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2x2 Microstrip Antenna Array Design for Bandwidth Enhancement Using four arm Spiral Electromagnetic Band Gap (EBG) Structure

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***Abstract*- The paper provides a detailed study of how to design a microstrip patch antenna array using electromagnetic band gap structured substrate. First an antenna array is designed with conventional ground plane. After this a spiral four arm ground plane is designed with 6 mm width of strip. For the simulation work IE3D V12.9 software of ZELAND software Inc. is used. And all simulated results are shown by the graph. By using the four arm spiral electromagnetic band gap structure, the bandwidth with respect to conventional patch antenna array is enhanced by approximate 150%. It is 0.67GHz in conventional ground plane and 0.93GHz in four arm spiral EBG structure with the width of 6mm and practically the bandwidth measured by antenna array with conventional ground plane is 0.25 GHz and 2 GHz by antenna array with 6 mm wide four arm spiral ground plane i.e. the bandwidth measure is enhanced by 800% by using the spiral ground plane.**

***Index Terms*- Microstrip Patch Antenna, Electromagnetic Band gap (EBG) Structure, bandwidth, Four Arm Spiral Structure.**

I. INTRODUCTION AND EBG STRUCTURE

Microstrip Patch Antenna has several advantages like small size, light-weight, low profile, low fabrication cost and planar configuration. That properties of microstrip antenna makes it fancy in these days. In spite of these advantages, the microstrip Patch Antenna suffers from certain limitations like low efficiency, high Q, low power handling ability, very narrow bandwidth and spurious feed radiation. The performance of antenna can be improved by various methods. To find ultra wideband response and minimization of array are important design issue. There has been an effort focused on increasing bandwidth by the using modified ground plane method.

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In these days there is a large demand of bandwidth but the disadvantage of microstrip patch antenna is it provides very less bandwidth. It can be increased by several methods. Many researchers have given their attention on this topic. Use of electromagnetic band gap structure is a widely used method for it. The structure having periodic arrangement of dielectric or magnetic materials is called as Electromagnetic band gap (EBG) structure. Electromagnetic waves travelling through such structures experience a periodic variation of dielectric permittivity or magnetic permeability. Surface waves are by-products in many antenna designs. Directing electromagnetic wave propagation along the ground plane instead of radiation into free space, the surface waves reduce the antenna efficiency and gain. The diffraction of surface waves increases the back lobe radiations; the band gap feature of Electromagnetic Band Gap (EBG) structures has found useful applications in suppressing the surface waves in various antenna designs. Electromagnetic Band gap (EBG) structures or high impedance ground planes have their interesting electromagnetic properties. These structures can decrease the propagation of electromagnetic (EM) energy along their surface over a frequency band. So electromagnetic interference can be used to reduce in circuits by it or even it can reduce radiation in a particular direction when coupled to an antenna.

In this paper four arm spiral EBG structure is used. The use of four arm spiral structure is because of its symmetry if the structure is rotated over 90 degree then there will not be any variation in the results.

II. METHODOLOGY

This paper is for the design of microstrip patch antenna with spiral ground plane. Here four arm spiral ground plane is used to enhance the bandwidth of the microstrip patch antenna. In first stage a 2X2 array with conventional ground plane designed and it is used as a reference antenna after this four arm modified spiral ground plane is used. The width of spiral arm varied and several values and best result found on the strip width of 6 mm.

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All the results simulated on IE3D V12.9 software of ZELAND software Inc. and its comparison is shown in the graph. It is seen that in the simulated result, the bandwidth enhanced by 150% using 6 mm wide strip four arm spiral ground plane and practically measured result shows that the bandwidth enhanced by 800%.

III. 2X2 PATCH ANTENNA ARRAY WITH CONVENTIONAL GROUND PLANE DESIGN AND RESULTS

The 2X2 array is designed with design specification as shown in table i and fig. 1 shown the designed antenna.

Table I Design specification of 2X2 array with conventional ground plane

Single Patch Length L_p	36mm
Single Patch Width W_p	30mm
Patch Separation d	46mm
Feed to patch L_fXW_f	2mmX18.75mm
Width of power distributer W_d	2.5 mm
Substrate Thickness h	1.6mm
The dimensions of ground plane	160mm X160mm
Dielectric Constant ϵ_r	4.4

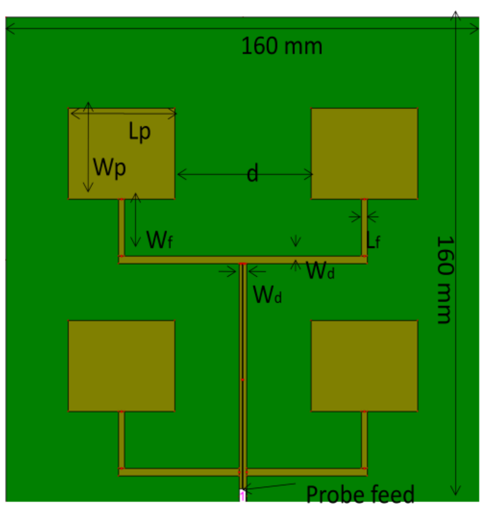


Fig. 1. 2x2 Array with Conventional Ground Plane

Fig. 2 shows the return loss comparison of the simulated and practically measured results. In simulation the maximum bandwidth is 0.67GHz (2.90GHz-3.57 GHz) and in practically measured maximum bandwidth is 0.25 GHz (3GHz-3.5GHz).

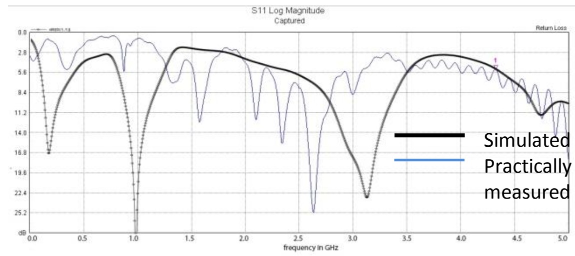
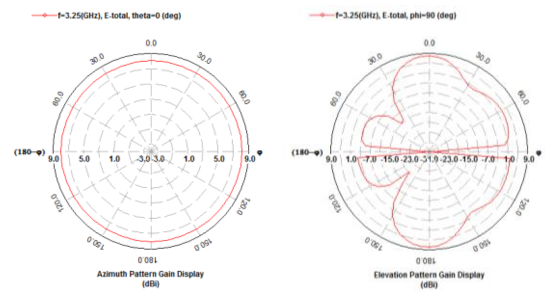


Fig. 2 Return loss of 2X2 array with conventional ground plane

Fig. 3 shows the Radiation pattern of the antenna. The operating frequency of the antenna is 3.25GHz at which the maximum gain has occurred. The radiation pattern plotted in the fig. 3(a) is the azimuth pattern at θ= 0° and in fig. 3(b) is the elevation pattern at φ=90°.



(a) (b)

Fig. 3 Radiation Pattern

The antenna is designed on a double sided printed circuit board on a given specification. The width of the printed circuit board is 1.6 mm. and it is shown in fig. 4. Fig. 4 (a) shows the array view or patch view and fig. 4(b) shows the ground plane of the array.

(a) Array (b) Ground plane

Fig. 4. Practically designed 2X2 array with conventional ground plane

IV. 2X2 PATCH ANTENNA ARRAY WITH SPIRAL GROUND PLANE DESIGN AND RESULTS

The ground is modified by 6 mm four arm spiral ground plane and a 2X2 array is designed with design specification as shown in table ii and fig. 5 shown the designed antenna.

Table ii Design specification of 2X2 array with spiral ground plane

Single Patch Length L_p	36 mm
Single Patch Width W_p	30 mm
Patch Separation d	46 mm
Feed to patch L_f X W_f	2 mmX18.75 mm
Width of power distributer W_d	2.5 mm
Substrate Thickness h	1.6 mm
The dimensions of ground plane	160 mm X160 mm
Dielectric Constant ϵ_r	4.4
Ground plane strip width and gap	6 mm

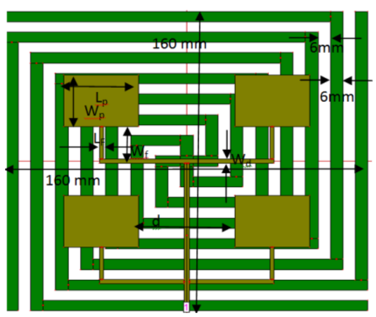


Fig. 5 microstrip patch antenna array with spiral ground plane

The return loss of the 2X2 microstrip patch antenna array with 6 mm spiral ground plane is shown in fig.6.

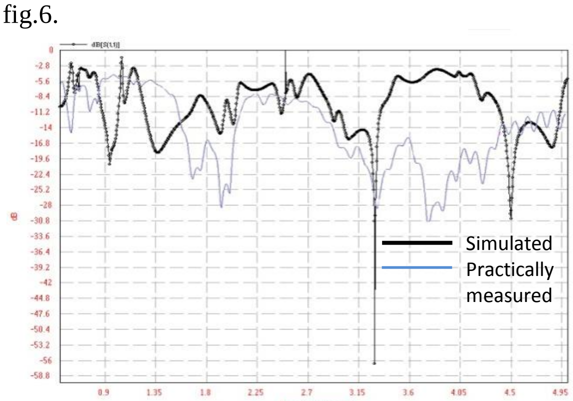
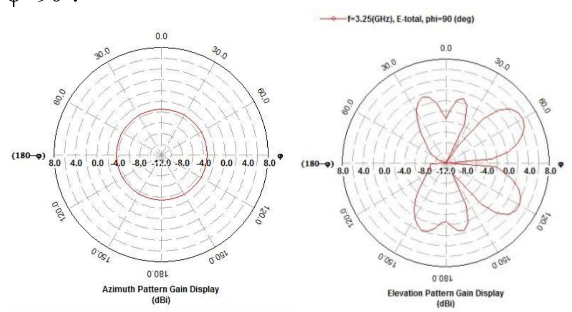


Fig. 6 Return loss of 2X2 array with spiral ground plane

It is shown in fig. 6 that the maximum bandwidth achieve by spiral ground plane antenna 0.93 GHz (simulated) (2.57GHz-3.50GHz) which is enhanced by approximate 150% in comparison to conational ground plane and 2GHz (practically measured) (2.75GHz-4.75GHz) which is enhanced by approximate 800% in comparison to conventional ground plane.

Fig. 7 shows the Radiation pattern of the antenna. The operating frequency of the antenna is 3.25GHz at which the maximum gain has occurred. The radiation pattern plotted in the fig. 7(a) is the azimuth pattern at $\theta = 0^o$ and in fig. 7(b) is the elevation pattern at $\varphi = 90^o$.



(a) (b)

Fig. 7 Radiation Pattern

The antenna is designed on a double sided printed circuit board on a given specification. The width of the printed circuit board is 1.6 mm. and it is shown in fig. 8. Fig. 8 (a) shows the array view or patches view and fig. 8 (b) shows the ground plane of the array.


Fig. 8. Practically designed 2X2 array with conventional ground plane

V. CONCLUSION

This paper shows that if an electromagnetic band gap (EBG) structure is used in proper manner then the bandwidth of the antenna can be increased. Here the 2 X 2 array increases its bandwidth by approximate 150% i.e. from 67 MHz to 93 MHz.

This is also shown in summarized result table. The EBG structure can be any type rectangular, spiral or any other shape. In this thesis the four arm spiral EBG structure is used and its strip width defines the characteristics of the antenna. Practically the measured result of the array with conventional ground plane is 0.25GHz and with four arms spiral EBG structured ground plane found 2GHz bandwidth which is 800% of conventional ground plane antenna.

There are several fields in which antenna needs large bandwidth and this is disadvantage of the microstrip patch antenna that it has low bandwidth. It can be overcome by using electromagnetic band gap structure. And there are several types of EBG structures can be formed which can provide better results. Like spiral EBG, rectangular, square etc. the design of EBG structure can be in 3D space. Means a three or four layer PCB can be used to design EBG structure which results can be analyzed.

REFERENCES

[1] D. Nashaat, H. A. Elsadek, E. A. Abdallah, and Hadia M. El Hennawy, “Ultrawide Bandwidth 2X2 Microstrip Patch Array Antenna Using Electromagnetic Band-Gap Structure (EBG)” presented at IEEE Transactions on Antennas and Propagation, VOL. 59, NO. 5,pp. 1528-1534, MAY 2011.

[2] Reghunath, V. Sukumaran and S.K., “Printed monopole UWB antenna with EBG structure for Wireless Body Area Network,” Contemporary Computing and Informatics (IC3I), 2014 International, pp. 1310-1314, Nov 2014.

[3] Zheng Guo, Huiping Tian, Xudong Wang, Qun Luo and Yuefeng Ji, “Bandwidth Enhancement of Monopole UWB Antenna With New Slots and EBG Structures” presented at Antennas and Wireless Propagation Letters, IEEE, Volume 12, pp. 1550-1553, 2013.

[4] D. Nashaat, H. A. Elsadek, E. Abdallah, H. Elhenawy, and M. F. Iskander, “Enhancement of ultra-wide bandwidth of microstrip monopole antenna by using metamaterial structures,” IEEE Int. Symp. on Antenna and Propagation Proceedings, Charleston, Jun. 2009.

[5] F. Yang, V. Demir, D. A. Elsherbeni, and A. Z. Elsherbeni, “Enhancement of printed dipole antennas characteristics using semi-EBG ground plane,” J. Electromagn. Waves Appl., vol. 20, no. 8, pp. 993–1006, 2006.

[6] W. Yun and Y. J. Yoon, “A wideband aperture-coupled microstrip array antenna using inverted feeding structures,” IEEE Trans. Antenna Propg., vol. 53, no. 2, pp. 861–862, Feb. 2005.

[7] A. R. Weily, L. Horvath, K. P. Esselle, B. C. Sanders, and T. S. Bird, “A planar resonator antenna based on a woodpile EBG material,” IEEE Trans. Antennas Propag., vol. 53, no. 1, pp. 216–223, Jan. 2005.

[8] L. Yang, M. Y. Fan, F. L. Chen, J. Z. She, and Z. H. Feng, “A novel compact electromagnetic band-gap structure and its applications for microwave circuits,” IEEE Trans. Microwave Theory Tech., vol. 53, no. 1, pp. 183–190, Jan. 2005.

[9] G. Cakir and L. Sevgi, “Design of a novel microstrip electromagnetic band-gap (EBG) structure,” Microw. Opt. Technol Lett., vol. 46, pp. 399–401, 2005.

[10] Bernhard, J.T., Mayes, P.E., Schaubert, D., and Mailoux, R.J.,”A commemoration of Deschamps’ and Sichak’s ‘Microstrip Microwave Antennas’: 50 years of Development, divergence,and new directions,” Proceedings of the 2003 Antenna Applications Symposium , Moticello, IIIinois , pp. 189-230, September 2003.

[11] A. Yu and X. Zhang, “A novel 2-D electromagnetic band-gap structure and its application in micro-strip antenna arrays,” Microw. Millimeter Wave Technol. Lett., pp. 580–583, Aug. 2002.

[12] F. Yang and Y. Rahmat-Samii, “Applications of electromagnetic band-gap (EBG) structures in microwave antenna designs,” Microw. Millimeter Wave Technol., pp. 528–553, Aug. 2002.

[13] R. Gonzalo Garcia, P. de Maagt, and M. Sorolla, “Enhanced patch- antenna performance by suppressing surface waves using photonic- band-gap substrate,” IEEE Trans. Microwave Theory Tech., vol. 47, no. 11, pp. 213 1–2138, Nov. 1999.

[14] Deschamps, G.A., “Microstrip Microwave Antennas”, Third symposium on the USAF Antenna Research and development program, University of IIIinois, Moticello, IIIinois, October 18-22, 1953.

[15] Randy Bancroft, 2nd edition, ”Microstrip and Printed Antenna Design” SciTech Publishing, Sep 2009

[16] Constantine A. Balanis,2nd edition, ”Antenna theory Analysis and design” John Wiley & Sons. Publication, 1997.