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Study of Rectangular Microstrip Antenna with Star EBG on the ground plane

Savita.M.S[1], Vani R.M[2], Prashant R.T[3], and Hunagund P.V[4]

Department of Applied Electronics, Gulbarga University, Gulbarga, India[1,3]

Reader & Head, University Science Instrumentation Centre, Gulbarga University, Gulbarga, India[2]

Professor and Chairman of Applied Electronics Department, Gulbarga University, Gulbarga, India[4]

Abstract: This paper presents the design and development of microstrip antenna with Star shape Electromagnetic Band Gap (EBG) on the ground plane of the antenna. The proposed antenna is simple and has been constructed from conventional rectangular microstrip antenna by embedding Star shape EBG on the ground plane of the microstrip antenna. The proposed antenna provides bandwidth of 34.56% compared to the Conventional Rectangular Microstrip Antenna (CRMA). The proposed study has been made by using Vector Network analyzer.

Keywords: Rectangular Microstrip Antenna, Electromagnetic Band Gap (EBG) structures, Return Loss, Bandwidth.

I. INTRODUCTION

In the past years, many techniques have been studied in order to overcome the narrow impedance bandwidth of microstrip antenna. Among the various techniques, there have been the popular ones such as use of increased substrate thickness, shorting walls, slots etc. These methods are effective at the cost of increase in the size of the antenna. The bandwidth of antenna can be enhanced by increasing the thickness of substrate but up to certain limit. Beyond certain thickness of substrate, the efficiency of antenna starts decreasing due to more surface wave generation. The surface wave generation can be reduced by using Electromagnetic Band Gap (EBG) [1-2]. The Electromagnetic Band Gap (EBG) surface also referred to as a Photonic Band Gap (PBG) surface or a high-impedance surface which has attracted extensive studies in applying its band gap phenomena for practical uses both in the optical domain and microwave and millimetre-wave areas. The birth of the Electromagnetic Band Gap structure has triggered many novel antenna applications. Electromagnetic Band Gap structure can be defined as artificial periodic (or sometimes non-periodic) objects that prevent or assist the propagation of electromagnetic waves in a specified band of frequency for all incident angle and polarization state. Two commonly employed features are suppressing unwanted substrate modes and acting as an artificial magnetic ground plane [3-4]. The main advantage of EBG structure is their ability to suppress the surface wave current. The generation of surface waves degrades the antenna efficiency and radiation pattern. Furthermore, it increases the mutual coupling of the antenna array which causes the blind angle of a scanning array [5]. EBG structures are usually realized by periodic arrangement of dielectric materials and metallic conductors. In general, they can be categorized into three groups according to their geometric configuration; (i) three-dimensional volumetric structures, (ii) two-dimensional planar surfaces and (iii) one-dimensional transmission lines. Two-dimensional planar EBG surfaces again classified into two categories, first one is mushroom like EBG surfaces and another one is uniplanar EBG surfaces [6].

In this study Rectangular microstrip antenna without change in height or size of the antenna EBG is loaded in the ground plane of the antenna to enhance the performance of the antenna. Also EBG slot loading techniques has freedom to add the desired EBG slots on the Ground Plane Or around the radiating patch to improve the antenna parameters.

II. DESCRIPTION OF ANTENNA GEOMETRY

The proposed antennas are developed using computer software AutoCAD-2006 and are fabricated on low cost glass epoxy substrate material of thickness h=1.6mm and permittivity of a dielectric constant is εr=4.4. Figure1 (a) shows the top view geometry of Conventional Rectangular Microstrip Antenna (CRMA) and Figure 1(b) shows the photographic view of CRMA which is designed for the resonant frequency of 6GHz, using the equations available in the literature. The substrate area of the CRMA is A=M×N (40mmX40mm).The antenna is fed by using microstripline feeding. This feeding has been chosen because of its simplicity this has length L and width W (15.24mm, 11.33mm) and quarter wave transformer of length Lt and width Wt which is fabricated along with the antenna element. At the top of microstripline feed, SMA connector is used for feeding the microwave power. The bottom surface of Figure1 is tight copper shielding which is ground plane.

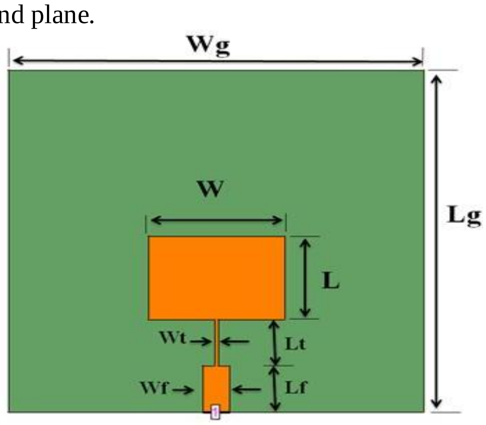

Figure1 (a): Top view of CRMA

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Figure 1(b) Photographic view of Top and bottom of CRMA

Figure2 (a) shows the top view of Rectangular Microstrip Antenna with Star EBG (RMASEBG) & Figure2 (b) shows the Photographic view of the RMASEBG. In RMASEBG the radiating patch is same as that of CRMA, in the ground plane a Star EBG is loaded. The length of the Star EBG is SEL=8mm, Star EBG width SEW=8mm the length of each slot of Star EBG is X=8mm, Y =1mm gap between each Star EBG is G=8mm. The feeding technique of this antenna is same as that of the CRMA.

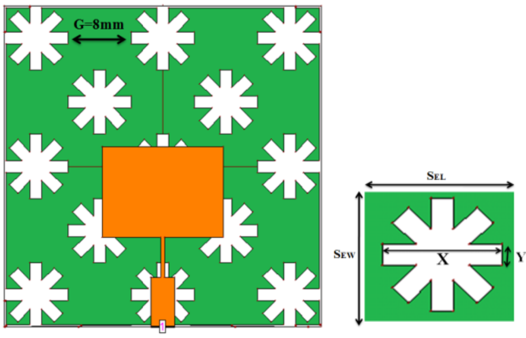

Figure2 (a) Top of RMASEBG and a enlarged single unit of star EBG

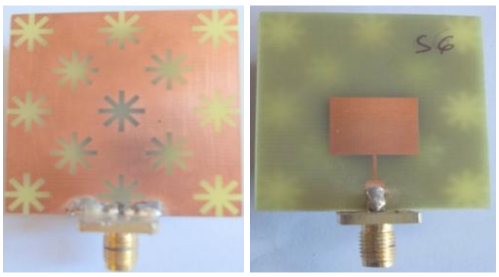

Figure2 (b) Photographic view Top and bottom of RMASEBG

III. EXPERIMENTAL RESULTS

The bandwidth over return loss less than -10dB for the proposed antennas is measured. The measurements are taken on Vector Network Analyzer (Rohde and Schwarz, Germany make ZVK model 1127.8651). The variation of return loss versus frequency of CRMA is as shown in Figure3(a). From this figure it is seen that, the antenna resonates very close to its designed frequency of 6GHz. This validates the design concept of CRMA. From Figure3, the bandwidth is calculated by using the equation,

$$\text{Impedance Bandwidth } (\%) = \left[fH - \frac{fL}{fC}\right] \times 100\%$$

Where, fH and fL are the upper and lower cut-off frequency of the band respectively when its return loss becomes -10dB and fc is the centre frequency between fH and fL. Hence by using equation (1) the bandwidth BW of CRMA is found to be 4.18% (176MHz).

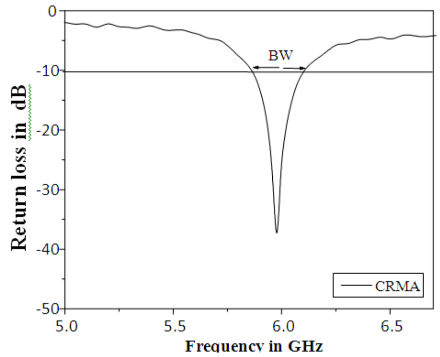

Figure3 (a): Return loss Characteristics of CRMA

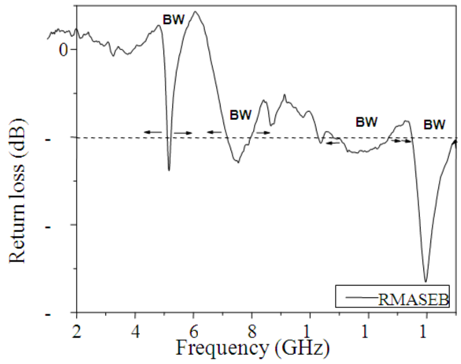

Figure3 (b): Return loss Characteristics of RMASEBG

Figure3 (b) shows the variation of return loss versus frequency of RMASEBG. From this figure it is seen that the antenna resonates at different frequencies with BW1= 5.143GHz, BW2=7.492 GHz, BW3=11.57GHz & BW3=13.96. The overall bandwidth of RMASEBG is 416MHz & 34.56 %.The impedance band width of the antenna increases from 2.93% to 34.56% more when compared with CRMA. The results are shown in the below Table1.

TABLE1: The results of CRMA and RMASEBG

Antenna	No. of Bands	Return loss in (dB)	Resonant Freq. (GHz)	BW in MHz	B W in (%)	Overall Bandwidth in (%)
CRMA	01	-15.25	5.99	250	4.18	4.18
RMASEBG	04	-13.87 -12.73 -11.82 -26.36	5.14 7.49 11.57 13.96	14 83 167 149	1.02 6.58 14.35 4.16	34.56

For the measurement of radiation pattern, the antenna under test (AUT) i.e. the proposed antennas and the standard pyramidal horn antenna are kept in far field region. The AUT, which is the receiving antenna, is kept in phase with respect to transmitting pyramidal horn antenna. The power received by AUT is measured from 0^0 to 360^0 with the steps of 10^0. The co-polar radiation patterns of CRMA, RMASEBG are measured in their operating bands respectively and are as shown in Figures. Figures 4 (a) & 4 (b) shows the experimental results of E-Plane and H-plane radiation pattern of all the CRMA and RMASEBG antenna. From the E-plane radiation pattern it is clear that the back lobe radiation of the RMASEBG is reduced as compared with the CRMA.

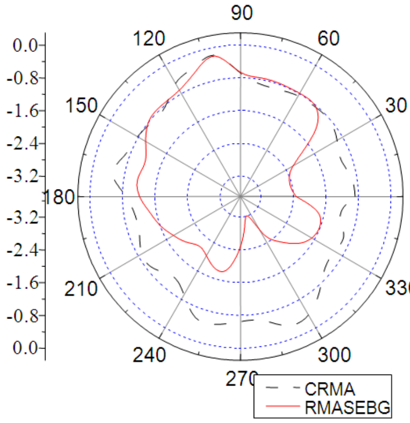

Figure 4(a) E-plane Radiation patterns of CRMA& RMASEBG

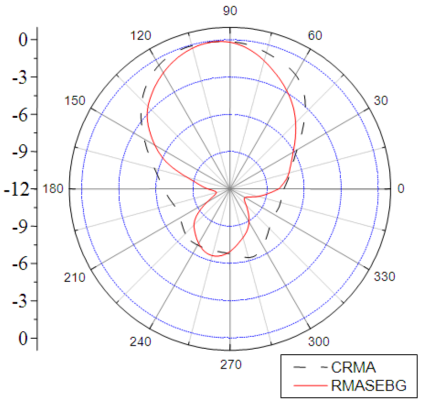

Figure 4(b) H-plane Radiation patterns of CRMA & RMASEBG

IV. CONCLUSION

From the detailed experimental study, it is concluded that there is increase in impedance bandwidth by 31.57 % (240MHz) by inserting Star EBG in the ground plane of the CRMA antenna. Also there is reduction in back lobe of the antenna with EBG structure on ground plane. The proposed antennas are simple in their design & construction & they use low cost substrate material. These antennas may find application in the communication system for WLAN & Wimax.

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BIOGRAPHY

Savita M Shaka received her M Sc from the department of Applied Electronics from Gulbarga University, Gulbarga in the year 2006 and her M Phil from the same department in year 2008. Currently she is pursuing her Ph.D in the field of Microwave Antennas from the department of Applied Electronics, Gulbarga University, Gulbarga.

Vani R. M. received her B.E. in Electrical and Electronics from the B.I.ET., Davanagere and M.Tech in Industrial Electronics from S.J.C.E., Mysore, Karnataka. She has received her Ph.D in Applied Electronics from Gulbarga University, Gulbarga, India, in year 2005. She is working as Reader & Head, University Science Instrumentation Center, Gulbarga University, Gulbarga, since 1995. She has more than 85 research publications in national and international reputed journals/Conference proceedings. she presented the research papers in National/ International conferences in India and abroad. She has conducted several courses, workshops for the benefits of faculties and field engineers. Her areas of interest are microwave antennas, PC based instrumentation, Embedded controllers and Wireless communication. She has one UGC major research project to her credit.

Prashant R T received his M Sc fron the department of Applied Electronics Gulbarga University, Gulbarga in the year 2011. He worked as a Project Fellow in the UGC sponcerd Majore Reserch Project 2012-2013. Currently he is persuing his Ph. D in the field of Microwave Antennas from the department of Applied Electronics, Gulbarga University, Gulbarga.

P. V. Hunagund, received his M.Sc and Ph.D from the Dept. of Applied electronics, Gulbarga University, Gulbarga, in the year 1982 and 1992 respectively. He is working as professor and chairman of Applied Electronics department, Gulbarga University, Gulbarga. He has more than 25 research publications in national and international reputed journals, more than 85 research publications in international symposium/Conferences. He presented the research papers in National/International conferences in India and abroad. He has guided many Ph.D and M.Phil students. He has three major research projects at his credit.