International Journal of Scientific Research in Mechanical and Materials Engineering
© 2018 IJSRMME | Volume 2 | Issue 3 | ISSN : 2457-0435

Design and Development of Metamaterial Antenna For 5.5 GHz Wi-Max Applications

Geetharamani . G[1], Aathmanesan . T*[2]
[1]Mathematics, Anna University, Tamilnadu, India
*[2]ICE, Anna University, Tamilnadu, India

ABSTRACT

Antenna design plays the primary role in wireless communication technology. In this paper novel metamaterial structure is added in the rectangular patch antenna for operating in 5.5 GHz Wi-Max applications. "Meta" is a Greek word which means "beyond" the materials provides properties beyond the conventional materials. A rectangular patch antenna is provided with the metamaterial ground structure which is used to improve the performance of the normal patch antenna. In this research FR4 substrate with dielectric permittivity of 4.4 and height of the substrate is 1.6 mm is used for developing the metamaterial antenna. The Proposed antenna having dimension 30 mm length and 30 mm width. This metamaterial antenna is designed with an integral based solver simulation software called CST Microwave studio v2018 and obtained VSWR 1.05, Return loss of -31.068 dB and Bandwidth of 150 MHz, Directivity of 5.95 dB, gain of 5.82 dBi at the resonant frequency 5.5 GHz. This metamaterial antenna is suitable for 5.8 GHz Wi-Fi applications.

Keywords: Metamaterial, Micro Patch Antenna, Wi-Max, Wireless Communication.

I. INTRODUCTION

Antenna design plays vital role in developing the wireless communication technology to support the faster growth of data communication. WiMax is the successor of existing Wi-Fi technology and this Wi-Max helps in wireless broadband and other commercial wireless data transfer services. This Wi-Max communication uses the 5.5 GHz microwave frequency for communication between the devices. Micro patch antennas are low profile antennas which are easy for design and fabrication [1]. Metamaterials are materials with different structures which poses enhanced properties than the ordinary materials which are used for the design of various semiconductor devices such as antennas.

Therefore, in this paper metamaterial antenna is developed for operating in resonant frequency of 5.5 GHz useful for Wi-Max applications. In literature review fundamentals of designing Patch antenna have been studied using [2-3], Metamaterial structures was first invented by V. G. Veselago [4] and its basic design fundamentals has been given in [5] and the contribution of metamaterial in electromagnetics has been given in [6-7]. A Compact Dual-Band Patch Antenna using Triangular Complimentary Split Ring resonators for

WiMax/WLAN Applications is discussed in [8]. A Novel Face-Like Triple-Band Antenna for WLAN/WiMAX Applications is discussed in [9]. A Compact Dual-Band Octagonal Slotted Printed Monopole Antenna for WLAN/ WiMAX and UWB Applications is discussed in [10]. A Printed Monopole Antenna for Triple-Band WLAN/WiMAX Applications is discussed in [11].

A Low-Cost Microstrip Antenna for 3G/WLAN/ WiMAX and UWB Applications is discussed in [12]. A Compact Triple-band Multi-polarized Slot Antenna for WLAN / WiMAX Application is discussed in [13]. A Dual-Wideband and High Gain Magneto-Electric Dipole Antenna and Its 3D MIMO System with Meta surface for 5G / WiMAX / WLAN / X-Band Applications is discussed in [14]. An Enhanced Bandwidth and Radiation Specifications of Patch Antenna for WiMAX Application is discussed in [15]. In this research metamaterial structure is used along with the regular rectangular micro patch antenna. The software used for the development of antenna is CST Microwave studio v2018. The CST microwave studio is an Electromagnetic field simulation software which is based on finite integration technique and for analysis of patch antennas time domain solver is used. This CST microwave studio is selected based on its simple user interface with a capability of simulating complex structures such as metamaterials.

II. ANTENNA DESIGN

The front view of the proposed metamaterial antenna is given in Figure 1. The back view is given in Figure 2. The front view consists of rectangular patch configuration which is made of 0.045 mm thickness copper with electrical conductivity of 5.8e+007. The back view consists of metamaterial structure hexagonal shaped split ring resonator. The complete antenna is designed on the surface of the FR4 material with the characteristics of thickness 1.6 mm with permittivity of 4.3 and loss tangent 0.02. Inset feeding with 50-ohm input impedance is used in the excitation of the proposed metamaterial antenna.

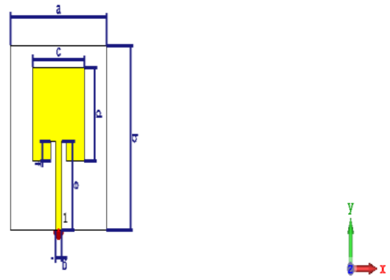

Figure 1. Front view of the metamaterial antenna

The Front view consists of a simple rectangular shaped copper patch in which inset feeding is used for the excitation purpose. Inset feeding selected because it is used to provide better impedance matching than the other kinds of feeding methods. The length of inset feed is 14.50 mm and the width 2 mm. The rectangular patch is having 16 mm length and 15.20 mm dimension. All dimensions for front view have been presented in Table 1.

Table 1. Geometrical Parameters Of Front View Of The Proposed Antenna

Parameter	Dimension (mm)
a	30
b	30
c	16
d	15.20
e	14.50
f	3.20
g	2

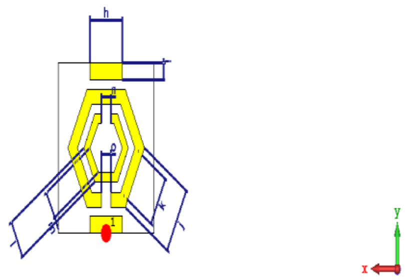

Figure 2. Back view of the metamaterial antenna

The back view of the proposed antenna having metamaterial structure which is hexagonal split ring resonator. The metamaterial structure consists of two hexagonal rings consists of the outer ring with 3 mm width and outer radius of 12 mm and inner radius of 10 mm and another ring which is also 3 mm width with the outer radius of 9 mm and inner radius of 7 mm. All dimensions used in the back view have been presented in Table 2.

Table 2. Geometrical Parameters Of Back View Of The Proposed Antenna

Parameter	Dimension (mm)
h	10
i	3
j	12
k	9
l	7
m	6
n	3
o	3

III. RESULTS AND DISCUSSION

The proposed metamaterial antenna is designed and simulated in CST Microwave studio v2018 and its results were discussed below.

3.1 Return Loss

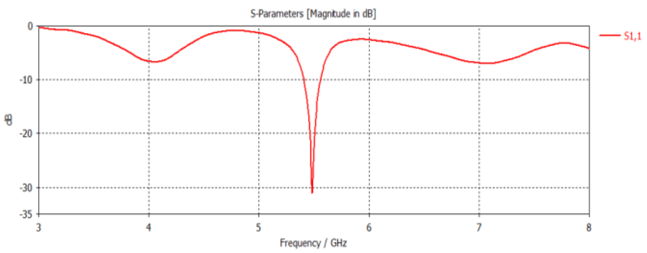

Figure 3. Return Loss

The minimum return loss obtained at 5.5 GHz is -31.068 dB for the proposed metamaterial antenna to operate in 5.5 GHz band Wi-Max applications which is given in Figure 3.

3.2 VSWR

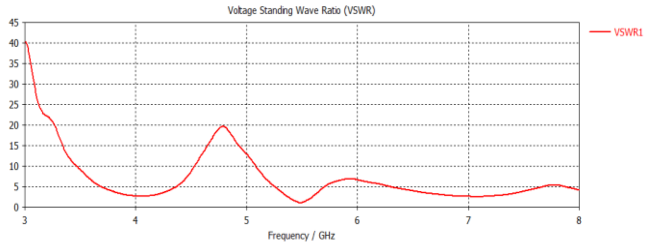

Figure 4. VSWR

The minimum Voltage Standing Wave Ratio VSWR obtained at 5.5 GHz is 1.05 for the proposed metamaterial antenna which is given in Figure 4.

3.3 Bandwidth

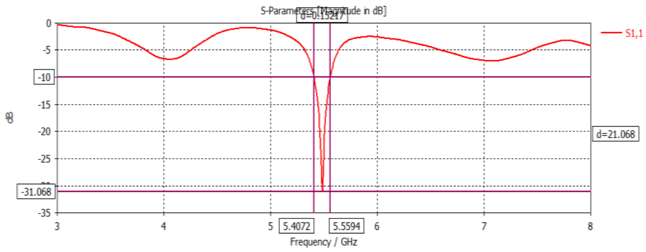

Figure 5. Bandwidth

The -10 dB Bandwidth obtained at 5.5 GHz is 150 MHz for the proposed metamaterial antenna which is given in Figure 5

3.4 Efficiency

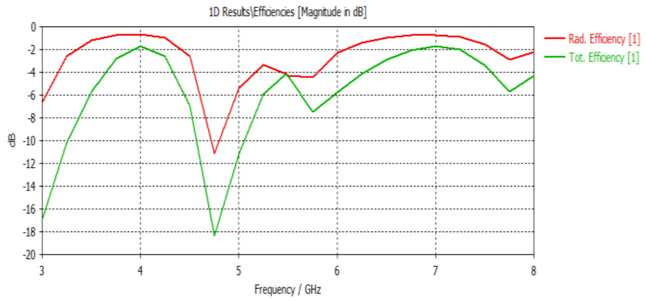

Figure 6. Efficiency

The Maximum Efficiency obtained at 5.5 GHz is 40 % for the proposed metamaterial antenna which is given in Figure 6.

3.5 Farfield Plots

3.5.1 Farfield Gain at 5.5 GHz

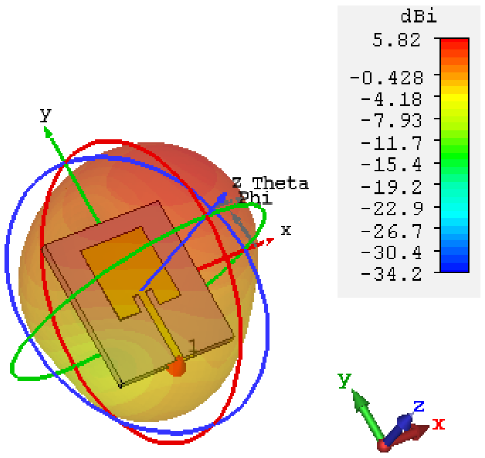

Figure 7. Farfield Gain at 5.5 GHz

3.5.2 Total Farfield Gain from 3 to 8 GHz

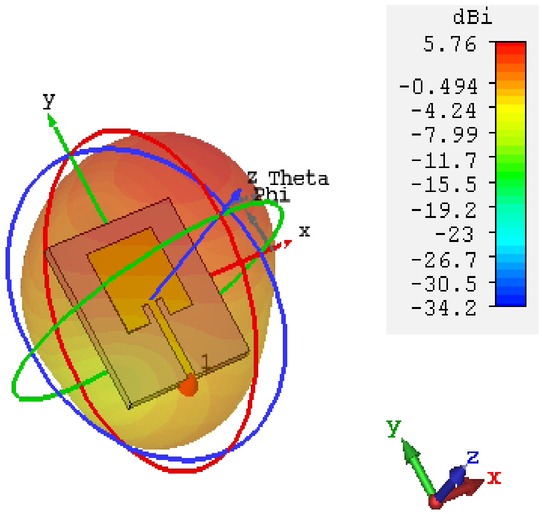

Figure 8. Total Farfield Gain from 3 to 8 GHz

3.5.3 Farfield Directivity, Abs Phi=0

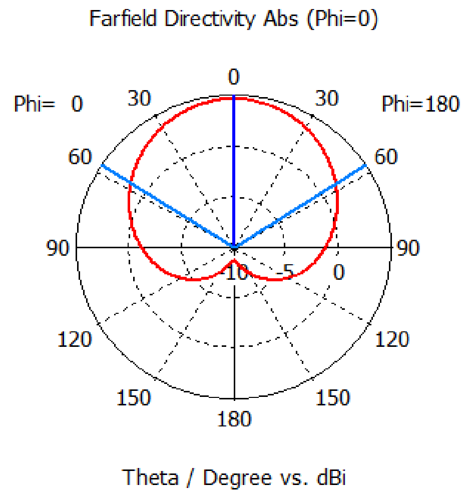

Figure 9. Farfield Directivity, Abs Phi=0

3.5.4 Directivity, constant Phi=90

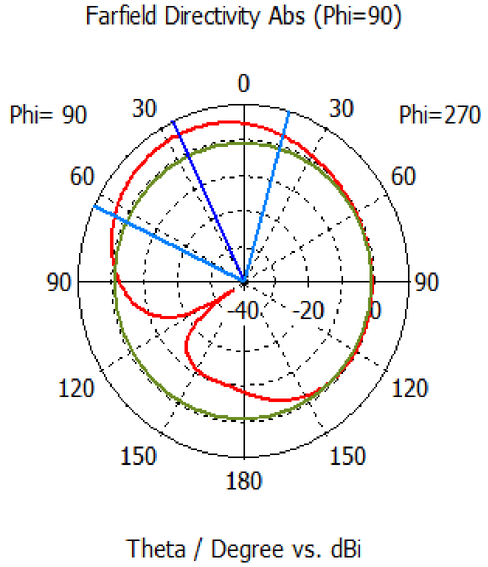

Figure 10. Directivity, constant Phi=90

3.5.5 Farfield Directivity Plot at Theta=0

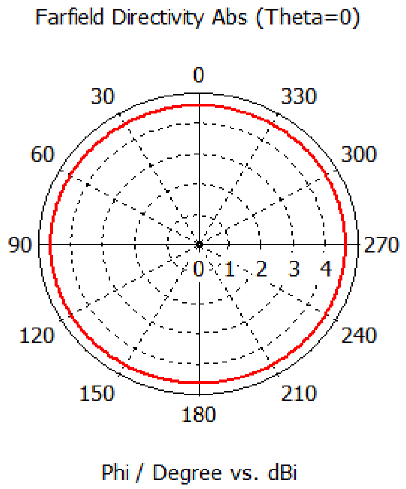

Figure 11. Farfield Directivity Plot at Theta=0

3.5.6. Farfield Directivity Plot at Theta=90

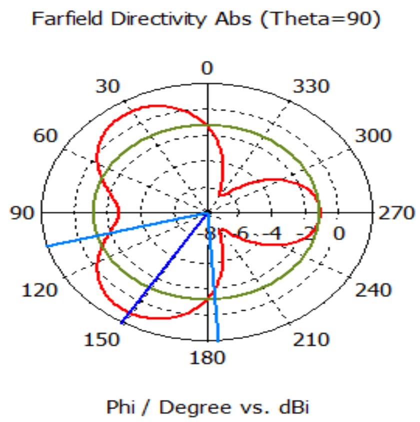

Figure 12. Farfield Directivity Plot at Theta=90

3.6 Front to Back Ratio

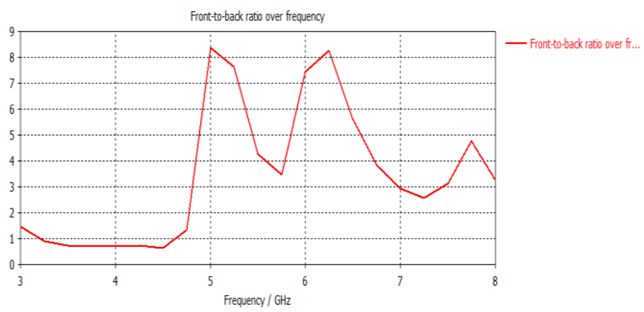

Figure 13. Front to Back Ratio

Front to Back Ratio is the ratio of power gain between the front and rear of a directional antenna. Front to back ratio at 5.5 GHz is 4.46 for the proposed metamaterial antenna.

3.7 E Field

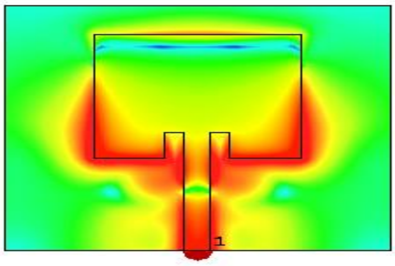

Figure 14. E Field Front View

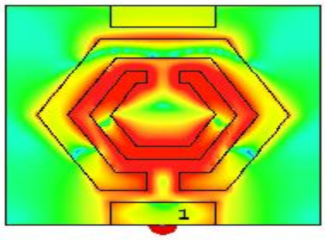

Figure 15. E Field Back View

3.8 H Field

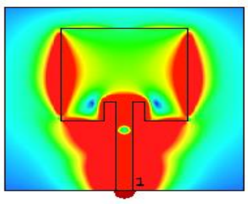

Figure 16. H Field Front View

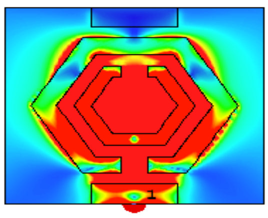

Figure 17 . H Field Back View

3.9 Surface current a distribution

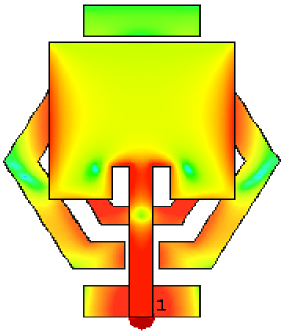

Figure 18. Surface current a distribution Front View

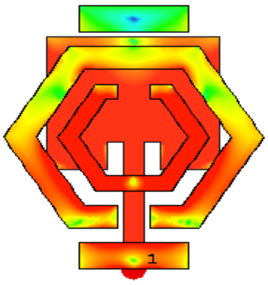

Figure 19. Surface current a distribution Back View

The Overall Results have been presented in Table 3.

Table 3. Overall Results

Parameter	Value
Operating Frequency	5.5 GHz
Return Loss	-31.068 dB
VSWR	1.50
Bandwidth	150 MHz
Efficiency	40 %
Directivity	5.95 dB
Gain	5.82 dBi
Front to Back Ratio	4.46

IV. CONCLUSION

The proposed metamaterial antenna achieved better radiation characteristics at the resonant frequency 5.5 GHz with the VSWR of 1.05, Return loss -31.068 dB and Bandwidth of 150 MHz, Directivity of 5.95 dB, gain of 5.82 dBi with 30*30 mm smallest dimension. This antenna is suitable for operating in wireless communication which operates on 5.5GHz frequency band Wi-Max applications.

V. REFERENCES

[1]. C. A. Balanis, Antenna Theory: Analysis and Design, 2nd ed. New York: John Wiley &Sons, 1997.

[2]. D. M. Pozar and D. H. Schaubert, Eds., Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays. New York: IEEE Press, 1995.

[3]. Yi Huang, Kevin Boyle. Antennas from theory to practice. John Wiley &Sons,2008.

[4]. V. G. Veselago "The Electrodynamics of Substances with simultaneously negative values of ε and μ.", soviet physics uspekhi-volume 10, number 4(1968):509-514.

[5]. D.R. Smith, W.J. Padilla, D.C. Vier, S.C. Nemat-Nasser, S. Schultz, Composite medium with simultaneously negative permeability and permittivity, Phys. Rev. Lett. 84 (2000) 4184–4187.

[6]. E. Shamonina , L. Solymar ,"Metamaterials: How the subject started" Elsevier B.V. Metamaterials 1 (2007): 12–18.

[7]. Ari Sihvola,"Metamaterials in electromagnetics", Elsevier B.V. Metamaterials 1 (2007): 2–11.

[8]. Bhavna Thakur, Ashwini Kunte, "Compact Dual-Band Patch Antenna using Triangular Complimentary Split Ring resonators for WiMax/WLAN." 2018 International Conference on Communication, Information & Computing Technology (ICCICT), Feb. 2-3, Mumbai, India.

[9]. Neng-Wu Liu, Long Yang, Zhi-Ya Zhang, Guang Fu, and Qiong-Qiong Liu, "A Novel Face-Like Triple-Band Antenna for WLAN/WiMAX Applications" Progress In

Electromagnetics Research Letters, Vol. 45, 105{110, 2014.

[10]. Praveen V. Naidu and Raj Kumar, " A Compact Dual-Band Octagonal Slotted Printed Monopole Antenna for WLAN/ WiMAX and UWB Applications" Journal of Microwaves, Optoelectronics and Electromagnetic Applications, Vol. 14 No. 1, June 2015.

[11]. Huiqing Zhai, Lu Liu, Zhihui Ma, and Changhong Liang, "A Printed Monopole Antenna for Triple-Band WLAN/WiMAX Applications" Hindawi Publishing Corporation International Journal of Antennas and Propagation Volume 2015.

[12]. Mohammed Al-Husseini, Member, IEEE, Youssef Tawk, Ali El-Hajj, and Karim Y. Kabalan, "A Low-Cost Microstrip Antenna for 3G/WLAN/WiMAX and UWB Applications" July 15-17, 2009 IEEE Zouk Mosbeh, Lebanon.

[13]. Sritama Dutta, Kahani Kumari, Debdeep Sarkar, Kumar Vaibhav Srivastava, "A Compact Triple-band Multi-polarized Slot Antenna for WLAN / WiMAX Application" 2018 3rd International Conference on Microwave and Photonics (ICMAP 2018), 9-11 February, 2018.

[14]. BOTAO FENG1, JIEXIN LAI, QINGSHENG ZENG, AND KWOK L. CHUNG, "A Dual-Wideband and High Gain Magneto-Electric Dipole Antenna and Its 3D MIMO System with Metasurface for 5G/WiMAX/WLAN/X-Band Applications" 2169-3536 , VOLUME 4, 2018 IEEE.

[15]. Abdul Rashid.O. Mumin, R. Alias, Jiwa Abdullah, Jawad Ali, Samsul Haimi Dahlan, "Enhanced Bandwidth and Radiation Specifications of Patch Antenna for WiMAX Application" 2018 IEEE.