International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Gain Enhancement Modelling of Coplanar Waveguide fed Circular Monopole Antenna with EBG Placement

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

Abstract: ***A circular monopole antenna with coplanar waveguide feeding is designed for wideband applications. Different electromagnetic bandgap structures are placed beneath the antenna ground plane to improve the gain and the radiation efficiency. The depicted model occupies the dimension of 50X50X1.60 mm on FR4 substrate with dielectric constant of 4.3. Aerial 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 2.10 and 10.20 GHz respectively. The final novel antenna design provides good correlation with simulation results.***

Keywords- bandwidth enhancement, coplanar waveguide feeding (CPW), monopole.

I. INTRODUCTION

The microstrip patch antenna with high gain is very significant in the transceiver module for wireless communication system. Microstrip-patch antenna suffers with low radiation, narrow bandwidth, small power handling capability, poor polarization purity, high Q and spurious feed radiation. Continuous efforts are going on with numerous novel methods to improve the performance of the antennas like array designs, substrate removal techniques, frequency selective surfaces (FSS) and electro-magnetic bandgap (EBG) structures etc. The array antenna can improve the gain, but the compactness of the model will be in the problem. Substrate removal techniques can provide small improvement in the gain, but spurious radiations will cause degradation in the bandwidth performance characteristics. Surfaces having frequency selection capability and the electro-magnetic band-gap structures are the best choice to provide good radiation characteristics with development in the gain [1-2]. This article providing the simulation and the experimental validation of different EBG structures on the circular monopole antenna to improve the impedance characteristics and the gain. Researchers put attention 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 decades [2]. Three significant categories of such materials are i) photonic crystals ii) electromagnetic band-gap structures and iii) metamaterials. The EBG structures will allow the electromagnetic waves to pass in different alternative directions other than the conventional guiding and provides stop band characteristics with filtering structures. The EBG structures can solve the problems like surface and leaky waves and provide good radiation efficiency [3-4]. The impedance matching characteristics can be improved with the placement of spiral EBG structures in the antenna design. We know that the period of the EBG lattice should be the half wavelength in general at stop band frequency [5]. In practical cases, there is a problem in the accommodation of large structures of EBG's. Researchers investigated many compact structures of EBG's like spiral like EBG, fork like EBG, UC-PBG and mushroom like ENB to provide compactness in the structure [6].

Revised Manuscript Received on October 30, 2019.
* Correspondence Author
Raghavaraju Aradhyula*, [1]Research Scholar, Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, 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

II. ANTENNA DESIGN

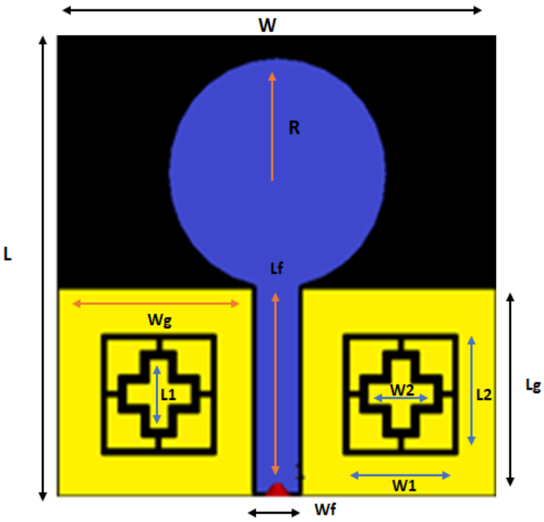
The circular shaped radiating element was taken on the feed line based on the following formula. Here 50-ohm impedance is chosen at the feed point to construct the model. A plus shaped defected ground is etched on the ground plane which acts as the electromagnetic bandgap structure for the current model. The placement of the EBG improving the bandwidth and providing additional resonant frequencies to operate without changing the overall length. The depicted model occupies the dimension of 50X50X1.60 mm on FR4 subbstrate has a value dielectric constant of 4.30.and loss tangent 0.020.

$$R_1 = \frac{F}{\sqrt{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\frac{\pi F}{2h}+1.7726\right]}} \text{-----}(1)$$

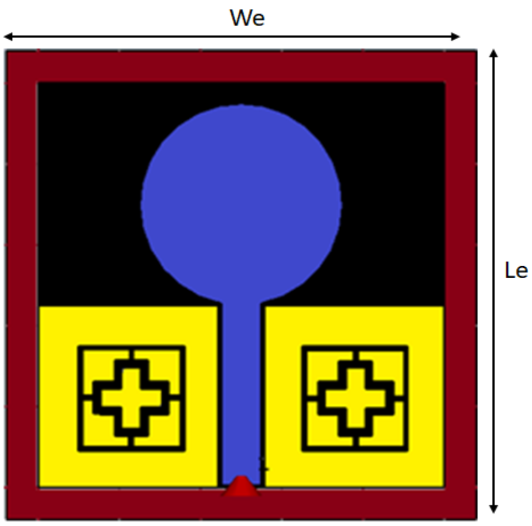
$$F = \frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}} \text{-----} (2)$$

where "f_r" is the resonant-frequency of the antenna, "ε_r" is the relative-permittivity of the dielectric material and "h" is the small thickness of the dielectric layer.

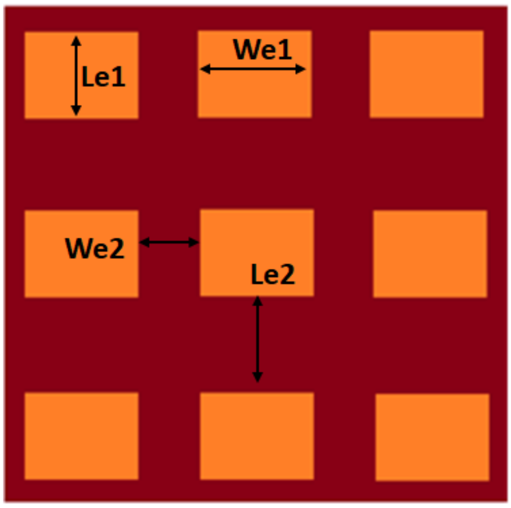
Two types of EBG structures are examined here for gain enhancement. The first structure consisting of square shaped conductive elements separated by equal amount of distance between them on FR4 substrate. This EBG structured design is placed exactly below the antenna structure. Fig 1(a) shows the circular monopole antenna with CPW feeding. Fig 1(b) shows the antenna placed on the EBG structure of dimension 58X58X0.8 mm.



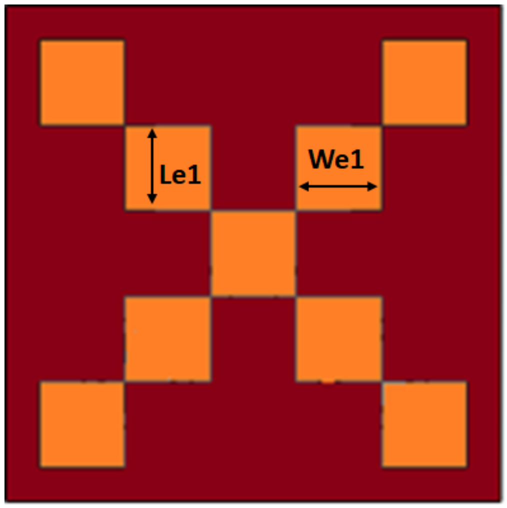
(a)



(b)



(c)



(d)

Fig.1:CPW fed circular monopole EBG antenna, (a) circular monopole, (b) circular monopole with EBG Layers, (c) EBG Layer 1, (d) EBG Layer 2

fig 1(c) presents the EBG layer1, which is placed below the antenna with distance of 0.1 mm. Square shaped elements acting like band-gap structures to notch the operating band of the antenna from 4-8 GHz. fig 1(d) shows the EBG layer2, which is also acting as band gap structure with quad band notching. The dimensions of the antenna are presented in Table 1.

Table1:Parameters Of The Proposed Antenna Model

Parameter	Dimension(mm)
R	12.5
Wf	5
L	50
W	50
h	1.6
Wg	22.2
t	0.2
Lg	20
W1	13
W2	8
L1	13
L2	8
Le1	10
We1	10
Le2	10
We2	10
Le	58
We	58

III. RESULTS & ANALYSIS

In order to provide design criteria the prototyped antenna model is tested with combinational analyzer for reflection coefficient and VSWR parameters and the radiation characteristics are examined in the anechoic chamber,fig2 shows the characteristics of VSWR for the antenna without EBG and with EBG of 2 different structures under the antenna model. Antenna model 1 of without EBG is providing notch band between

International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

4 to 5 GHz with bandwidth of 2 GHz at first resonant band and 10 GHz at second resonant band. The antenna model 2 of EBG layer 1 is notching wideband from 4 to 8 GHz and providing bandwidth of 2 GH at first band and 5 GHz at second band. The antenna model 3 of EBG layer 2 is notching quad band. The notch bands are between 2 to 3 GHz, 4 to 5 GHz, 6 to 8 GHz and 11 to 12 GHz with operating bands at 1.6 GHz (GPS), 3.6 GHz (Wi-Fi), 5.8 GHz (WLAN) and 10.6 GHz (Satellite Applications).

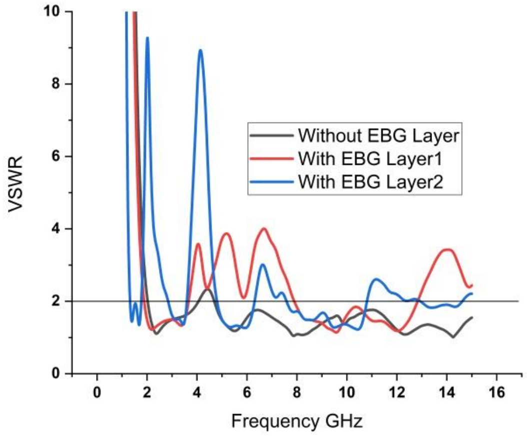


Fig.2: Frequency vs VSWR of without EBG & with EBG layer1 and 2

The designed antenna model dimensions are optimized before the fabrication and presented here in Fig 3 and 4. The width of the feed line dimensions are verified for optimized dimension and found the best suitable value at 5 mm. when dimensions are below 5 mm then antenna is not in the operating range.

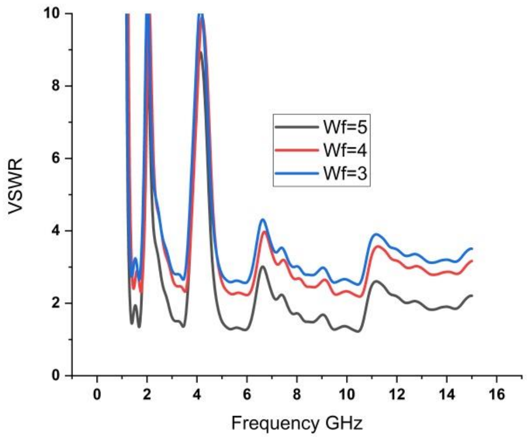


Fig.3: parametric analysis with change in feed width 'Wf'

The radius of the patch is also varied from 10.5 to 12.5 mm and found the best performance characteristics at 12.5 mm. After doing the parametric analysis, we realized that for the radius value of below 12.5 mm there is no resonance in the antenna operating band. The radiation patterns of the antenna in three conditions are presented from Fig 5 to 7. The gain of the antenna can be three-dimensional radiation characteristics here.

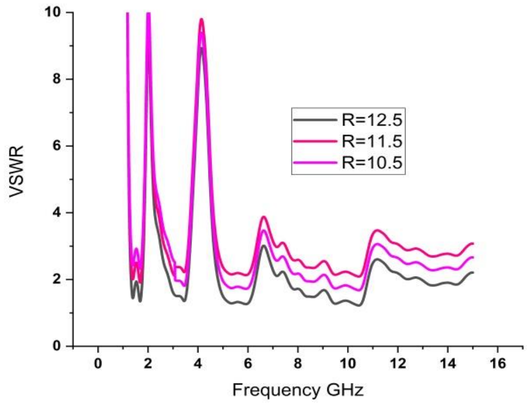
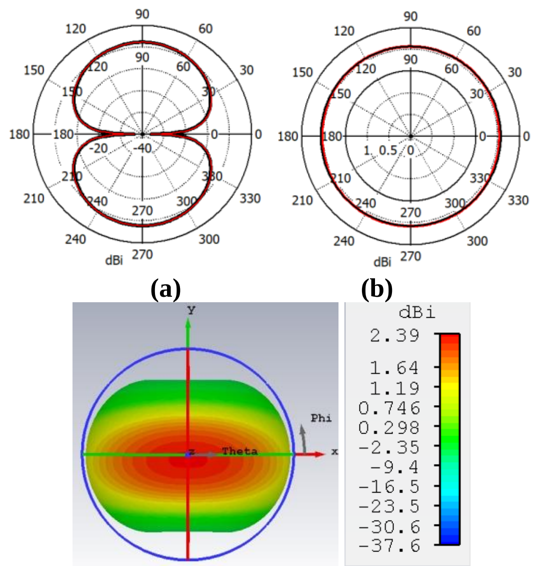


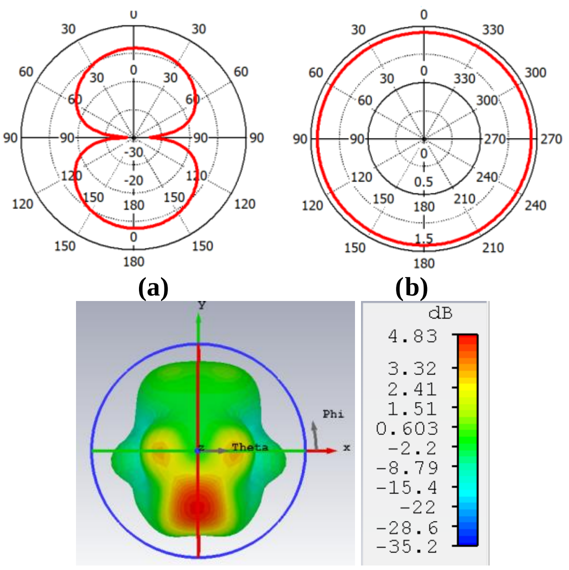
Fig.4: Parametric analysis with change in radius of the patch 'R'



(a) (b)

(c)

Fig.5: Radiation pattern at 2.1 GHz for without EBG, (a) E-Plane, (b) H-Plane, (c) 3D-Pattern

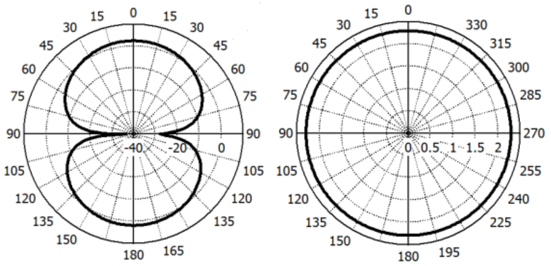


(a) (b)

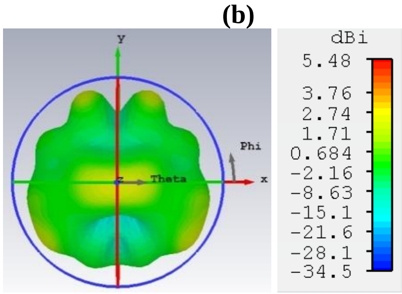
(c)

Fig. 6: Radiation Pattern at 2.1 for EBG Layer1,

(a) E-Plane, (b) H-Plane, (c) 3D-Pattern



(a) **(b)**

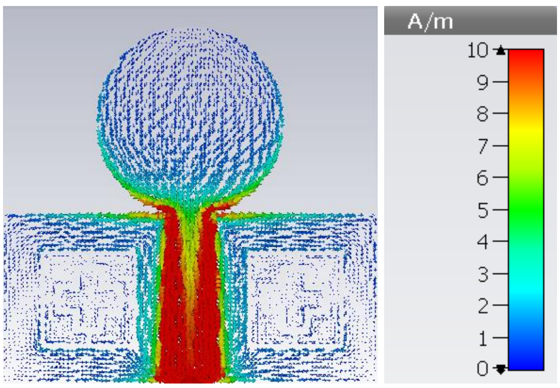


(c)

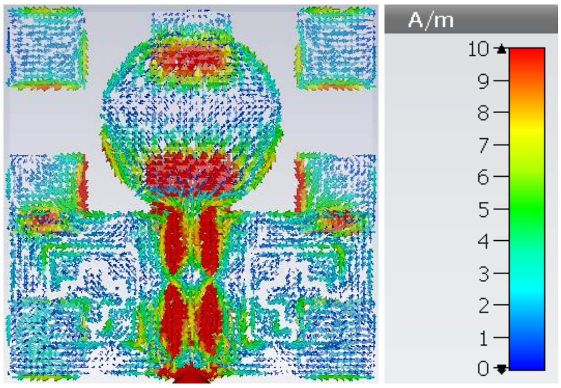
Fig.7:Radiation pattern at 1.6 GHz for EBG Layer2, (a) E-Plane, (b) H-Plane, (c) 3D-Pattern

The radiation characteristics are analyzed in anechoic chamber with turn table mechanism setup. The designed antenna without EBG is providing peak realized gain of 2.39 dB with monopole like pattern in E-plane and quasi omni directional in H-plane. The antenna model with EBG layer 1 providing the peak gain of 4.83 dB and antenna model with EBG layer 2 providing the peak gain of 5.83 dB as shown in Fig 6(c) and 7(c).

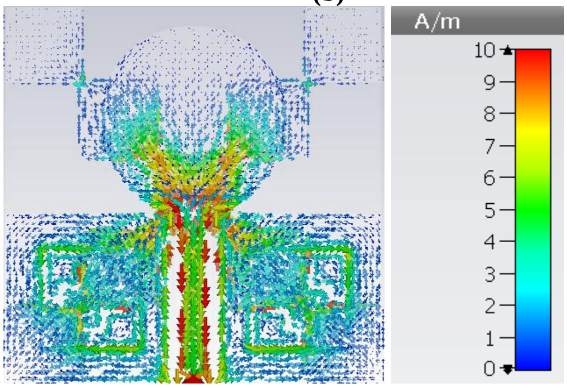
Fig.8: Radiation Pattern Measurement In The Anechoic Chamber



(a)



(b)



(c)

Fig.9: Surface current distribution of the antenna, (a) Without EBG, (b) With -EBG layer1, (c) With- EBG layer2

The surface current distribution of the antenna model with EBG and without EBG are presented in Fig9 The current density is focused at feed line in the first case, but in the EBG based cases the current is at lower and the upper parts of the radiating element also. The gain characteristics of the antenna with and without EBG is presented in fig 10. Here we can observe the peak realized gain and the average gain over the operating bands and the improvement in the gain parameter with the placement of EBG structures.

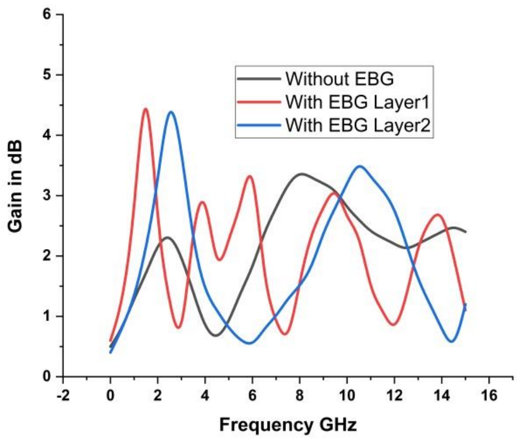


Fig.10: Frequency Vs Gain plot

Retrieval Number F8329088619/2019©BEIESP
DOI: 10.35940/ijeat.F8329.088619
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

The prototyped antenna of circular monopole with plus shaped defected ground on FR4 substrate can be observed from fig 11.

The measurement of refflection coefficiient for the designed antenna on aniritsu combinational analyzer is presented in Fig 12. The designed electromagnetic band gap structures of layer 1 with square shaped conductive structures can be observed from Fig 13. To prepare this layer, we have used conductive copper tapes on the 0.8 mm thickness substrate.

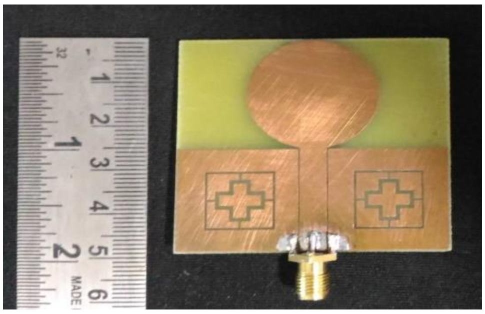


Fig.11: Fabricated Antenna without EBG

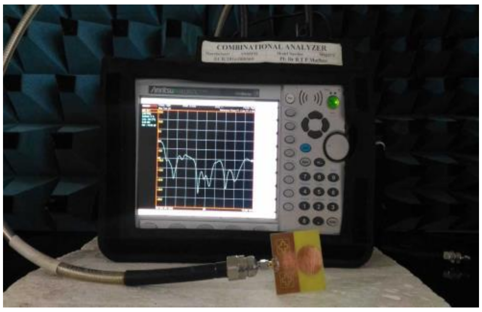


Fig.12: Measurement of S_{11} on VNA

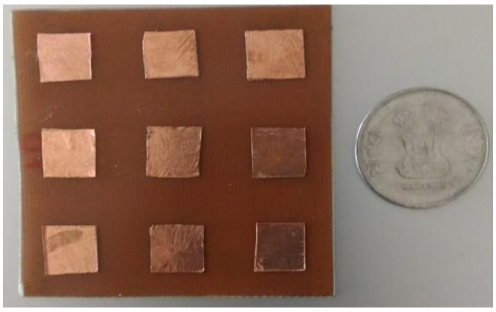


Fig.13: Prototyped EBG Layer 1

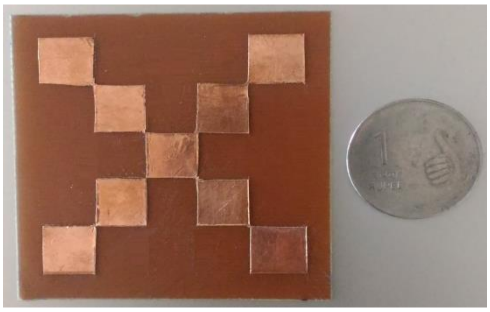


Fig.14: Prototyped EBG Layer 2

Another EBG structure of cross shaped conductive layer is presented in Fig 14. These two structures are placed beneath the antenna in two cases and examined the bandwidth and the gain. The measured radiation pattern and the gain are presented in Fig.7 and Fig.10. The placement of EBG structures below the antenna for measurement are presented in Fig 15 and 16.

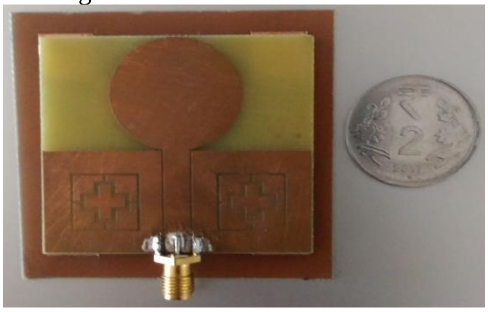


Fig.15: Antenna with EBG Layer 1

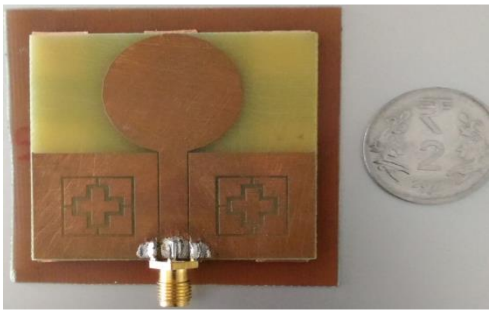


Fig.16: Antenna with EBG Layer 2

The evidence of gain improvement with the placement of ebg structures is presented in this article. The measured results are providing good matching with the simulation results obtained from the CST microwave studio.

IV. CONCLUSIONS

In this paper the design and analysis of circular monopole antenna with plus shaped defected ground structure discussed. Square shaped electromagnetic band-gap structured elements are placed beneath the designed antenna to improve the gain of the antenna. Two EBG structures are designed and examined in this work. The first EBG layer 1 providing peak realized gain of 4.830 dB and the second EBG layer 2 providing peak realized gain of 5.480 dB.

ACKNOWLEDGMENT

The authors acknowledge the technical support of ECE department of chebrolu engineering college and K .L University.

REFERENCES

1. McViay, K. and M. Enogheta. (2003), A high impedance photonic surfaces by using Hilbert inclusions IEEE microwave antenna and communication letter, 14(2): 120-122.
2. H.Mossallei and K. Saarabandi. (2006). “Antenna curtail and band-width improvement with reactive high impedance artificial substrate”, “IEEE transactions in antenna and wave propagation”, 42(8): 2402 – 2416.
3. Lii, Y., G. Foan, G. Cheen, K. she, and Y. Hong. (2003). “An improved compact electromagnetic-bandgap model and its applications in WiMax”, “IEEE transactions on radar microwave signals and energy applications”, 26: 283-290.
4. Zhoeg, W.-A., B.-S. Bin, Z.-H. , and M.-D. Yoan. (2015). “a novel design characteristics and applications of spiral electro-magnetic wide bandgap structure”, “journal of high electroband-magnetic signals and applications” ,22(3):319-323.

5. S.-R. Kiom, G.-Y. Lee, T. U. Nouyen, and K.-J. Jong. (2013). Performance improvement of MIMO antenna with 1D EBG ground structures for wideband application. IEEE antennas and wireless Pro. let12: 168–1571
6. N. V.G Biimal, Vijay Sharma, Ankita T, Prashant D, "Rectangular Microstrip Patch Antenna design with Pentagonal Rings Shaped Metamaterial Cover," 2012 International Conference on Comm. Systems and Network Technologies, 2012.
7. W. T. Y. Z.K. Z. Dafalla, A. M. A Rahman, and S. T. Shudakar, "Design of a Rectangular Microstrip Patch Antenna at 1 GHz," RF and Microwave Conference, 2014.
8. A. S. Bimal G, Rahul Dev, "Design of Double-F Metamaterial Structure for Enhancing Bandwidth of Patch Antenna with Negative μ and y," International Conference on Comm Systems and Network Technologies, 2012.
9. M. K. A. R. a. T. M. H. A. Masjid, "Left Handed Metamaterial Design for Microstrip Antenna for WiLAN Application," IEEE International RF and Microwave Conference Proceedings, 2008.
10. M. L. S. Tretyakov, "Contemporary notes on design and analysis metamaterials," IET Microwaves, Antenna & Propagation, vol. 1, pp. 3-11, 2007.
11. A. O. Ahmad A. Sulaiman, Mohd H. Gusoh, N. H. Baba, Robi'atun A. Awang, Mohd F. Ain, "Small Patch Antenna on Omega Structure Metamaterial," European Journal of Scientific Research, vol. 43, pp. 527-537, 2010