ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

*International Journal of Advanced Research in Computer and Communication Engineering*
*Vol. 2, Issue 4, April 2013*

# Design and Analysis of Monopole Antenna with two layered EBGS at One side

J. Doondi Kumar[1], D.Sushma[1], J. Tagoor Babu[2], S. Mallikharjuna Rao[3],B.Santhi kiran[3]

M.Tech student, Assistant Professor, ECE, LBRCE, Vijayawada, India [1]

B.Tech student, ECE, GMRIT, Rajam, India [2]

Assistant professor, ECE, ALIET, Vijayawada, India [3]

**Abstract**: EBG structures are drawing lot of interest in electromagnetic and antenna research these are compact in size. So the idea to use this EBG structures in patch antennas is good and in this paper we illustrate the Two layered EBG usage on monopole antenna. This EBG are designed and analysed in many shapes for different purposes. This structures will manipulate the antenna parameters and alter them according to the designer to improve the conventional antenna parameters to reach the requirements of new technologies. The EBG have periodic metal plates on metal pin vias. The gap between the plates have capacitance and metal pin exhibits inductance these C and L together makes EBG's as high impedance electromagnetic surfaces. This EBG presence will reduce the surface wave propagation and enhance the antenna general parameters.

**Keywords**: HIS, Surface wave, Rectangular Patch, Energy band gap structures.

## I. INTRODUCTION

Mostly the monopole antennas are widely used in mobile and wireless communications because of their easy compatibility but this monopole antenna suffer due to their low BW. And lose of radiating energy which will affect its performance. So we use this EBG structures to improvise its parameters and it is explained in ref[1]. Now here we use two layered EBG structure for further improvement the designed model is simulated by using HFSS software and the simulated results are presented.

## II. DESIGN CONSIDERATIONS

The monopole antenna which is of height and operating at 2.4312GHz frequency is taken for analysis and the conventional monopole antenna along with 2-layered EBG design is shown in below figure [1].

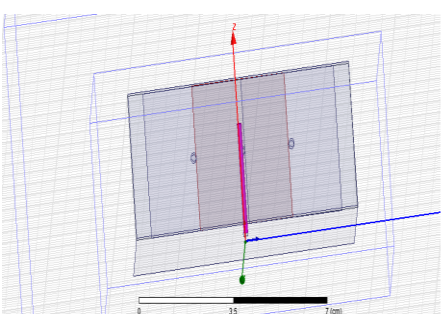

Fig 1. Designed antenna

A Two Layer EBG

The Two layers EBG constructed from the single layered EBG structure. First the EBG consists of a metallic plate which is base on it the metal pins are positioned at equal distance and on top of this pins the metallic patches are placed this is like one layer the another set of pins are placed between the gaps of first setup and with less height and again the metal plates are placed the first layer metal plates and the second layer metal plates will overlap. And the equivalent representation of this 2-layered EBG is shown in the figure [2].Here the surface impedance of EBG is depends on circuit parameters like capacitance, inductance and equivalent resistance due to dielectric losses.

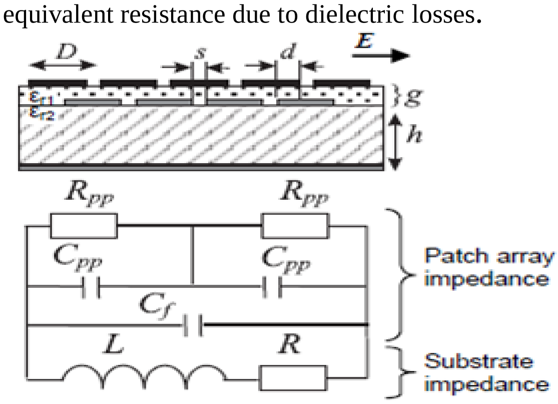


Fig 2: 2- layered EBGS unit cell, its equivalent

The circuit have two parts one is substrate part and another one is array of metal plates. The impedance of this structure

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

*International Journal of Advanced Research in Computer and Communication Engineering*
*Vol. 2, Issue 4, April 2013*

is analysed based on inductance and capacitance. Representing the ground plane with inductance L and series equivalent resistance R develops due to losses in dielectric. The dielectric substrate with a ground plane is considered as a shorted (Practical line of finite length) transmission line section the input

Impedance of transmission line at a distance h.

$$Z(h)= Z_0[ Z_L+Z_0\tanh(\gamma h)]/[ Z_0+ Z_L\tanh(\gamma h)]$$

Where $Z_0 = \sqrt{\mu_0\mu_{r2} /\varepsilon_0 \varepsilon_{r2}}$

$Z_0$ Is the characteristic impedance of transmission line.

$Z_L$ Is load impedance

$\gamma = Jk_0 \sqrt{\mu r_2 \varepsilon r_2}$ is complex propagation constant

$k_0$ is wave number,

$\varepsilon_{r2}$ relative permittivity,

$\mu_{r2}$ relative permeability of substrate medium.

Since load end of transmission line is shorted, the load impedance will be zero.
Then the input impedance will be

$$Z(h)= Z_0[ Z_L+Z_0\tanh(\gamma h)]$$
$$Z(h)= J\sqrt{\mu_0\mu_{r2} /\varepsilon_0\varepsilon_{r2}}\tan(hK_0 \sqrt{\varepsilon_{r2}})$$

Since we take the distance h is very smaller than the wave length $\lambda$, Tailor series for expansion of tangent is used. Grouping real and imaginary parts the substrate input impedance is

$$Z(h)=Jk_0\, h[1+ (hK_0)^2\, \varepsilon_{r2}/3]_{+}\ (hK_0)^3\varepsilon_{r2}\tan\delta_2\ [\ 1/3+2(hK_0)^2\, \varepsilon_{r2}/5]$$

This is equivalent to $Z_{substrate}= JwL +R$ after equating real and imaginary parts we get inductance and resistance. Where $\tan\delta_2$ is loss tangent of substrate.

The input impedance at two arrays of upper and lower patches is determined by parallel plate capacitance $C_{pp}$ with dielectric losses is determined by $R_{pp.}$

$$C_{pp}=(Wd\varepsilon_0\varepsilon_{r1}/g)[1+g/\pi d+g\ln(\pi d/g)/\pi d][1+g/\pi W+g\ln(\pi W/g)/\pi W]$$

$$R_{pp}=g/(w\ \varepsilon_0\varepsilon_{r1}\tan\ \delta_1 A)$$

g is gap between upper and lower patches

A is overlapping area between upper and lower patches

$\tan\delta_1$ is loss tangent of thin dielectric film between upper and lower patches

The fringing capacitance between lower patches is

$$C_f = W\varepsilon_o(1+\varepsilon_r) \cosh^{-1}((2W+g)/g)/\pi$$

Total equivalent capacitance of array of patches is

$$C_t=0.5C_{pp}+ C_f$$

Effective impedance of patch array is

$$Z_{patch}=2R_{pp}/(1+2JWC\ R_{pp})$$

Total input impedance of multi layer High Impedance Surface is

$$Z_{MHIS}= Z_{patch}Z_{substrate}/(Z_{patch}+Z_{substrate})$$

## III. SIMULATION RESULTS

The monopole antenna is initially simulated to get what are results that can occur without using any EBGS and then by using EBG-2 layered structure we try to enhance the simulated results of conventional type. Design and simulation is done by using HFSS software. And comparative results are presented it is shown with the results that 2-layered EBG will enhance antenna parameters further.

A. Return loss

The return loss curve will also explains that the surface waves propagation which effects antenna losses is reduced or suppressed by the EBGS. And the antenna BW also increased the return loss curves vs frequency are shown in figure [3].

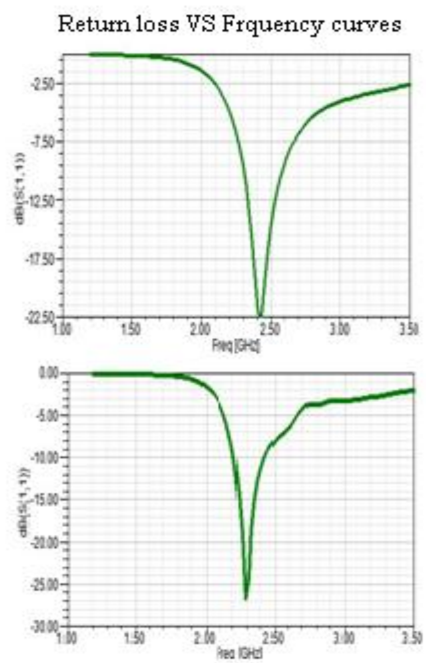


Fig 3: Return loss Vs Freq curves a) only monopole antenna b) monopole antenna with 2-layered EBGS.

By figure [3] we can see that the designed monopole antenna gives return loss of -22.50dB only where as by using 2-layered EBGS it is improved to -27.1dB.

B. Radiation Pattern

Here, we have placed EBGS at one side of the antenna so it is better to represent radiation pattern in Phi direction if we see in top view we can clearly understand how the radiation is enhanced in the opposite direction of EBGS and this is due to EBGS properties to absorb or reflect the radiation form antenna according to their phases. Comparative radiation pattern curves are shown in the below figure [4].

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

*International Journal of Advanced Research in Computer and Communication Engineering*
*Vol. 2, Issue 4, April 2013*

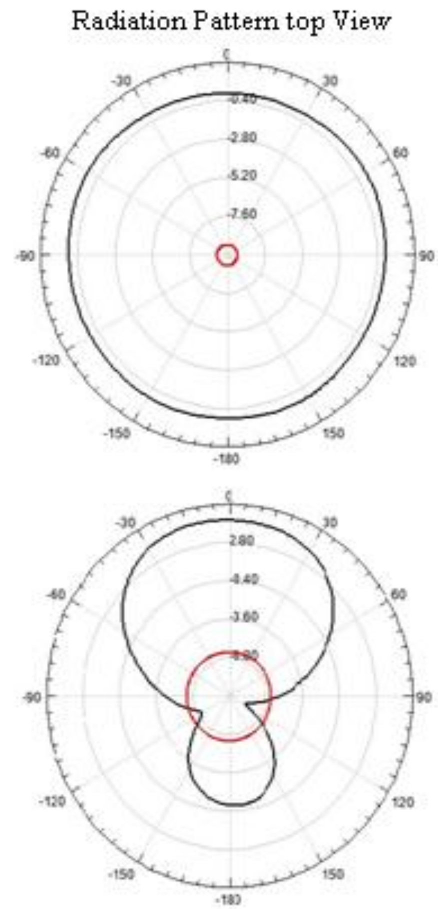


Fig 4: Radiation Pattern a) monopole antenna

b) Monopole antenna With 2- layered EBGS

By the above figure [4] we can say that at first the monopole antenna radiation pattern is Omni directional after placing EBGS it forces most of the energy to propagate in the opposite direction the it reached 0.40 levels to more than 2.80 levels which explains that 2-layered EBGS can vastly enhance or improve the antenna radiation in desired direction.

C. Gain in 3D

It explains how much the gain of the antenna is improved with the help of EBG the comparative results is illustrated in the below figure [5].

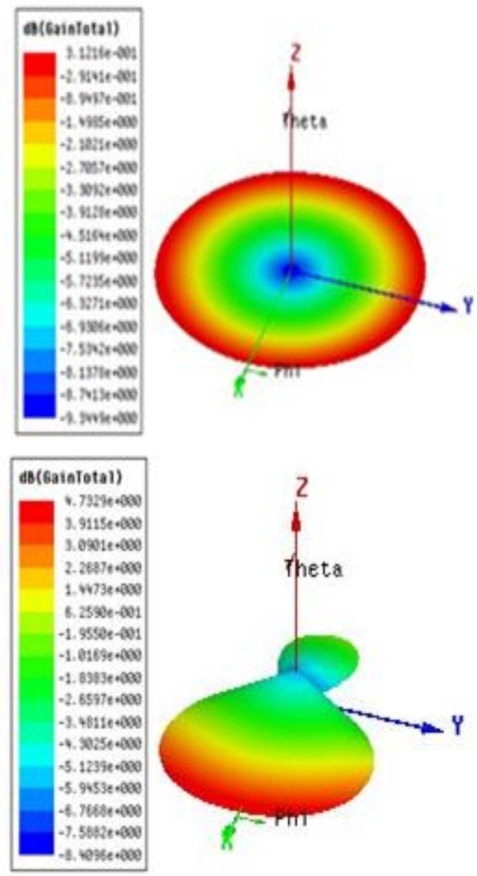


Fig 5: Gain in 3D a) monopole antenna b) monopole antenna with 2-layered EBGS.

Form figure [5]a. We see that the maximum gain in over all directions is 3.121dB. for monopole antenna in the absence of EBGS. But form [5]b we can see that by placing 2-layered EBGS at one side the maximum gain is enhanced to a level 4.732dB.

D. Antenna parameters

The comparison between some other antenna parameters is illustrated in the table [1].

This explains the changes in peak gain, peak directivity, maximum intensity, Radiation efficiency, and front to back ratio.

| Quantity | Value | |
|---|---|---|
| Max U | 0.127149 (W/sr) | 0.453745 (W/sr) |
| Peak Directivity | 1.72433 | 5.68946 |
| Peak Gain | 1.74092 | 5.72511 |
| Peak Realized Gain | 1.59784 | 5.70207 |
| Radiated Power | 0.926642 (W) | 1.00222 (W) |

*International Journal of Advanced Research in Computer and Communication Engineering*
*Vol. 2, Issue 4, April 2013*

| | | |
|---|---|---|
| Accepted Power | 0.917812 (W) | 0.995975 (W) |
| Incident Power | 1 (W) | 1 (W) |
| Radiation Efficiency | 1.00962 | 1.00627 |
| Front to Back Ratio | 1.97379 | 4.49451 |

Table [1] : Antenna parameters

## IV. CONCLUSION

The EBGS will enhances the antenna gain, BW, Return loss, and improves radiation in desired direction. The EBGS with two layered with proper adjustments will improves them further. Because of their compactness and easy of manufacturing they could be utilized in improved communication applications.

## REFERENCES

[1] [10] C. Balanis, Antenna theory, Analysis, and Design 2nd ed., John Wiley and sons, New York (1997)
[2] Yang, F. and Y. Rahmat-Samii, “Reflection phase characterizations of the EBG ground plane for low profile wire antenna applications,” *IEEE Trans. Antennas Propag.*, Vol. 51, No. 10, 2691– 2703, 2003.
[3] Feresidis, A. P., S. Wang, and J. C. Vardaxoglou, “Artificial magnetic conductor surfaces and their application to low-profile -gain planar antennas,” *IEEE Trans. Antennas Propag.*, Vol. 53, No. 1, 209–215, 2005.
[4] P. S. Huang, C. S. Chiang, C. P. Chang, and T. M. Tu, "Robust spatial watermarking technique for colour images via direct saturation adjustment," Vision, Image and Signal Processing, IEE Proceedings -, vol. 152, pp. 561-574, 2005.
[5] Sievenpiper, D., “High-impedance electromagnetic surfaces,” Ph.D. Thesis, University of California, Los Angeles, 1999.
[6] J. Doondi kumar , “Analysis of Monopole Antenna by Placing High Impedance Absorber Surface at one Side” /Volume-2Number-1PP-317-321.pdf
[7] J. Doondi kumar , “Design and Analysis of C0-axial Feed Rectangular Patch Antenna on High Impedance Surface” /Volume-2Number-1PP-405-410.pdf
[8] D. Sievenpiper, E. Yablonovitch, U.S. provisional patent application, serial number 60/079953, filed on March 30,1998.
[9] Hashmi RM, Siddiqui AM, Jabeen M, Shehzad K, Abbas SM and Alimgeer KS, “Design and Experimental Analysis of High Performance Microstrip Antenna”, International Journal of Computer and Network Security, vol. 1, no. 3, (2009) December.
[10] Sievenpiper, D. F., \High-impedance electromagnetic surfaces," Doctorate thesis, University of California, 1999.
[11] Sievenpiper, D, F., \Review of theory fabrication and applications of HIS ground planes," Metamaterials: Physics and Engineering, Explorations, Chap. 11, 287{311, Edited by N. En- gheta and R. Ziolkowski, Wiley Interscience, 2006
[12] Yang, F. and Y. Rahmat-Samii, “Step-like structure and EBG structure to improve the performance of patch antennas on high dielectric
[13] substrate,” Proc. IEEE AP-S Dig., Vol. 2, 482–485, July 2001.
[14] C. Balanis, Antenna theory, Analysis, and Design 2nd ed., John Wiley and sons, New York (1997)

## BIOGRAPHY

**J.Doondi Kumar**, was born in A.P, india in 1989. completed B.Tech in 2011 from Lakkireddy Bali Reddy college of Engineering affiliated to JNTU Kakinada. And worked as Assistant professor in Sri vani educational society. Presently he is pursuing M.Tech in LBRCE. He has published international journals in antenna field.

**D. Sushma,** was born in AP, india in 1988. Completed M.Tech in LBRCE. And presently working as Assistant professor in LBRCE.

**J. Tagoor babu,** under graduate [B. Tech, ECE] student of GMRIT, Rajam.

**S. Mallikharjuna Rao**, got M.Tech degree from S.R.K.R engineering college on Communication systems, and presently working as Assistant professor in ALIET.

**B. Santhi Kiran**, got M.Tech degree from Gudlavalleru engineering college on Embedded systems, and presently working as Assistant professor in ALIET.