin Agrawal, Vijay Sharma, Ankita Tomar, Prashant Dubey, "Rectangular microstrip patch antenna with "pentagonal rings" shaped metamaterial cover," *Proc. of Int. Conf. on Communication Systems and Network Technologies*, CSNT, 11–13 May 2012, Rajkot (IEEE, 2012), pp. 40–44, DOI: 10.1109/CSNT.2012.18.
8. R. Pandeeswari, S. Raghavan, Pravin A. Bagde, Ananda Kumar Chittipothul, "A compact multi-split ring resonator loaded antenna," *Proc. of Int. Conf. on Communications and Signal Processing*, ICCSP, 3–5 Apr. 2013, Melmaruvathur (IEEE, 2013), pp. 807–810, DOI: 10.1109/iccsp.2013.6577168.
9. Jaegeun Ha, Kyeol Kwon, Youngki Lee, Jaehoon Choi, "Hybrid mode wideband patch antenna loaded with a planar metamaterial unit cell," *IEEE Trans. Antennas Propag.* **60**, No. 2, 1143 (Feb. 2012), DOI: 10.1109/TAP.2011.2173114.
10. Wenquan Cao, Yang Xiang, Bangning Zhang, Aijun Liu, Tongbin Yu, Daosheng Guo, "A low-cost compact patch antenna with beam steering based on CSRR-loaded ground," *IEEE Antennas Wireless Propag. Lett.* **10**, 1520 (2011), DOI: 10.1109/LAWP.2011.2181316.
11. H. Attia, O. Siddiqui, O. M. Ramahi, "Artificial magneto-superstrates for gain and efficiency improvement of microstrip antenna arrays," *Proc. of Progress in Electromagnetics Research Symp.*, 5–8 Jul. 2010, Cambridge, USA (2010), pp. 878–881.
12. Merih Palandoken, Andre Grede, Heino Henke, "Broadband microstrip antenna with left-handed metamaterials," *IEEE Trans. Antennas Propag.* **57**, No. 2, 331 (Feb. 2009), DOI: 10.1109/TAP.2008.2011230.
13. Preet Kaur, S. K. Aggarwal, Asok De, "Design of compact rectangular patch antenna using square grid and I shaped metamaterial," *Proc. of Int. Conf. on Signal Processing and Communication*, ICSC, 16–18 Mar. 2015, Noida (IEEE, 2015), pp. 132–135, DOI: 10.1109/ICSPCom.2015.7150634.
14. Michal Blaha, Jan Machac, "Planar resonators for metamaterials," *Radioengineering* **21**, No. 3, 852 (Sept. 2012), http://www.radioeng.cz/fulltexts/2012/12_03_0852_0859.pdf.
15. Preet Kaur, S. K. Aggarwal, Asok De, "Double H shaped metamaterial embedded compact RMPA," *Proc. of Int. Conf. on Advances in Computing, Communications and Informatics*, ICACCI, 24–27 Sept. 2014, New Delhi (IEEE, 2014), pp. 483–486, DOI: 10.1109/ICACCI.2014.6968492.
16. David M. Pozar, Daniel H. Schaubert, *Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays* (IEEE Press, NewYork, 1995), DOI: 10.1109/9780470545270.
17. A. M. Nicolson, G. F. Ross, "Measurement of the intrinsic properties of materials by time-domain techniques," *IEEE Trans. Instrum., Meas.* **19**, No. 4, 377 (Nov. 1970), DOI: 10.1109/tim.1970.4313932.
18. W. B. Weir, "Automatic measurement of complex dielectric constant and permeability at microwave frequencies," *Proc. IEEE* **62**, No. 1, 33 (Jan. 1974), DOI: 10.1109/PROC.1974.9382.
19. R. W. Ziolkowski, "Design fabrication, and testing of double negative metamaterials," *IEEE Trans. Antennas Propag.* **51**, No. 7, 1516 (Jul. 2003), DOI: 10.1109/TAP.2003. 813622.