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# DESIGN ANALYSIS OF MICRO-STRIP PATCH ANTENNA USING CROSS AND U-SHAPE SLOTTED EBG STRUCTURE FOR UWB

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## Abstract

***This paper presents Micro strip antenna design with novel shapes of 2D-electromagnetic band-gap structure (2D-EBG). The two novel shapes of 2D-EBG presented are U-shape and cross shape slots. Simulated results show improved performance of the antenna with or without EBG slots of different shapes on the substrate of antenna. This ensures that bandwidth increases greatly while size is nearly unaffected. The designed patch antenna has a size of 13.3 mm * 8.9 mm. Antenna operation in wide band is obtained in the range of 5 to 8.5 GHz which is advantageous for transmitting information over a larger bandwidth. Wideband antennas find its applications in mobile sensors, data collection, precision locating and tracking applications.***

**Keywords:** Patch antenna, Cross slot, U slot, Electromagnetic band gap (EBG), Wideband antenna

## 1. INTRODUCTION

A micro strip patch antenna is widely used in compact and portable communication devices due to its small size, thin profile configurations, conformity and low cost. In spite of these remarkable advantages, the patch suffers some serious drawbacks like low bandwidth (due to small size). Bandwidth can be increased but at the cost of size of the patch, making it large and bulky [15]. To overcome this problem, a multiple-layer dielectric substrate has been used to improve bandwidth [1]. In this paper bandwidth improvement and reduction in losses has been achieved by EBG design. There are different types of losses in antenna, one of which is surface wave loss due to the permittivity of the material and thickness of the substrate [8]. Due to excitation of surface waves, patch antenna also suffers from reduced gain and efficiency.

In this paper, parts of the substrate surrounding the patch have been strategically removed to suppress surface wave losses, and thereby increase gain and bandwidth range [9]. It is known that for a particular resonant frequency, the bandwidth increases with increase in size of patch antenna, with high dielectric constant [10, 11]. The patch antenna of low dielectric has a moderate bandwidth but large size. Two substrates have been combined so as to include the quality of both high and low dielectric, i.e., high bandwidth and low patch size respectively [9]. A micro strip patch antenna implemented on substrate having dielectric constant ($\varepsilon_r$ = 4.65) has high bandwidth with a small sized patch and at a difference of top 1.6 another substrate is placed having dielectric constant ($\varepsilon_r$= 2.45). In this paper, a multiple-layer substrate is made by sandwiching layers so as to reduce the antenna size as much as possible. The method to improve the gain is to reduce the loss of the micro strip antenna. The gain of the antenna can be increased by reducing the loss due to surface wave propagation. One method to do so is by replacing the substrate of patch with low dielectric values or with air ($\varepsilon_r$ = 1). Periodic structures of electromagnetic band-gap (EBG) can be used to block the surface waves from propagating in a certain band of frequency. A common method to generate EBG structures is to drill holes in substrate to synthesize a lower dielectric constant substrate. However, in this paper, a simpler version of EBG structure approach has been used by partially removing the substrate surrounding the patch by drilling periodic holes of different shapes. Removing the substrate partially stops the propagation of surface wave in the substrate, which reduces the power coupled in backward direction and enhances the forward coupled power. As a result the gain increases. Two different shapes of 2D-EBG as U- Shaped and Cross-Shaped etched on the substrate are designed simulated and measured.

## 2. COMPARISON OF ANTENNA DESIGN

### 2.1 Antenna design using EBG Structure:

A simple patch Antenna of size 8.9*13.3 has been studied , simulated and various point of coaxial feed position were changed and it was observed that the best result is obtained when the feed position at either upper left or right extreme corner of the patch. The Fig. shown below is a Patch of Lp*Wp of 8.9*13.3mm. The result return loss (S11) is of -10 at a frequency of 8.45 GHz, as shown in Fig 2. The radiation pattern was also in one direction with no back lobe & a gain obtained is of 3.57 GHz as shown in Fig.3.

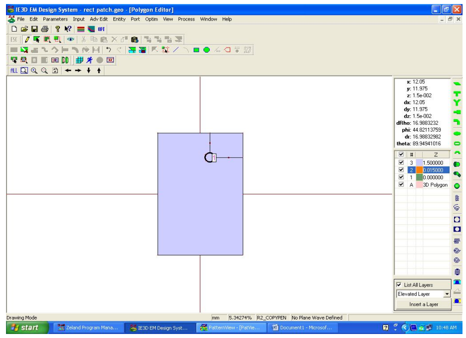

**Figure 1** Simple Patch Antenna with feed

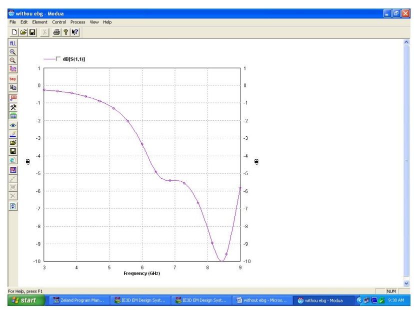

**Figure 2** Return loss ($S_{11}$) of antenna without EBG structure

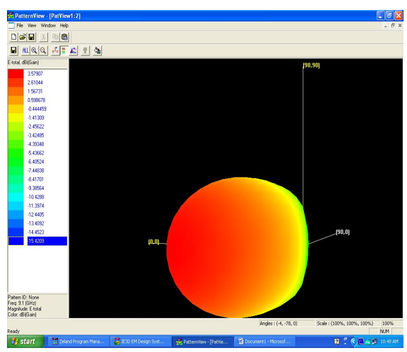

**Figure 3** Radiation pattern of antenna without EBG structure

To eliminate the effect of surface wave Electromagnetic band gap (EBG) structures were used. Various shapes of EBG can be used like circular, rectangular, star and H-shape. Here in this paper micro strip patch antenna using cross shaped and U-shaped EBG structure has been studied.

### 2.2 Antenna design using U-Shaped EBG Structure:

An EBG structure of U slot was made at the ground plane of the patch antenna. This EBG structure consists of two layers and the radiating element printed on the upper surface of the top layer. The bottom layer carries an array of U-Shape slots. The patch antenna with EBG structure is shown in Fig. 4.

A substrate of dimension (Lsub*Wsub) of 22*22 mm, thickness (h) of 1.5 mm, dielectric constant of 4.65 and loss tangent of 0.02 was taken for making a ground plane. U-shapes of dimensions 3*3 mm slot were cut on the ground plane, width of U slot was 0.5 mm length of 4.5mm and distance between two slots is 3.5 mm vertically and 2 mm horizontally. A patch is placed on the dielectric substrate at a height of 1.6 mm having width of patch 13.3 mm and length of patch 8.9 mm. The layout of the structure is as shown in figure 4. The feed to the patch is applied at the centre of the patch.

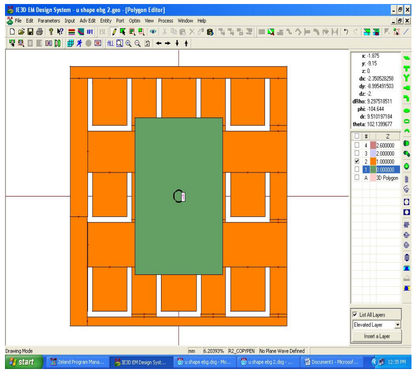

**Figure 4** Patch Antenna with U-shaped EBG slots

Resonance frequency of the patch occurs at 6.49 GHz with band width in the range of 6 to 6.85 GHz. The return loss was -20 dB as shown in figure 5. Radiation pattern of this EBG structure is different as it has a back lobe as shown in figure 6. This antenna design does not have a wide band width and the back lobe is also present in the radiation pattern.

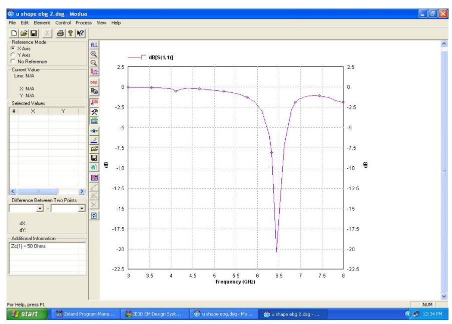

**Figure 5** Return loss ($S_{11}$) of antenna with U slot EBG structure

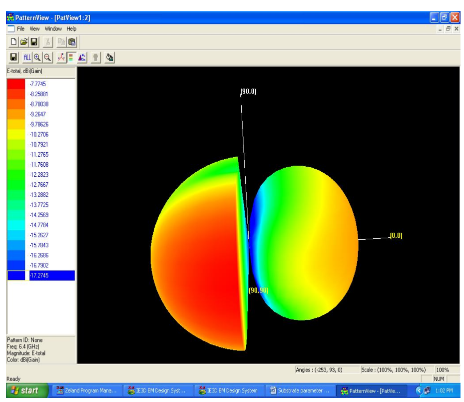

**Figure 6** Radiation pattern of antenna with U slot EBG structure

### 2.3 Antenna design using cross shape EBG Structure:

The schematic diagram of the coaxial probe fed cross shaped EBG ground plane antenna is shown in Fig. 7. Here again two layers of substrate and one radiating element printed on the upper surface of the top layer were taken. On the ground plane cross slots of dimension 7*7 mm were cut. The feed applied at the (2, -5). The light purple parts represent the metallic periodic structure and the maroon part is the radiator. The antenna designed on a dielectric substrate with dimension of (22×22 mm). The EBG structure has cross slots of 2×1 mm unit cells; each cross slot is at a distance of 1mm. The dielectric substrate has a thickness of 1.6 mm, relative permittivity ($\varepsilon_1$) of 4.65 and loss tangent (δ) of 0.02. A rectangular radiating patch of (Lp*Wp) of dimensions 8.9*13.3 mm is printed on the top layer. The return loss of this antenna was between -35 to -40 dB over a frequency range of 6.6 to 7.5 GHz, making it a wide band application antenna. The radiation pattern of the antenna obtained is unidirectional and better Gain is obtained as compared to earlier designed antennas. This antenna finds its application in wide band operations. The return loss is shown in figure 8 and radiation pattern is shown in figure 9.

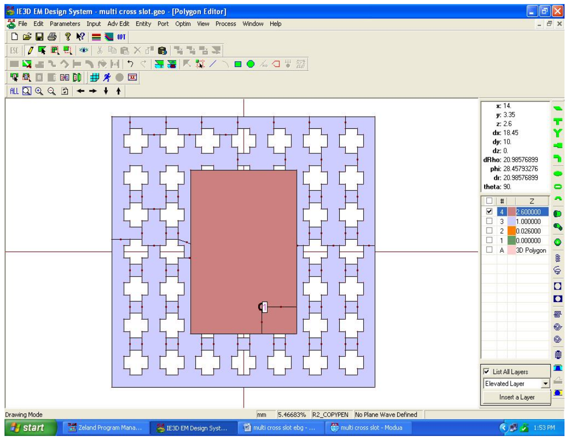


**Figure 7** Patch Antenna using cross shaped EBG slots

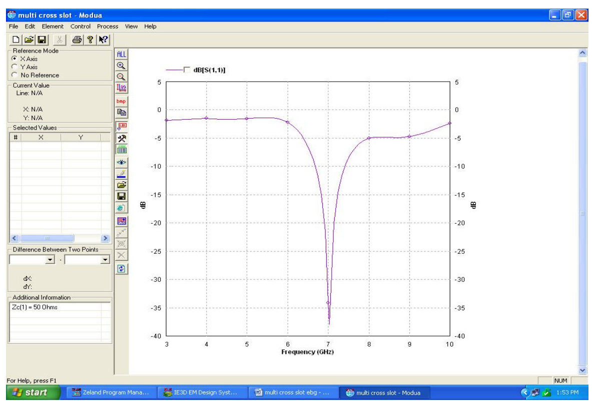


**Figure 8** Return losses ($S_{11}$) of antenna with cross slot EBG structure

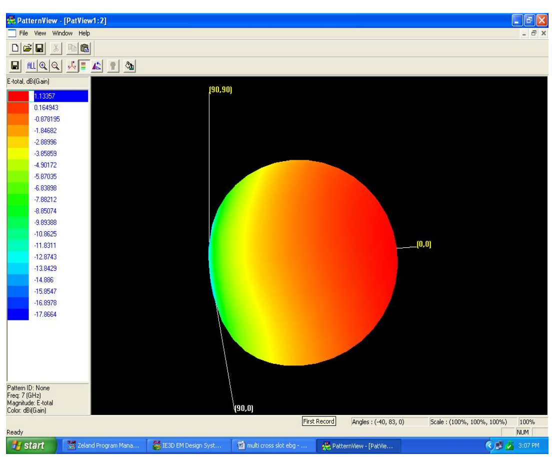


**Figure 9** Radiation pattern of antenna with cross slot EBG structure

## 3. RESULT AND DISCUSSION

It is observed after simulation, on the ZELAND IE3D software that a better result is obtained using cross slotted EBG structures for wideband antenna operation. The ground EBG structure not only reduces the losses but also help in making a wide band antenna. As without EBG, we observed that the return losses were large and results obtained were at high frequency range. It was observed that using cross slotted EBG on micro strip patch antenna return loss was in the range of -35 to -40dB, while by using U-shaped slot return loss was -12dB. The 3D radiation pattern shows that positive gain is obtained using the cross slotted EBG structure; there was no back lobe in any case cross shaped EBG structure. It is also observed from the simulation result that the dislocation of the probe feed to patch highly effects the simulation results of the micro strip patch antenna like return losses but does not effect the directivity of the antenna

### 3.1 Result Comparison

**Table 1**: Result comparison

| Shape of 2D-EBG | Reflection Coefficient (db) | Band width (%) | F0 (GHz) | Feed position |
|---|---|---|---|---|
| Without EBG | -10 | 4.7 | 8.5 | (1, 4.5) |
| U-shape EBG | -20 | 4.4684 | 6.49 | (0, 0) |
| 7*7 Cross shape EBG | -35 to -40 | 10.7143 | 7 | (2, -5) |

## 4. CONCLUSIONS

Here simple patch is compared with U and cross slotted EBG structures of specific dimensions. Further design of EBG structure like H, V or star can also be compared. More over the dimensions of slots as well as the position of Coaxial feed can also be changed for further optimization to get the best results. Here we have seen that EBG structures had improved return loss, gain, radiation pattern and beam shaping of micro strip antenna. They not only assist in reducing surface waves, but also make the antenna a wide band antenna. This wide band antenna can be used for sensor network and tracking of objects accurately.

## References

**[1.]** S. M. Metev and V. P. Veiko, *Laser Assisted Microtechnology*, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.

**[2.]** J. Breckling, Ed., *The Analysis of Directional Time Series: Applications to Wind Speed and Direction*, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.

**[3.]** S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," *IJASTRE Electron Device Lett.*, vol. 20, pp. 569–571, Nov. 1999.

**[4.]** M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, "High resolution fiber distributed measurements with coherent OFDR," in *Proc. ECOC'00*, 2000, paper 11.3.4, p. 109.

**[5.]** R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, "High-speed digital-to-RF converter," U.S. Patent 5 668 842, Sept. 16, 1997.

**[6.]** *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification*, IJASTRE Std. 802.11, 1997

**[7.]** Kim, J., H. Kim, and K. Chun, *"Performance enhancements of a micro strip antenna with multiple layer substrates,"* International Symposium on Signals, Systems and Electronics 2007.

**[8.]** Fan Yang and Yahya Rahmat-Samii, *"Design of Low Profiled Antennas Using PBG Surfaces"*, 2000 Annual Research Review, UCLA Electrical Engineering Department, Los Angeles, September 21-22, 2000.

**[9.]** Qu, D., L. Shafai, and A. Foroozesh, *"Improving micro strip patch antenna performance using EBG substrates,"* IEEE Proc. Microwave, Antennas Propagation.

**[10.]** Yeap, S. B. and Z. N. Chen, *"Micro strip patch antennas with enhanced gain by partial substrate removal,"* IEEE Transactions on Antennas and Propagation, Sept. 2010.

**[11.]** Zaker, R., C. Ghobadi, and J. Nourinia, "Novel modified UWB planar monopole antenna with variable frequency band-notch function," IEEE Antenna and Wireless Propagation.

**[12.]** Yoshimura, Y. *"A micro strip line slot antenna"* .IEEE Trans. Microwave Theory Tech.

**[13.]** Vinoy, K. J., "Fractal shaped antenna elements for wide and multi-band wireless applications," Thesis, Pennsylvania, Aug. 2002.
**[14.]** R. Movahedinia, M.N. Azoreans*," Ultra-wideband band-notched printed monopole antenna"*, IET Microwave Antennas Propag. 2010.
**[15.]** Federal Communications Commission, Washington, DC*, "FCC report and order on ultra wideband technology"*, 2002.
**[16.]** G. Wang, J. Siden, P. Jonsson, and T. Olsson*, "RFID Antenna Investigation,"* Rapport series FSCN Mid Sweden University, 2002.
**[17.]** Jakson, D. R., J. T. Williams, A. K. Bhattacharayya, R. L. Smith, J. Buchleit, and S. A. Long*, "Micro strip patch designs that do not excite surface waves,"* IEEE Transactions on Antennas and Propagation, Aug. 1993.
**[18.]** Yeap, S. B. and Z. N. Chen*, "Microstrip patch antennas with enhanced gain by partial substrate removal,"* IEEE Transactions on Antennas and Propagation, Sept. 2010.
**[19.]** Gonzalo, R., P. de Maagt, and M. Sorolla*, "Enhanced patch-antenna performance by suppressing surface waves using photonic-band gap substrates,"* IEEE Transactions on Microwave Theory and Techniques, Nov. 1999
**[20.]** Agi, K., M. Mojahedi, B. Minhas, E. Schamilogu, and K. J. Malloy*, "The effects of an electro-magnetic crystal substrate on a microstrip patch antenna,"* IEEE Transactions on Antennas and Propagation, Apr. 2002.
**[21.]** F. Yang and Y. Rahmat-Samii, "Micro strip antennas integrated with electromagnetic band-gap (EBG) structures: A low mutual coupling design for array applications," IEEE Trans. Antennas Propag, Oct. 2003.
**[22.]** T. Huynh and K. F. Lee*, " Single-layer single-patch wideband micro strip antenna,"* Electron. Letts, vol. 31, no. 16, pp. 1310–1312, Aug. 3, 1995.
**[23.]** D. N. Elsheakh, Student Member, IEEE, H. A. Elsadek, E. A. Abdallah, H. Elhenawy, and M. F. Iskander, Member, IEEE*, "Enhancement of Microstrip Monopole Antenna Bandwidth by using ebg structures"*, IEEE antennas and wireless propagation letters, vol. 8, 2009.
**[24.]** Llombart, N., A. Neto, G. Gerini, and P. de Maagt*, "Planar circularly symmetric EBG structures for reducing surface waves in printed antennas,"* IEEE Transactions on Antennas and Propagation, Oct. 2005.
**[25.]** Gauthier, G. P., A. Courtay, and G. H. Rebeiz*, "Micro strip antennas on synthesized low dielectric-constant substrate,"* IEEE Transactions on Microwave Theory and Techniques, Aug. 1997.
**[26.]** Colburn, J. S. and Y. Rahmat-Sammii*, "Patch antennas on externally perforated high dielectric constant substrate,"* IEEE Transactions on Microwave Theory and Techniques, Dec. 1999.

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