Electromagnetic Bandgap Structured CPW Fed Circular Monopole Antenna with Bandwidth Enhancement for Wideband Applications

Raghavaraju Aradhyula, T V Rama Krishna, B T P Madhav

Abstract: A circular monopole antenna with coplanar wave guide feeding is constructed with the combination of Electromagnetic Band Gap structure for the improvement of bandwidth. A plus shaped defected ground is etched on the ground plane to obtain the EBG characteristics in the proposed antenna model. A complete analysis with respect to reflection coefficient, VSWR, impedance, radiation pattern, current distribution, gain and efficiency are presented in this work. The proposed model occupying the dimension of 50X50X1.6 mm on FR4 substrate with dielectric constant of 4.3. Antenna operating in the dual band of 1.5-3.6 GHz (GPS, LTE, Bluetooth and Wi-Fi applications) and 4.8-15 GHz (WLAN, X-Band and Satellite communication applications) with bandwidth of 2.1 and 10.2 GHz respectively. A peak realized gain of 4.8 dB and peak efficiency more than 80% are the key features of the current design.

Index Terms: Bandwidth Enhancement, Coplanar Waveguide Feeding (CPW), Electromagnetic Bandgap (EBG), Monopole, Wideband.

I. INRODUCTION

Researchers are focusing on achieving ultra wideband characteristics of antenna and focusing on the design of triple and multiband antennas with moderate bandwidth and gain [1]. Different novel structures are been proposed and intense interest is shown in making structures and materials in modern years [2]. Three significant categories of such materials are i) Photonic Crystals ii) Electromagnetic band-gap structures and iii) Metamaterials. Primary goal of this work is to centre on the second category mentioned above, that is EBG structures [3].

II. II.METHODOLOGY

The problem associated with planar monopole antennas emerges in guiding the plane waves by a plane between two media: conductor-dielectrics or dielectrics-dielectrics. The Electromagnetic energy between the interfaces transforms into surface waves. It is observed that, the higher the permittivity of dielectrics and thicker the substrate, the impact of surface waves is more grounded. Another major issue is that the electromagnetic waves emanated into substrate and achieve the air-dielectric interface at edges more than the condition spoke to as fallows are totally reflected [4]. The power which is changed into surface waves does not add to the primary radiation example of the receiving wire, still it dissipates off the edges of the ground plane which leads to ripples in radiation pattern, increased back radiation, depreciation of gain and low polarization purity which are not desirable for practical applications. These problems can be justified by assimilating EBG while designing an antenna [5], which finally results in increase of gain that can be obtained by reducing backward radiation [6]. Along with that, EBG contributes in reduction of mutual coupling which strongly improves the performance of antenna arrays. Although different EBG's like 2-D, 2.5-D, 3D, exist a uni-planar unit cell EBG structure is chosen in this paper for simplicity and ease of fabrication.

$$\theta_c = \sin^{-1} \varepsilon^{-1/2} \tag{1}$$

The proposed antenna comprises a combination of uni-planar EBG structure and the excitation is provided by a common micro strip line. The reflection coefficient and Frequency bands of operation are dependent on the physical dimensions of EBG which is based on DGS. EBGs are embedded on the ground plane which alters the performance characteristics of antenna. In this work, simple monopole radiator feature is compared with a model which is incorporated with uniplanar EBG structures. EBG has many advantages such as improvement in gain, return loss and radiation pattern**.** The antenna works for all bands of 802.11.It is suitable for WLAN and Wi-Max applications. Important interesting factor is that this antenna works beyond UWB range which is suitable for RADAR and oth**e**r satellite Communication applications.

Revised Manuscript Received on August 01, 2019.

Raghavaraju Aradhyula, [1]Research Scholar, Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India

[2]Associate Professor, Chebrolu Engineering College, Chebrolu, Guntur DT, AP, India

T V Rama Krishna, [3]Professor, Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India

BTP Madhav, [4]Professor, Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India

III. Antenna Design

The circular shaped radiating element was taken on the feed line based on the following formula. Here 50Ωimpedance is chosen at the feed point to construct the model. A plus shaped defected ground is etched on the ground plane which acts as the electromagnetic bandgap structure for the current model. Placing the EBG improves the bandwidth and provides additional resonant frequency. The inclusive dimension of the antenna is about 50X50X1.6mm on FR4 substrate material of relative permittivity 4.30

$$r1 = \frac{F}{\sqrt{1+\frac{2h}{\pi \varepsilon F}\left[\ln\frac{\pi F}{2h}+1.77\right]}} \quad \text{--(2)}$$

here *'h'* is the dielectric material thickness.

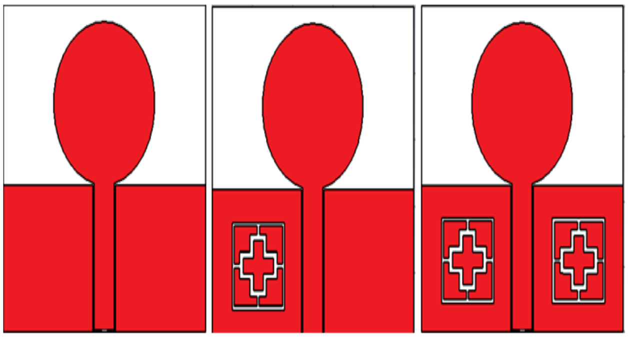

Fig 1. EBG Antenna Iterations, (a) CPW Fed Circular Monopole, (b) Single EBG, (c) Double EBG

IV. III Results and Discussion

Fig 2 shows the reflection coefficient of different models, antenna model 1 is resonating at 5 GHz with radio bandwidth of 6.9 GHz and impedance bandwidth of 72.4% where model 2 resonating at dual band of 2 to 5.8 GHz and 8 to 13 GHz with bandwidth of 3.2 GHz and 5 GHz individually. The recommend antenna model is resonating at dual wideband at 1.5 to 3.6 GHz and 4.8 to 15 GHz with bandwidth of 2.1 GHz and 10.2 GHz respectively. The same can be witnessed from Fig 3, where the reflection coefficient and the VSWR are plotted in the single figure for analysis.

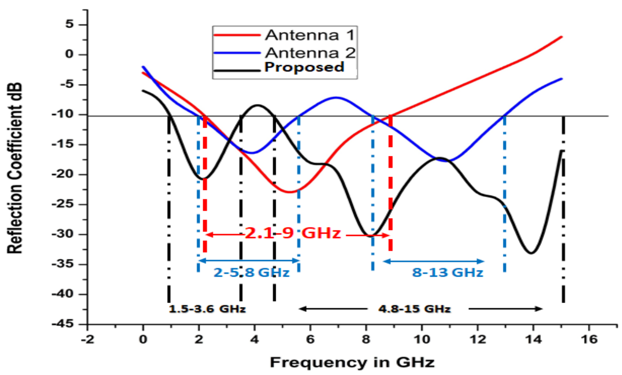

Fig 2. Frequency Vs Reflection Coefficient of Antenna Iterations

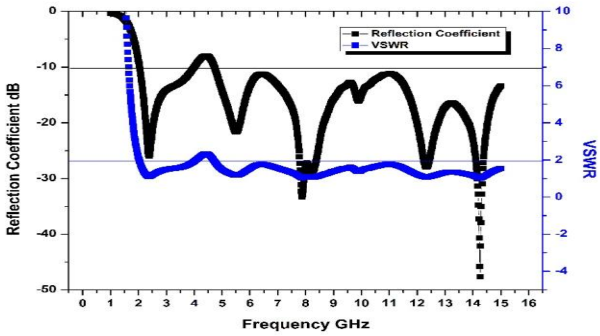

Fig 3. Proposed Antenna Reflection Coefficient and VSWR

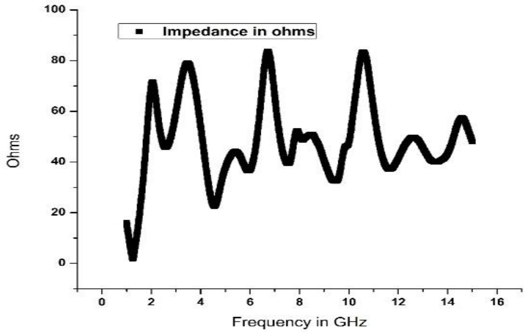

Fig 4. Frequency vs. Impedance

the impedance behavior of the antenna in the working band can be noticed from the Fig 4. Throughout the operating band the impedance is varying in and around 50 ohms, which gives the information regarding good impedance matching.

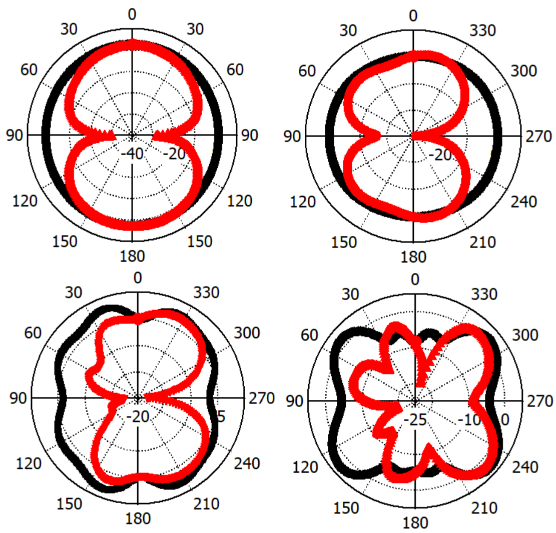

Fig 5. Radiation Pattern at 2.4, 5.5, 7.8 and 14.2 GHz

The radiation characteristics of the model at all operating bands presented in the Fig 5. Omnidirectional pattern in H-plane for lower bands and quasi omni for higher bands can be observed in H-plane. Monopole like pattern at 2.40 and 5.50 GHz and disturbed pattern at 7.8 and 14.2 GHz can be perceived in E-plane.

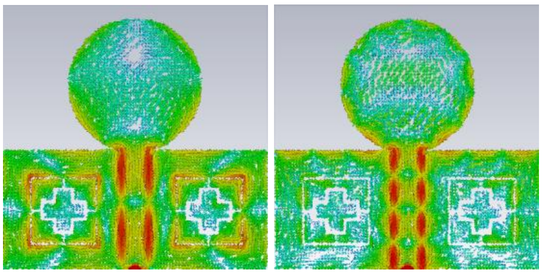

Fig 6.Surface current at 2.4 and 5.5 GHz

the antenna electric surface current distribution and time domain analysis displayed in Fig 6 and Fig 7. The current distribution over the feed line is more when compared with radiating structure. At low operating band of 2.4 GHz, we can observe the current intensity is concentrated on the edges of the EBG structure also. The intensity is small on EBG due to rejection of certain radiation at 5.5 GHz, the time domain perusal of the model antenna is reported in Fig 7. The analysis is presented here with normalized amplitude on the y-axis as shown.

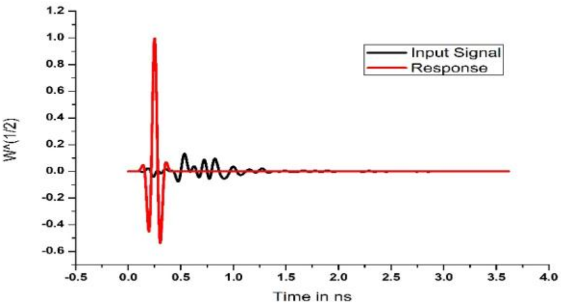

Fig 7 . time domain analysis

the gain parameter corresponding to the operating frequency is presented here in fig 8. peak realize gain of about 4.8 dB & an average gain of 3.4 dB can be observed here. The efficiency of the antenna is also observed in simulation and measurement.

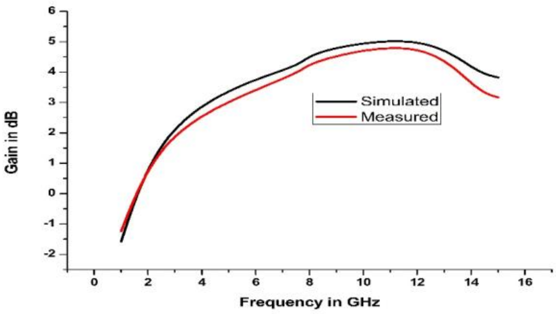

Fig 8. plot for frequency Vs gain

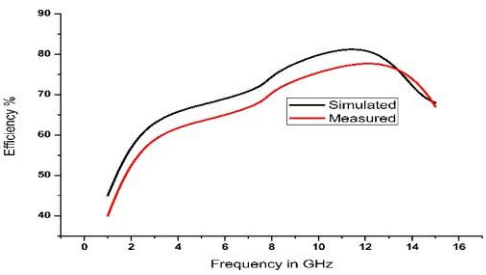

Fig 9. Plot forFrequency Vs Efficiency

Fig 9 shows the overall efficiency of the device in the operating band. It can be observed that an efficiency of more than 80% achieved at 12 GHz in the case of simulation and 76% in the case of measurement.

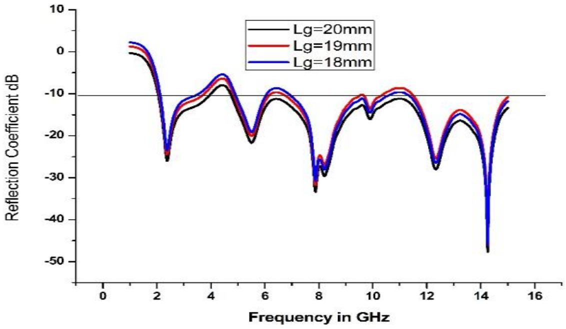

Fig 10. antenna performance with change in ground plane length 'Lg'

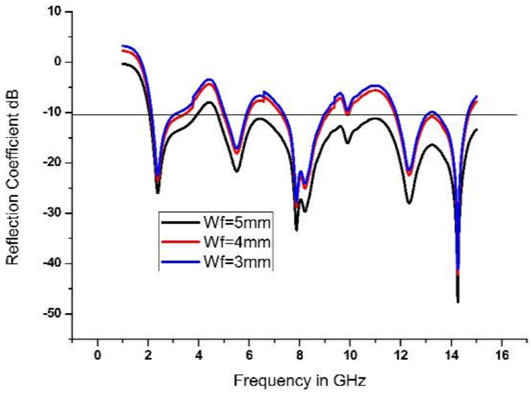

Fig 11. antenna performance with change in feed width(Wf)

The performance analysis of the antenna about the length of the ground and width of the feed line was performed. The optimized dimensions are finalized before fabrication of the antenna model. Fig 10 and 11 shows the parametric analysis results for the optimization of the dimensions 'Lg'=20 mm and 'Wf'=5 mm.

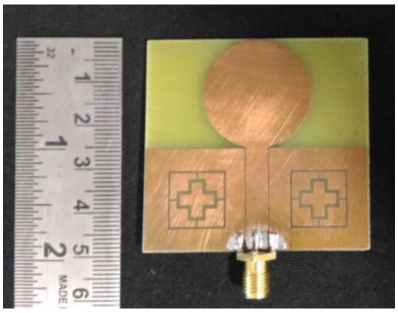

Fig 12. Fabricated Antenna

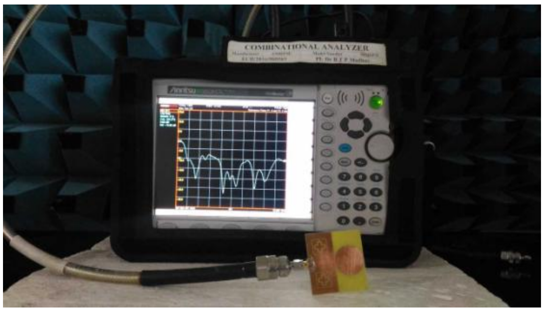

Fig 13. Measurement of S_{11} on VNA

The prototyped antenna on FR4 can be recorded from Fig 12 and the measurement of r.c can be observed from Combinational analyzer in VNA mode.

V. CONCLUSION

A compact dimension of antenna based EBG structured antenna is designed and the analysis is submitted here. The designed antenna operating in the multi band with wide bandwidth in the operating bands, which covers the most of the wireless communication applications. Antenna covering Radar and satellite communication applications at higher operating bands. Antenna meets gain of 3.4 dB and average efficiency of 72%. The observed results are providing excellent matching with the simulation results for validation.

ACKNOWLEDGEMENTS

Authors like to acknowledge ECE department of Chebrolu Engineering College and K L University for their support. We thank DST through ECR/ 2016/ 000569 and EEQ / 2016 / 000604.

REFERENCES

1. Krishnam Naidu Yedla, G.S., Kumar, K.V.V., Rahul, R., , "Fractal aperture EBG ground structured dual band planar slot antenna", International Journal of Applied Engineering Research, ISSN 0973-4562, Volume 9, Number 5, (2014), pp 515-524.
2. VGKM Pisipati, Habibulla Khan, D Ujwala, " Fractal shaped Sierpinski on EBG structured ground plane", Leonardo Electronic Journal of Practices and Technologies, ISSN 1583-1078, Issue 25, (2014), pp 26-35.
3. M S S S Srinivas, T V Ramakrishna, N Bhagyalakshmi, S Madhavi, K Venkateswarulu, "A Novel Compact CPW Fed Slot Antenna with EBG Structure", ARPN Journal of Engineering and Applied Sciences, ISSN 1819-6608, Vol. 10, No. 2, (2015), pp 835-841.
4. D. Naga Vaishnavi, G. Vanaja, G. Jayasree and S. Mounika, Design and analysis of metamaterial antenna with EBG loading, Far East Journal of Electronics and Communications, ISSN: 0973-7006, Vol 14, No 2, (2015), pp 127-136. http://dx.doi.org/10.17654/FJECJun2015_127_136.
5. Mounika Sanikommu, M. N. V. S. Pranoop, K. S. N. Manikanta Chandra Bose and B. Sriram Kumar, CPW Fed Antenna for Wideband Applications based on Tapered Step Ground and EBG Structure, Indian Journal of Science and Technology, ISSN: 0974-6846, Vol 8, Issue 9, (2015), pp 119-127.
6. Yalavarthi Usha Devi, Mulpuri S. S. Rukmini, A Compact Conformal Printed Dipole Antenna for 5G Based Vehicular Communication Applications, Progress in Electromagnetics Research C, Vol. 85, (2018), pp 191–208.
7. B T P Madhav, T Anil Kumar, Design and study of multiband planar wheel-like fractal antenna for vehicular communication applications, Microwave and Optical Technology Letters, Vol 60, (2018), pp 1985-1993, DOI: 10.1002/mop.31290.
8. B T P Madhav, T. Anilkumar, Sarat K. Kotamraju, Transparent and conformal wheel-shaped fractal antenna for vehicular communication applications, AEU-International Journal of Electronics and Communications, ISSN: 1434-8411, Vol 91, (2018), pp 1-10.
9. B Sreekanth Deepak, V S V Prabhakar, Lakshman P, T Anilkumar, M Venkateswararao, Design and Analysis of Hetero Triangle Linked Hybrid Web Fractal Antenna for Wide Band Applications, Progress in Electromagnetics Research C, Vol 83, (2018), pp 147-159.
10. M Purna Kishore, Bandwidth Enhancement of CPW-Fed Elliptical Curved Antenna with Square SRR, International Journal of Intelligent Engineering and Systems, Vol 11, No 2, (2018), pp 68-75.
11. B T P Madhav, M Purna Kishore, Bandwidth enhanced CPW fed elliptical wideband antenna with slotted defected ground structure, International Journal of Engineering and Technology, Vol 7, Issue 2.8, (2018), pp 365-3.