ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 6 , June 2016

Metamaterial Based Step Shape Patch Antenna for Wireless Application

D. Patir, Dipak Kr. Neog

Research Scholar, Department of Electronics, Dhemaji College, Dibrugarh University, Assam, India
Associate Professor, Department of Electronics, Dhemaji College, Dibrugarh University, Assam, India

ABSTRACT: A step shaped patch antenna using metamaterial structure in the ground plane have been studied and analyzed in this paper. After loading metamaterial in the ground plane the resonant frequency shifted to lower frequencies and bandwidth and gain is also increased. The proposed microstrip line fed patch antenna resonates at frequency of GSM, Wi-Fi and Wi-MAX application. This antenna has been investigated and performance was analyzed with the aid of Ansoft HFSS. The simulated and experimental results of fabricated on FR4 substrate with dimension (25×38×1.6) mm^3 are in good agreement.

KEYWORDS: Microstrip patch antenna, Metamaterial, GSM, HFSS, WiMAX, Wi-Fi.

I. INTRODUCTION

Wireless communication, as a platform for 3C technology (computer technology, communications technology and control technology), is increasingly being introduced in all dimensions and areas of everyday life, providing intelligent and omnipresent solutions. An antenna is the most important element of any wireless communications and its rapid development led to great demand for wireless devices that can operate at different standards. In this rapidly growth world of wireless application high gain, large bandwidth, multiband and high efficiency is the primary goal of researchers. But it is complex to achieve the performance indices, so different loading techniques like slotting, meandering stacking, shorting pin, defected ground structure (DGS) etc. have been used to uplift the required performance parameters [1-5]. There is a need to design small size, easily fed and low cost antenna for multi-band applications. Recently metamaterial is an innovative approach to improve the performance of the patch antenna due to have exquisite material characteristics and ability to control and guide the electromagnetic waves in such a way that natural materials cannot. In 1968 Victor Veselago first introduced the theoretical concept of metamaterial [6]. These materials are not found in nature and have possesses negative permeability and/or negative permittivity, which also termed as negative index materials (NIM) and shows reversal of Snell's law. To enhance the antenna performance like dual/triband antennas, lower the resonant frequency, enhance the bandwidth, radiation pattern with gain different metamaterial structures have been utilized in various ways on it [7-11].
In this paper a slotted metamaterial based step shape patch antenna with dimension (25×38×1.6) mm^3 and a 50Ω microstrip line feed is reported which provides improved capability of the new standard service telecommunication system. This patch antenna provides the operating bands for Global System for Mobile Communication (GSM), Wireless Fidelity (Wi-Fi) and Worldwide Interoperability for Microwave Access (WIMAX) application.

II. ANTENNA DESIGN

The geometrical structure of step shaped patch antenna with microstrip line feed and defected ground is shown in fig.1. It was printed on a 1.59 mm thick low cost FR4 substrate with permittivity 4.4 and dielectric loss tangent of 0.02. The ground plane was printed on the substrate with dimension of (38×25) mm^2 small enough to fit on circuit boards for many wireless communication applications. A microstrip feed line with length 12mm and width 2.4 mm was used to couple the input signal to the microstrip patch antenna connected to a 50Ω coaxial SMA connector as a feeding port. The dimensional parameters of the patch antenna are L_s=38mm, W_s= 25mm, L_m=12mm, L_g=11mm, a = b = 5mm, s = 8mm and g = 5mm.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 6 , June 2016

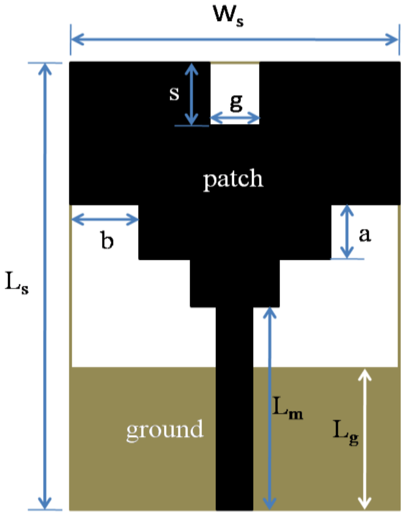


Fig. 1 Geometry of the proposed antenna

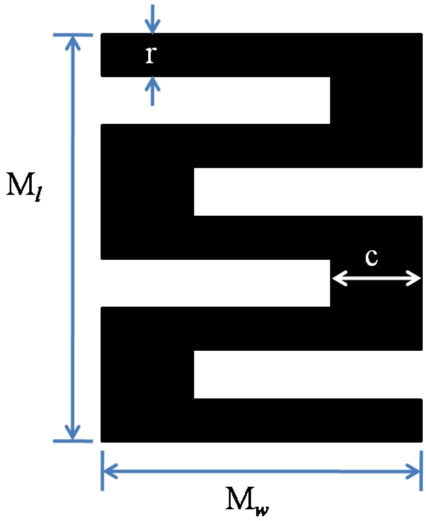
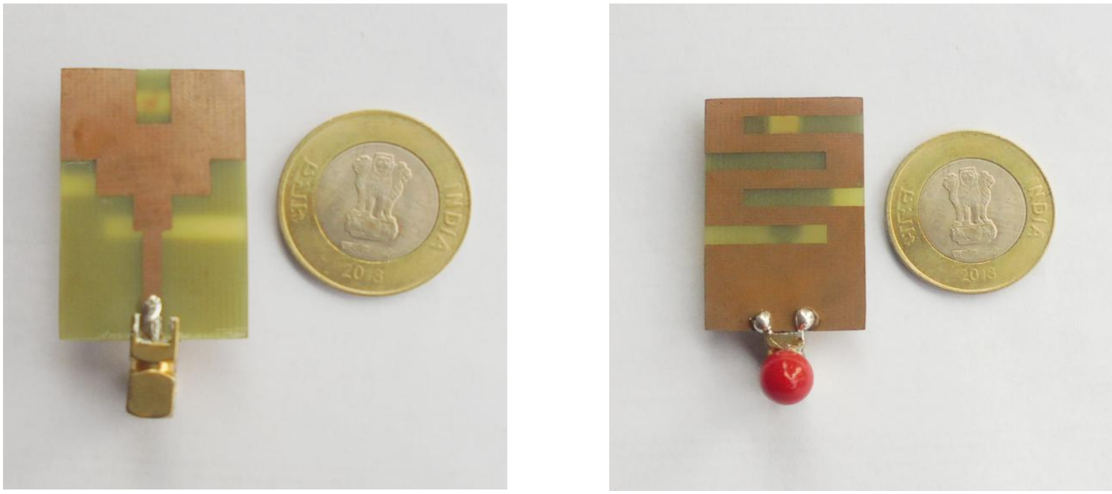


Fig.2 Geometry of the metamaterial structure

The Z type metamaterial structure with dimension parameter is shown in fig.2. The dimension are M_l = 27mm, M_w = 25mm, C = 6mm and r = 3mm. To enhance the bandwidth and lower the resonant frequency this Z type metamaterial structure is placed in the ground plane of the patch antenna. The Ansoft HFSS-13 full wave simulator is used to simulate the metamaterial loaded patch antenna. The prototype of the fabricated antenna with top view and back view is shown in fig.3. Top view is the radiating patch with microstrip line feed and back view is ground plane with the metamaterial structure.



(a) (b)

Fig.3 Fabricated metamaterial based antenna (a) Top view (b) Back view

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 6 , June 2016

III.RESULTS AND DISCUSSION

The real permittivity and real permeability characteristics of the Z type structure is extract using S-parameter retrieval method. To extract the S-parameters of the MTM unit element a appropriate boundary conditions and excitations are assigned to the surfaces of 3-dimensional periodic MTM and simulated in Ansoft HFSS. The metamaterial characteristics have been tested and verified using a MATLAB code developed for S-parameter retrieval technique. Fig. 4 shows the real permeability and real permittivity curve of the metamaterial structure.

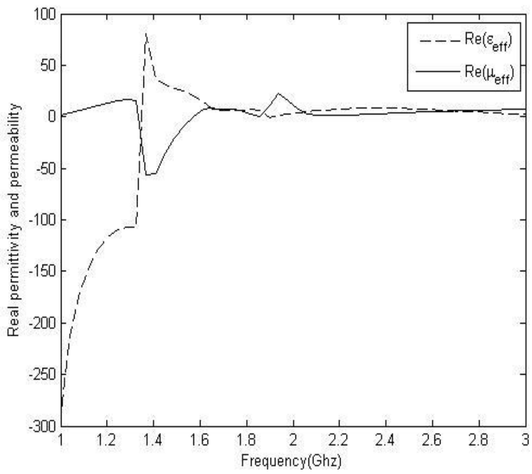


Fig. 4 Real permeability and permittivity curve of the metamaterial

The simulated return loss of the patch antenna with the rectangular ground (fig.1) is shown in Fig.5. In this structure the defected ground plane with two L type slotted patch make the antenna resonates at 2.9GHz and 6.1 GHz. An increase in bandwidth is achieved by etching a rectangle at the top of the patch with the bandwidth of 52.41% and 33.93% respectively.

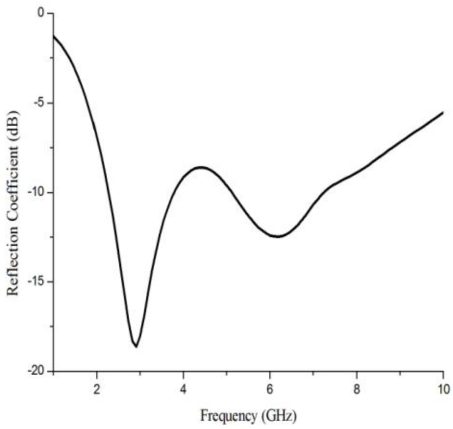


Fig. 5 Simulated reflection coefficient of the unloaded patch antenna

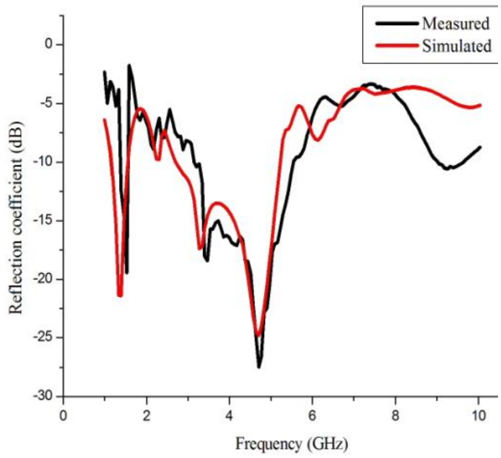


Fig. 6 Comparison of simulated and measured reflection coefficients of the metamaterial based antenna

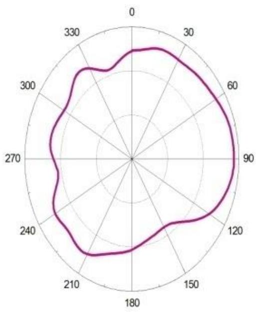
After that the ground plane of the antenna is loaded with the metamaterial structure for which the resonant frequency is obtained at 1.8GHz, 3.36 GHz and at 4.72GHz (Fig. 6). The metamaterial loaded antenna provides impedance

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 3, Issue 6 , June 2016

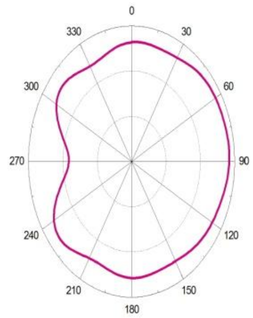
bandwidth upto of 7.7% (1.74-1.88 GHz) and 81.25% (2.54-5.27GHz). Simulated peak gains at the specific resonant frequencies are -5dBi, 1.62dBi and 2.94dBi respectively which are good for better efficiency.

The proposed antenna was fabricated (fig.3) and the reflection coefficient was measured using Agilent VNA E8362C. Fig.6 compares the simulated and measured reflection coefficients where it can be seen that the simulated antenna offers good matching with the measured one, which helps to validate the design accuracy.

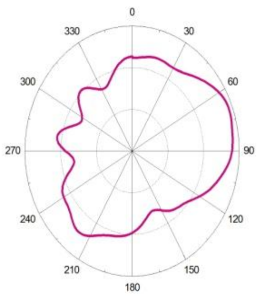
A setup consists with an Agilent MXG-N5183A signal generator and Agilent U200A USB power sensor with PC controlled turn table arrangement was used for radiation pattern measurement. The measured E plane and H plane patterns at 3.36 GHz and 4.72 GHz are plotted and which is shown in Fig. 7. The radiation pattern characteristics show that the antenna is omnidirectional in nature.



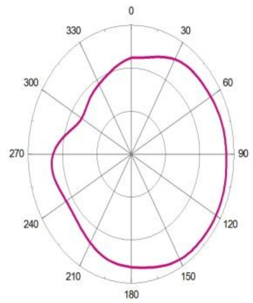
E plane at 3.36 GHz



H plane at 3.36 GHz



E plane at 4.72 GHz



H plane at 4.72 GHz

Fig. 7 Measured E plane and H plane Radiation pattern

IV. CONCLUSION

In this proposed work a monopole metamaterial loaded step shaped patch antenna is presented. The metamaterial loading approach is used for reduction of resonant frequency to lower one and also to enhance the gain and bandwidth. The metamaterial based antenna resonates with resonate frequencies at 1.8 GHz, 3.36 GHz and 4.72 GHz which are suitable for GSM, Wi-Fi and Wi-MAX applications. Now a day's modern communication system requires microwave components with high performance with small size and this antenna fulfil all these requirements.

V. ACKNOWLEDGEMENT

The authors would like to acknowledge faculty members and support staff of Physics Department and ECE Department, Tezpur University, Assam, India for their help to measure return loss value and radiation pattern of the proposed antenna.

REFERENCES

[1] Lai, C. H., T. Y. Han, and T. R. Chen, "Broadband aperture-coupled microstrip antennas with low cross polarization and back radiation", Progress In Electromagnetics Research Letters, Vol. 5, 187-197, 2008.

[2] Mandal, K., S. Sarkar, and P. P. Sarkar, "Bandwidth enhancement of microstrip antenna by staggering effect", Microwave and Optical Technology Letters, Vol. 53, 2446-2447, 2011.

[3] Iddi, H. U., M. R. Kamarudin, T. A. Rahman, A. Y. Abdulrahman, M. Khalily, and M. F. Jamlos, "Triple band CPW-fed planar monopole antenna for WLAN/WiMAX applications", Microwave and Optical Technology Letters, Vol. 55, 2209-2214, 2013.

[4] Liu, W. X., Y. Z. Yin, and W. L. Xu, "Compact self similar triple band antenna for WLAN/WiMAX applications", Microwave and Optical Technology Letters, Vol. 54, 1084-1087, 2012.

[5] D. K. Neog, S. S. Pattnaik, M. Dutta, D. C. Panda, S. Devi and B. Khuntia, "A novel patch antenna for wide band generation", Proceeding of international conference on antenna technologies, pp. 345-348, 2005.

[6] V. G. Veselago, "The electrodynamics of substances with simultaneously negative values of ε and μ", Soviet Physics USPEKHI, vol.10, no.4, pp.509-514, 1968.

[7] Majid, H. A., M. K. Abd Rahim, and T. Masri, "Microstrip antenna's gain enhancement using left-handed metamaterial structure", Progress In Electromagnetics Research M, Vol. 8, 235-247, 2009.

[8] A. Ahmadi, S. Saadat, and H. Mosallaei, "Resonance and Q performance of ellipsoidal ENG subwavelength radiators", IEEE Trans. Antennas Propag., vol. 59, no.3, pp.706–713, Mar.2011.

[9] J. G. Joshi, Shyam S. Pattnaik and S. Devi, "Metamaterial Loaded Dual Band Microstrip Patch Antenna", IEEE-IAW 2011, Kolkata, pp.1-4, ,2011.

[10] Segovia-Vargas, D., F. J. Herraiz-Martinez, E. Ugarte-Munoz, L. E. Garcia-Munoz, and V. Gonzalez-Posadas, "Quad-frequency linearly-polarized and dual-frequency circularly-polarized microstrip patch antennas with CRLH loading", Progress In Electromagnetics Research, Vol. 133,91-115, 2013.

[11] G. Zhao, F.S. Zhang, Y. Song, Z.B. Weng, and Y. C. Jiao, "Compact Ring Monopole Antenna with Double Meander lines for 2.4/5ghz Dual-band Operation", Progress in Electromagnetics Research, PIER 72, 187–194, 2007