GRINREY

Advances in Electrical and Electronics Engineering

Sandip A. Kale
Editor

Research Transcripts in Computer, Electrical and Electronics Engineering | Volume 01

3

Improvement of Performance Parameter of Micro-Strip Patch Antenna Using EBG Structure

Vaishali M. Dhede[a,*], Amol M. Shelke[a] and Prasanna L. Zade[c]

[a]Department of Electronics and Telecommunication, Jaihind College of Engineering, Kuran, Pune, India
[c]D. M. Institute of Engineering, Technology and Research, Wardha, India

*Corresponding author: vaishali_dhede@rediffmail.com

ABSTRACT

This article attempts to improved microstrip antenna performance using uniform electromagnetic band-gap (EBG) configuration at 2.45 GHz. EBG implementation is easy to develop as it is without holes configuration. Initially rectangular microstrip antenna is designed at 2.45 GHz. An antenna designed on FR4 substrate that has a dielectric constant (ε_r) 4.4 using HFSS simulation software. Then 2 × 1 array of microstrip patch is designed without EBG used as a reference antenna which gives simulated return loss is -17.98 dB, VSWR 1.28 and directivity 7.34 dB. Then square EBG structure is implemented along feed line and outer edges of patch. Square EBG configuration gives simulated return loss -15.92 dB, simulated VSWR 1.57 and directivity is 7.64 dB. Thus, implementation of EBGs along sides of patches and feed line of 2 x 1 microstrip patch antenna array gives better results than 2 x 1 arrays without EBGs. Hence designed antenna structure is fabricated and tested. Simulation results of array with EBG are compared with results of fabricated antenna array with EBG. The surface wave's reductions are achieved using EBG. The new approach gives an improvement in directivity. Thus Implementation of square EBG gives better performance.

Keywords: 2X1 Array, EBG (Electromagnetic Band-Gap), Directivity

Advances in Electrical and Electronics Engineering | ISBN: 978-81-948951-1-4
Book Series: Research Transcripts in Computer, Electrical and Electronics Engineering | Vol: 01

1. INTRODUCTION

An antenna is a special part of the communication system. An antenna is designated a metal structure for the reception or conversion of radio waves in the RF system [1]. With the appropriate design of the antenna, system requirements can be reduced. Various antenna configurations have been planned. Microstrip patch antenna has been seen as an effective feature of the communications system and is basically used in many industrial applications. Unfortunately, it suffers from inconveniences like contracted bandwidth, lower gain, and low efficiency [3][4]. Microstrip antennas are implemented usually in military and industrial applications. These can be fixed on satellites, military devices, automobiles, and also in handheld devices [4]. A patch excited by a microstrip line feed. Feed device of benefits such as those which can be grafted on the same substrate, hence the form stays planer [5]. However, the disadvantage is that the feed line is radiated, leading to an increase of the cross-polar level. The millimeter-wave spectrum and feed line distance are both relative to the patch size, which contribute to excessive radiation being increased. For dense substrates, commonly use to achieve gain, both of the above MSA feeding methods have problems [6]. In addition, It's necessary that to develop wireless networks as well high-gain antennas for a variety of modern wireless applications including WLAN[2]. The design of the necessary compact broadband antenna, for the latest microwave applications, is the main challenge [7]. For applications such as high-performance air-craft, satellite, military radar system, radio, and wireless systems, low cost, low shape, easy installation and incorporation of feed networks are the key obstacles. Also, with technological advances, the antenna requirement for more frequencies [1].

Microstrip patch antenna has more advantages than the traditional antennas, including low manufacturing expense, promoting both linear and circularly polarized. Surface wave excitation and narrow bandwidth are some demerits of patch antenna. The antenna array can be used to improve the Gain [5].

The inset feed use to exciting line and also terminated by a slot, which length is selected width of 2.8 mm. This feeding method is simple which allows for planer feeding and easy to use with array structure. For input matching, this method is very easy [1].

In most large-scale communication applications, the basic need is to raise the gain with high performance. Consideration can be given to the reorganization of electrical parameters of a particular antenna. Another path by a congregation of transmitting elements in geometrical and an electrical arrangement formation of new antenna configuration due to multi-elements called as an array for directive antenna [8], a field from the array are added constructively to the needed directions and canceled in the other space. For transmitting as well as receiving the radio waves, multiple antennas are connected together and act as an antenna called an antenna array. The radio waves propagated from every single antenna combined and adding together as per their design. Hence increase in the power radiated at the desired direction, and reduce transmission of power in other directions by this way, radiation pattern of side lobe can be reduced and front lobe power is improved.

By using arrays we can improve signal strength, directivity, reduction in side lobes. Due to arrays, we can obtain high gain and better performance by eliminating power wastage. Patch antennas are popularly used today due to their merits of lighter weight, less volume, lower cost, easy to install, and easily compatible with integrated circuits[6]. In a communication system, some applications require a smaller configuration of microstrip antenna to make it suitable for that application. For the last four years, significant improvement in the configurations of patch antennas has been presented so different aspects or methods have come forward to fulfill this purpose.

An idea of SIW rises from the microstrip and waveguide. Most patch antennas designed with multiple patches in various structural 2-dimensional array [9]. The antenna is normally attached by foil micro strip transmission lines to the transmitter or receiver. The frequency current in the receiving antennas is also generated between an antenna and ground [10]. Patch antennas have much appreciated in recent years due to its thickness that can attract users towards it, defense appliances like aircraft and missiles where this antenna fit properly and securely [11]. Microstrip patch arrays comparatively provide higher gain as single patch at additional charge [5]. At another side phase adjustment and matching also performed with patch structure.

This type of array antennas is a simple technique to make phase array of antenna using active beam creating property [8][2]. Additional patch antennas also have a diversity of polarisation. Patch antennas with longitudinal, lateral, right hand circular (RHCP) and left hand circular (LHCP) polarizations may easily be built by using various feed points and single feed point with asymmetric patch structures [12]. Due to the exceptional property of patch antennas they used in many types of various communication applications with rise in requirements [13]. EBG (Electromagnetic Band-Gap) structure is used to enhance the gain in simple microstrip patch array antenna. EBG structures are defined as artificially design structure which having identical substructure components joined together which contribute to electromagnetic wave propagation in the desired frequency band for all incident angles. It has several applications due to its performance and good polarization [14][15]. EBG improves the radiation or gain patterns also decreases the noise or losses in transmissions [12][13]. Circular, hexagonal, square, uniplanar defect ground structures (DGC), and Co-Planer Waveguide (CPW) fractals are the main types of planer EBG structures.

2. METHODOLOGY

Microstrip Patch Antenna is proposed to operate at frequency 2.46 GHz. 2X1 microstrip patch antenna with square EBG structure is designed in HFSS simulation software to operate at 2.46 GHz, with FR4 substrate material.
Patch width:

$$W = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad where\ c = speed\ of\ light \qquad (1)$$
$$W = 39\,mm$$

Effective dielectric constant:

$$\varepsilon_e = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left(1 + 12\frac{h}{W}\right)^{-1/2}$$
$$\frac{\Delta L}{h} = 0.412\left[\left(\frac{\varepsilon_e + 0.3}{\varepsilon_e - 0.258}\right)\left(\frac{\frac{W}{h} + 0.264}{\frac{W}{h} + 0.8}\right)\right] \qquad (2)$$

Patch length:

$$L = \frac{c}{2fr\sqrt{\varepsilon_e}} - 2\Delta_L \qquad (3)$$

Feed length:

$$Z = \frac{377}{\sqrt{\varepsilon_r\left(\frac{W}{h} + 2\right)}} \qquad (4)$$

Initially rectangular microstrip 2X1 antenna array is devised using HFSS simulation software for resonance frequency 2.46 GHz. The length and width of the patch are 38mm and 29mm respectively. The feed point is 7.5mm from the center of the patch. Width of transmission line is 0.98 mm and for feed line is 2.98 mm with respect to impedance. Electromagnetic Band Gap Structure (EBG) designed with size 2 mm x 2 mm and placed with pitch distance of 3.5 mm as shown in fig 2 which has improved the performance of system. EBGs were placed at outer vertical edges of the patch and feed line. It is observed that surfaces waves were reduced after implementing EBGs along the sides of patch and feed line.

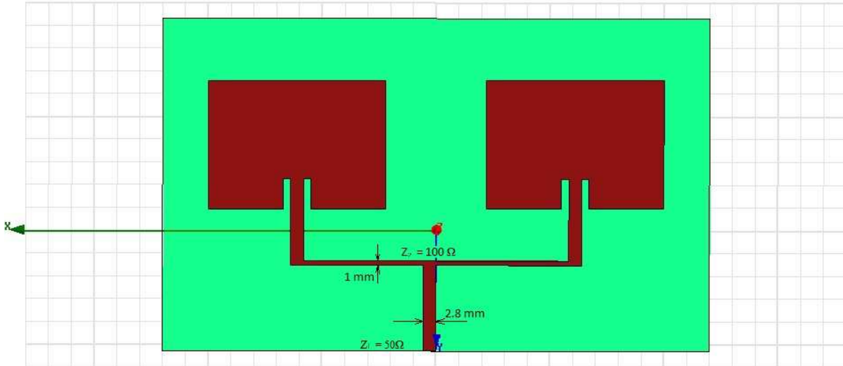

Fig.1. Simulated 2X1 microstrip patch antenna array without EBG

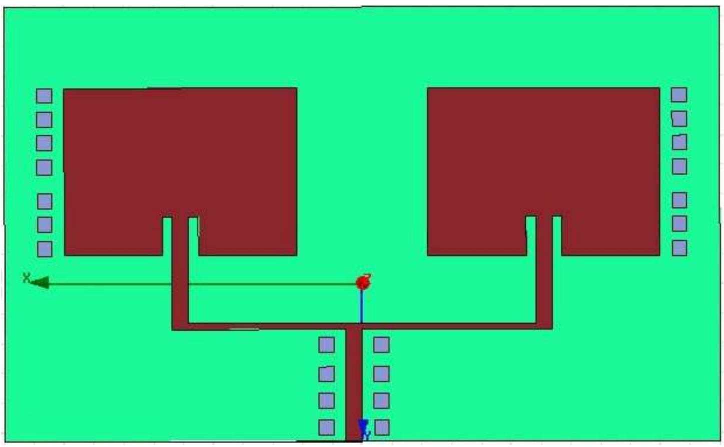

Fig.2. Simulated 2X1 microstrip patch antenna array with EBG

Simulated results of the designed structure with EBG gives better results as compared to simple 2X1array. Also no more dimensional changes were required to improve performance.

3. METHODOLOGY

Rectangular microstrip 2X1 antenna array is simulated using Antenna simulation software and results are observed. Simulated return loss is -17.98 dB, VSWR 1.28 and directivity 7.34 dB as shown in fig. 3, 4 and 5 respectively.,then square EBG structure is implemented along feed line and outer edges of patch as shown in fig.2.

Square EBG configuration gives simulated return loss 15.92 dB and simulated VSWR is 1.57 as shown in fig. 6 & 7.

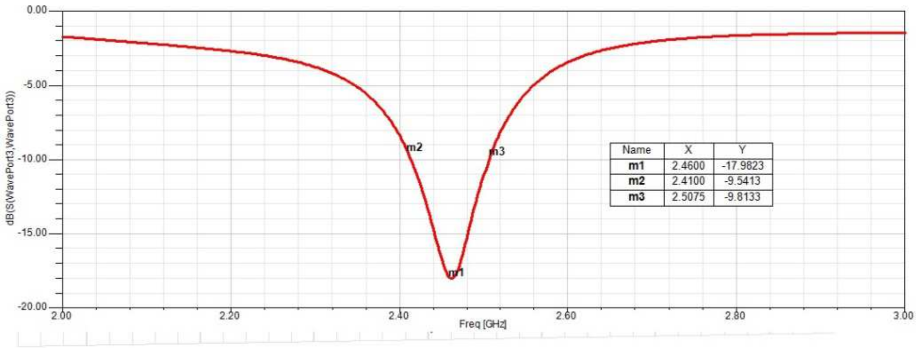

Fig.3. Simulated S11 of 2X1 microstrip antenna array without EBG

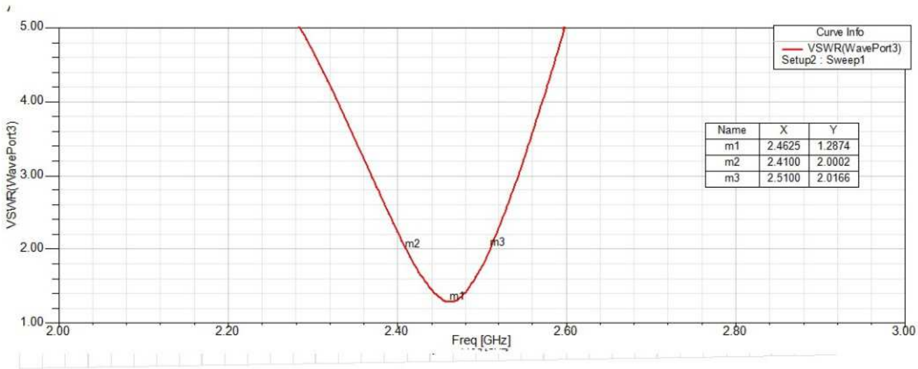

Fig.4. Simulated VSWR of 2X1 microstrip antenna array without EBG

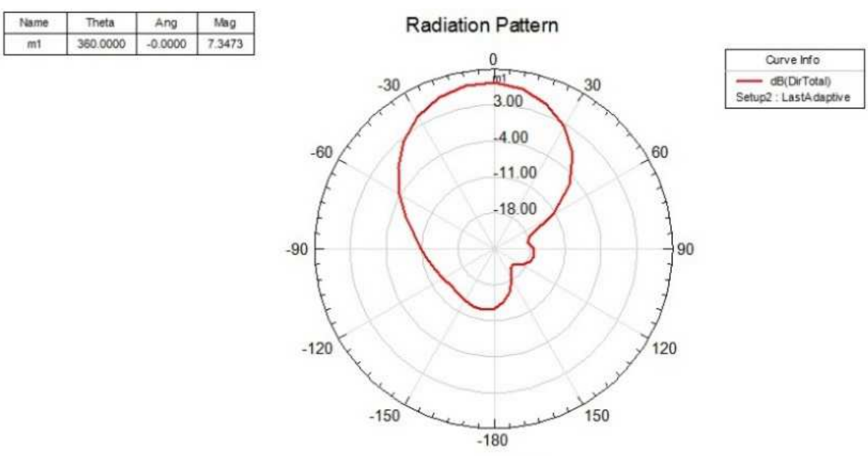

Fig.5. Simulated Directivity of 2X1 microstrip antenna array without EBG

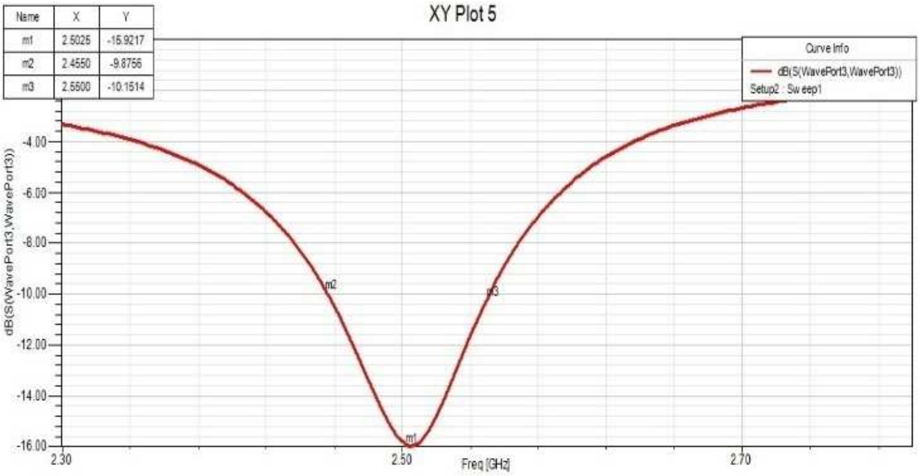

Fig.6. Simulated S11 of 2X1 microstrip antenna array with EBG

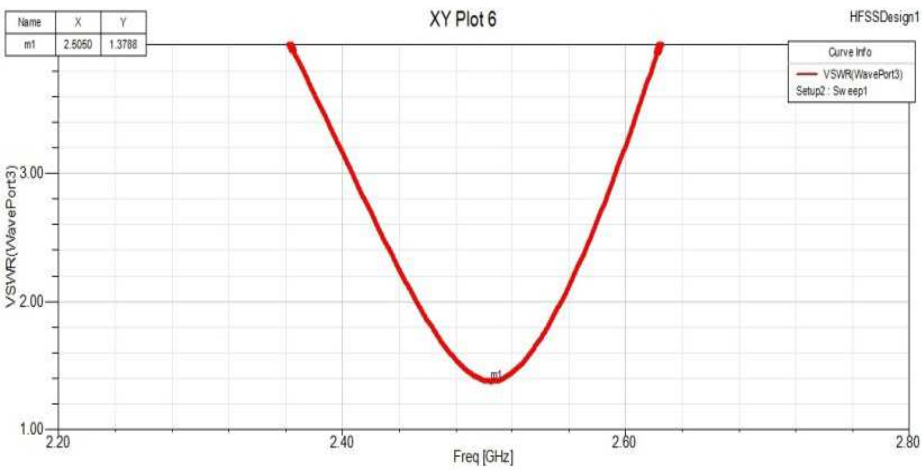

Fig.7. Simulated VSWR of 2X1 microstrip antenna array with EBG

Radiation pattern is shown in fig. 8 for directivity and it is 7.34 dB. The surface wave's reductions are achieved using EBG as shown in fig. 9.

2 x 1 microstrip antenna array designed using EBGs along sides of patches and feed line was fabricated as shown in fig.10. FR4 Epoxy dielectric substrate is used to fabricate antenna which is light in weight and good strength. Fabricated proposed array is tested using Network Analyser for obtaining return loss and VSWR. Measured results are shown in fig. 11, 12 and 13 for return loss, VSWR and directivity respectively.

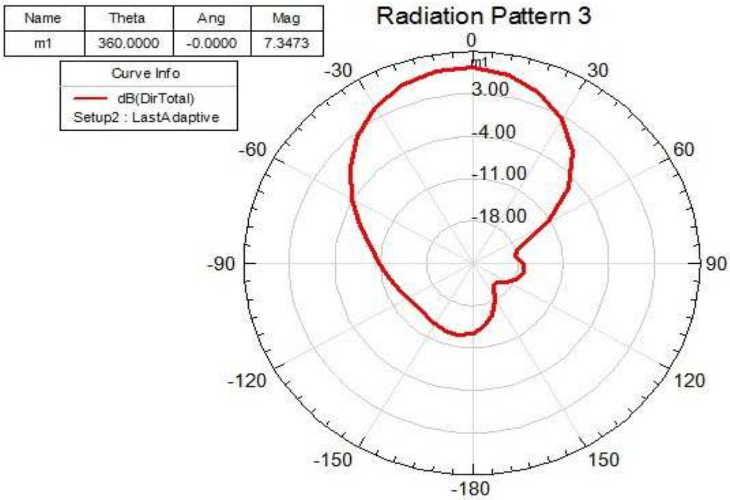

Fig.8. Simulated directivity of 2X1 microstrip antenna array with EBG

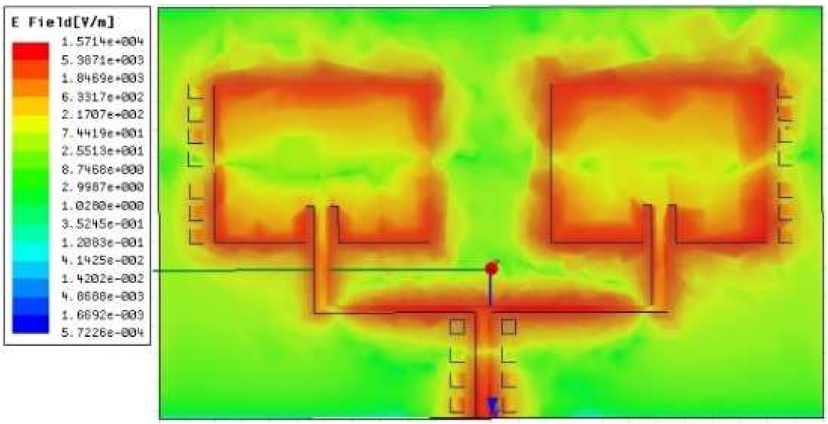

Fig.9. Current of 2X1 microstrip antenna array with EBG

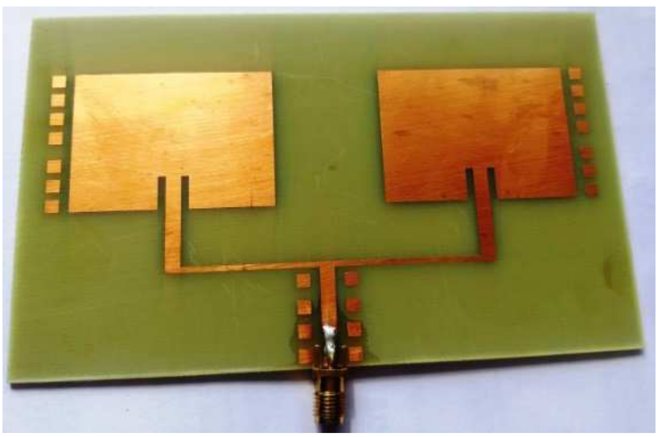

Fig.10. Fabricated 2X1 microstrip patch antenna with EBG

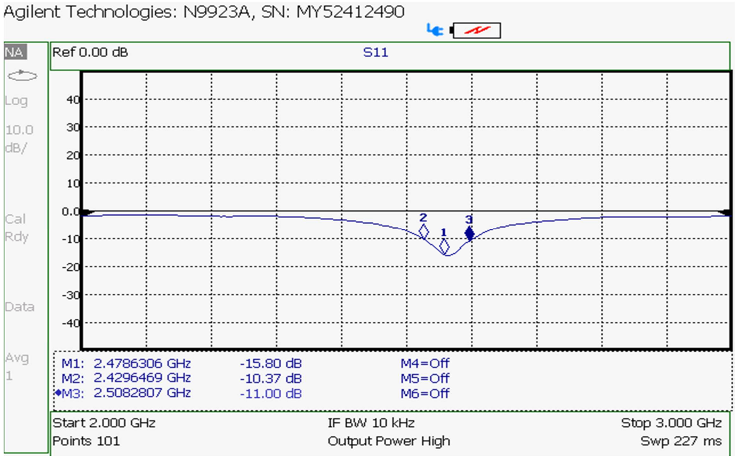

Fig.11. Measured return loss of 2X1 microstrip antenna array with EBG

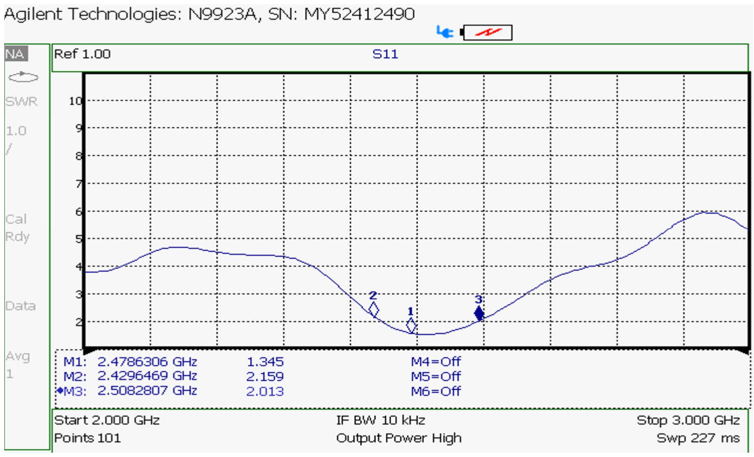

Fig.12. Measured VSWR of 2X1 microstrip antenna array with EBG

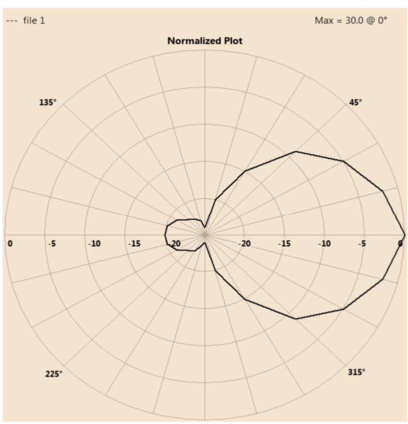

Fig.13. Directivity plot of 2X1 microstrip antenna array with EBG

4. DISCUSSION

It is observed that implementation of EBGs along sides of patches and feed line of 2 x 1 microstrip patch antenna array gives better results than 2 x 1 array without EBGs. Antenna parameters like return loss, VSWR and mainly directivity are achieved better. Hence designed antenna structure is fabricated and tested. Results are shown in table 1 for simulation and fabricated antenna array. In simulation microstrip patch antenna array with EBG resonates at frequency 2.5 GHz and its return loss, VSWR & directivity gives better results as shown in table 1. And then simulation results of array with EBG are compared with results of fabricated antenna array with EBG.

Table 1. Comparison of Simulated and Measured Result

Sr. No.	Parameter	Simulation Values (2 x 1 array without EBG)	Simulation values (2 x 1 array with EBG)	Measured values (2 x 1 array with EBG)
1.	Frequency (GHz)	2.46	2.5	2.47
2.	VSWR	1.28	1.38	1.345
3.	S_{11}	-17.98	-15.92	-15.80
4.	Bandwidth (MHz)	90	85	81
5.	Directivity (dB)	7.34	7.64	7

5. CONCLUSION

Microsotrip antenna array with EBGs along with sides of patches and feed line designed and fabricated successfully. It is observed that EBGs have reduced the surface waves which improve the performance of system. With the help of proper inclusion of EBGs we can improve its performance without changing geometrical parameters of the system. Directivity of antenna array is obtained 7 dB at 2.47 GHz resonant frequency with bandwidth of 81 MHz. Thus, system performance parameters improve using EBG structure. Simulation result validates with experimental results. The proposed antenna array gives better performance antenna system.

NOMENCLATURE

CPW		Coplanar waveguide
DGS	:	Defect ground structure
EBG	:	Electromagnetic Band-Gap
FR	:	Flame retardant
HFSS	:	High Frequency Structure Simulator
LHCP	:	Left hand circular polarization

MSA	:	Microstrip antenna
RF	:	Radio frequency
RHCP	:	Right hand circular polarization
VSWR	:	Voltage standing wave ratio
WLAN	:	Wide local area network
ε_r	:	Dielectric constant

REFERENCES

1. C. A. Balanis, Antenna Theory Analysis And Design, 4th Ed., *Wiley Publication*
2. Diego Caratelli, Renato Cicchetti, Giorgi Bit-Babik, and Antonio Faraone, "A Perturbed E-Shaped Patch Antenna for Wideband WLAN Applications", *IEEE Transactions on Antennas and Propagation,* 2006, 54(6) 1871-1874.
3. Ferdows B.Zarrabi, Sachin Sharma, Zahra Mansouri and Fatemeh Geran, "Triple band Microstrip slot antenna for WIMAX/WLAN applications with SRR shape ring.", *Fourth International Conference on Advanced Computing & Communication Technologies,* 2014, 368-371.
4. Devang V. Katrodiya and Vivek Ramamurthy, "Design of Microstrip Patch Antenna Array for Wireless Applications.", 2015, *International Journal of Electronics & Communication Technology*,6(2), 61-64
5. M. A. Soliman, T. E. Taha, W. Swelam, and A. Gomaa, "3.5/5GHz Dual-Band 8x8 Adaptive Array Antenna", *Progress In Electromagnetics Research C*, 2013, 34, 85-98.
6. Ekke Vaishali R and P. L. Zade, "Gain Enhancement of Microstrip Patch Antenna Array by using Substrate Integrated Waveguide for Wireless Communication System", *International Conference on Automatic Control and Dynamic Optimization Techniques (ICACDOT), IEEE Explorer*, 2016
7. Ahmed Khidre, Kai-Fong Lee, Atef Z. Elsherbeni, and Fan Yang, "Wide Band Dual-Beam U-Slot Microstrip Antenna", *IEEE Transactions on Antennas and Propagation*, 2013, 61(3), 1415-1418.
8. Ekke Vaishali R and P. L. Zade, "Gain Enhancement of Microstrip PatchAntenna Array with AMC Structure Using Multilayer PCB Technology" , *SmartCom 2016, CCIS,* 628, 632–639.
9. Anil K. Gautam, Aditi Bisht and Binod Kr Kanaujia, "A wideband antenna with defected ground plane for WLAN/WiMAX applications.",

International Journal of Electronics and Communications (AEÜ), 2016, 70(3), 354-358.

10. Anshika Khanna Dinesh Kumar Srivastava, Jai Prakash Saini, "Bandwidth enhancement of modified square fractal microstrip patch antenna using gap-coupling", *Engineering Science and Technology, an International Journal*, 2015, 18(2), 286-293.
11. Naveen Jaglan, Binod K. Kanaujia, Samir D. Gupta, and Shweta Srivastava "Triple Band Notched UWB Antenna Design Using Electromagnetic Band Gap Structures.", *Progress In Electromagnetics Research C*, 2016, 66, 139–147.
12. Monika Mohinani and Shailesh Kumar, "Base–Shaped Coaxial Feed Microstrip Patch Antenna for WLAN and WIMAX Applications", *Iconic Research and Engineering Journals*, 2019, 2(8), 128-130.
13. Ekke Vaishali R and P. L. Zade, "Implementation of EBG configuration for asymmetric microstrip antenna to improve radiation properties" *Journal of Telecommunication, Electronic and Computer Engineering*, 2017, 9(1), 61-66.
14. Ekke Vaishali R and P. L. Zade, "Design and Implementation of Artificial Magnetic Conductor Structure along with feed line for Microstrip Patch Antenna Array", *IEEE Global Conference on Wireless Computing and Networking (GCWCN)*, 2014, 51-55.
15. Guoping Gao ; Ruifeng Zhang ; Chen Yang ; Huijia Meng ; Wenfei Geng ; Bin Hu, "Microstrip monopole antenna with a novel UC-EBG for 2.4 GHz WBAN applications", *IET Microwaves, Antennas & Propagation*, 2019, 13(13), 2319-2323.

Cite this article

Vaishali M. Dhede, Amol M. Shelke and Prasanna L. Zade, Improvement of Performance Parameter of Micro-Strip Patch Antenna Using EBG Structure, In: Sandip A. Kale editor, Advances in Electrical and Electronics Engineering, Pune: Grinrey Publications, 2021, pp. 39-50