Design And Implementation of Micro Strip Patch Antenna Using EBG Substrate For Improving Performance Parameters

Prof.M.S.Kanitkar[1], Mehak Biala[2], Prajakta Mhasawade[3]
[1, 2, 3] Dept of Electronics And Telecommunication
[1, 2, 3] PES's Modern College Of Engineering,Pune,India

Abstract- *To compare the performance parameters like the resonance frequency, return loss, radiation pattern, antenna gain, directivity, bandwidth and efficiency of the conventional microstrip patch antenna with the EBG integrated microstrip patch antenna of different structures namely, rectangular, hexagonal and plus shaped substrate.*

The performance of a microstrip antenna integrated with an electromagnetic band gap substrate is described. Electromagnetic Band Gap (EBG) substrate is used as antenna structure to improve the performance of the patch antenna. The antenna structure is made from common FR-4 substrate and operates at the 2.486 GHz wireless band. The design of the microstrip patch antenna, band gap substrate, and their integration is presented. It consists of a band gap array which improves the antenna gain.

Keywords- Microstrip patch Antenna,Electromagnetic band gap structures(EBG),HFSS

I. INTRODUCTION

Microstrip patch antennas are the almost mutual form of printed antennas. A microstrip patch antenna is widely utilized in covenant and portable communication devices ascribable to its little size, dilute profile configurations, accordance and low price. Hence it can be employed in a broad form of applications roaming from mobile communication to satellite, aircraft and other applications **.** The patch antennas gain can be enhanced by applying multiple patches attached to an array or by coming down the surface wave which can produce ripples in the radiation pattern. Various methods have been aimed to bring down the consequences of surface waves. One approach path proposed is the synthesized substrate that lets down the effectual dielectric constant of the substrate either below or all over the patch . Other approach paths are to apply parasitic elements or to apply a minimized surface-wave antenna.

In this paper, the functioning of a rectangular microstrip patch antenna has been mended utilizing various electromagnetic band-gap (EBG) substrates. The patch antenna is fed by a driven terminal and is integrated within the electromagnetic band-gap substrate, based on the plus shaped and hexagonal substrate to raise the antenna gain. The outcome suggested that the surface waves which spread along the surface of the substrate can be inhibited by the multiple photonic band-gap structure because of its consequences of forbidden band, that it can diversify almost of electromagnetic waves' energy in the substrate importantly, and that it has lower return loss compared to the conventional patch antennas and enhanced gain.

The electromagnetic band gap substrate is used in planar antenna to improve the performance of antenna like antenna gain, return loss, antenna directivity and bandwidth. The electromagnetic energy device between the interfaces, and forming into surface waves, is valuable an elementary dipole, placed on a uniform substrate with no losses. The dual-band EBG material is used which act as a high-impedance surface to reduce backward radiation and make the antenna bearable to positioning on the body and Simulated by using HFSS software .

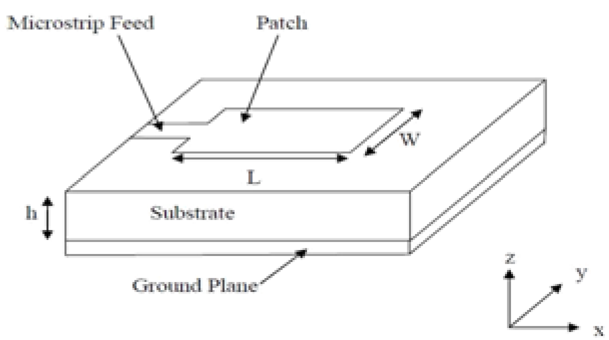
EBG structures also known as Photonic crystals. It utilizes the inherent properties of dielectric substrate material to improve the microstrip patch antenna performance.Electromagnetic band gap (EBG) have found wide variety of useful in advance components for microwave and millimeter wave devices, as well as in antenna designs This project is to design conventional patch antenna and the patch antenna integrated with EBG substrates of different EBG patch width, with same physical dimensions, with the resonance frequency of 2.486GHz and measured the performance parameter of patch antenna when EBG structure added on it.

Electromagnetic band gap (EBG) structures in printed circuits are thin complex dielectric layers with periodic metallic patterns (generally backed by a metal ground plane), and have one or multiple frequency band-gaps in which no substrate mode can exist. This alone ownership has been utilized to design antenna systems with a improve gain and efficiency, lower side-lobes and back-lobe levels amend isolations within array elements, by crushing surface wave modes . The EBG substrate has been utilized to alleviate some withdraws of conventional microstrip antennas.

II. MICROSTRIP PATCH ANTENNA

In its most basic form, a Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side . The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

Consider figure below, which shows a rectangular microstrip patch antenna of length L, width W resting on a substrate of height h. The co-ordinate axis is selected such that the length is along the x direction, width is along the y direction and the height is along the z direction.



Formulae : Height of Antenna(h)=1.6mm , Dielectric constant (Er) = 4.3 ,
Operating Frequency(f_r) = 2.486GHz ,

$$W = \frac{v_o}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

=37mm

Length of Patch

$$L = \frac{v_o}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

=59mm

Effective Dielectric constant

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}$$

=3.98mm

Fringing Length

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(W/h + 0.264)}{(\varepsilon_{reff} - 0.258)(W/h + 0.8)}$$

=0.74mm

Effective length

$Le = L+2*\Delta L$

= 60mm

1. ADVANTAGES OF MICROSTRIP PATCH ANTENNA

- Light weight and low volume.
- Low profile planar configuration which can be easily made conformal to host surface.
- Low fabrication cost, hence can be manufactured in large quantities.
- Supports both, linear as well as circular polarization.
- Can be easily integrated with microwave integrated circuits (MICs).
- Capable of dual and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

2. DISADVANTAGES OF MICROSTRIP PATCH ANTENNA

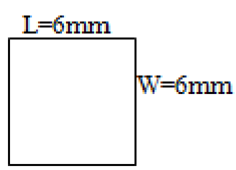
- Narrow bandwidth
- Low efficiency
- Low Gain
- Extraneous radiation from feeds and junctions
- Poor end fire radiator except tapered slot antennas
- Low power handling capacity.
- Surface wave excitation.

III. DESIGN OF EBG STRUCTURES

The main feature of EBG structures is their capability to affect the radiative dynamics within the structure so that there are no electromagnetic modes available within the dielectric. This feature is analogous to periodically arranged atomic lattice of a semiconductor which gives rise to the allowed values of energy that an electron can have at the valence band and at the conduction band, with an energy band-gap separating the two. The optical analogy to this situation is a periodic dielectric structure with alternating high and low values of permittivity, which gives rise to a photonic band-gap

In this paper purily dielectric planer types of EBG structures is designed to suppress surface waves. The EBG structures are designed on the FR-4 substrate having dielectric constant 4.4, thickness 1.6 mm. The unit cell of EBG structure in all three types is taken as 5mm x5mm.

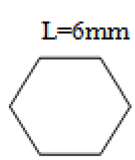
A . RECTANGULAR TYPE EBG



Rectangular EBG strcture is a two dimensional planer type EBG structure. The transmission characteristics depends on the size of patch and structure. The transmission characteristics also depends on the thickness and type of substrate material used. The single unit of ractangular EBG is shown above.

B . HEXAGONAL TYPE EBG

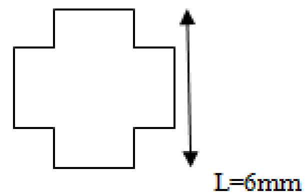
The unit cell of hexagonal type EBG structure is shown below.



A hexagonal patch has been selected instead of the rectangular patch used in case of mushroom type EBG. The hexagonal patch has a side length of 5 mm and the diameter of via used is 0.3 mm. FR-4 is used for the substrate having thickness of 1.6 mm.

C . PLUS SHAPED EBG

The plus shape EBG structure is connected to the bottom plane by a conductive wires at the center with 0.3mm radius. The unit cell of our proposed structure with 5 X 5 mm dimension is shown in the fig.



2. MicroStrip Ptach Antenna With EBG

A. Rectangular EBG

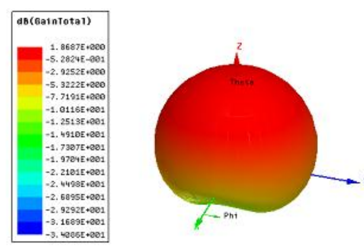


Fig4.Radition Design Of Antenna

IV.RESULT

1. Microstrip Patch Antenna Without EBG

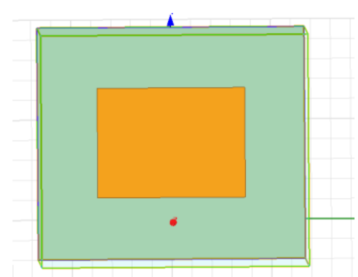


Fig.1:Patch Design

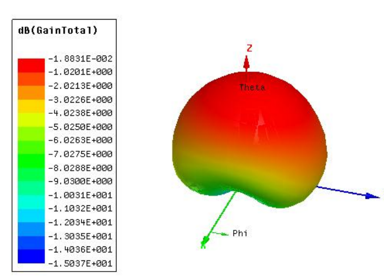


Fig2:Radition Design of antenna

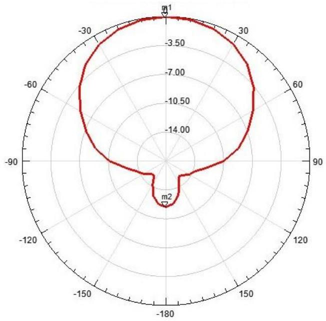


Fig.3:Radition Pattern

VSWR value of antenna is 1.23.Bandwidth is 50MHz.Gain of antenna is -1.88.

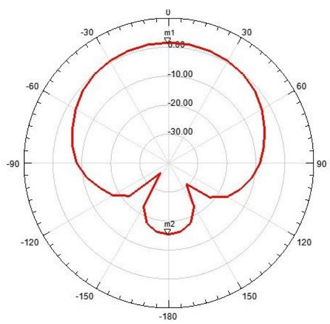


Fig.5:Radiation Pattern

VSWR value of antenna is 1.31and Bandwidth is 60MHz Gain of antenna is 1.86

B.Hexagonal EBG

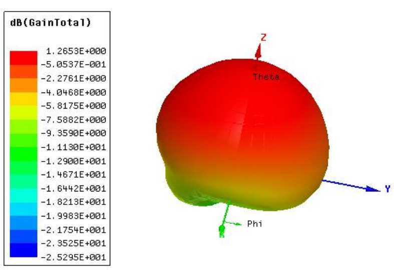


Fig6:Radition Design of antenna

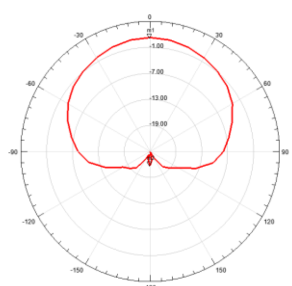


Fig7:Radiation Pattern.

VSWR value is 1.31 and Bandwidth is 50MHz. Gain of antenna is 1.23

C.Plus Shaped EBG

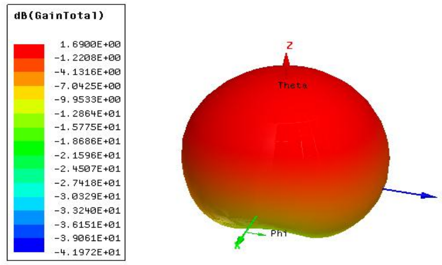


Fig8:Radition Design of antenna

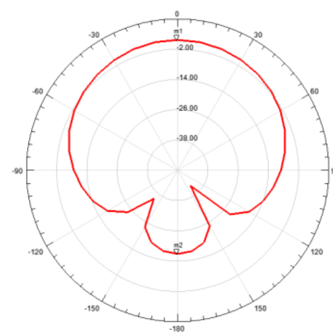
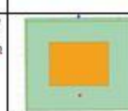
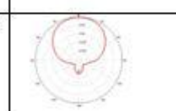
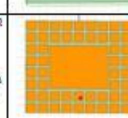
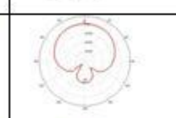
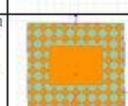
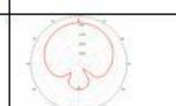
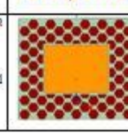
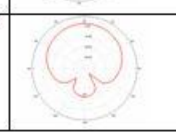


Fig9:Radiation Pattern.

VSWR value is 1.2 and Bandwidth is 60MHz Gain of antenna is 1.69

Table of Comparision

Antenna	Image	Bandwidth	Gain	Radiation pattern	VSWR
Conventional Microstrip patch antenna		50 MHz	-1.88		1.23
Microstrip patch antenna with rectangular shaped EBG		60 MHz	1.86		1.31
Microstrip patch antenna with plus shaped EBG		60 MHz	1.69		1.31
Microstrip patch antenna with hexagonal shaped EBG		50 MHz	1.265		1.2

V. CONCLUSION

We studied the software HFSS (High Frequency Structure Simulator) and designed a microstrip patch antenna with the frequency 2.486GHz. We measured the performance parameters like return loss, bandwidth, radiation pattern and gain. Hence,observed that performance of antenna is improved like bandwidth is increased to 60 MHz ,backlobes are reduced and we saw significant improvement in gain of antenna after using different EBG structures.

REFERENCES

[1] Gaurav Kumar Sharma and Narinder Sharma, "Design of Rectangular Microstrip Patch Antenna by Improving the Performance Parameters with EBG Structures '', International Journal of Computer Applications (0975 – 8887) Volume 95– No.17, June 2014

[2] Komal V. Tumsare and Dr. P. L. Zade, "Microstrip Antenna using EBG Substrate'', International Journal on Recent and Innovation Trends in Computing and Communication, Volume: 4 Issue: 12, PP 73-76, December 2016

[3] Nagendra Kushwaha and Raj Kumar, "Study of Different Shape Electromagnetic Band Gap (EBG) Structures for Single and Dual band Applications'', Journal of Microwaves, Optoelectronics and Electromagnetic Applications, Vol. 13, No. 1, June 2014

[4] "A Low Mutual Coupling Design for Array Microstrip Antennas Integrated with Electromagnetic Band-Gap Structures", 9th International Conference Interdisciplinarity in Engineering, INTER-ENG 2015, 8-9 October 2015, Tirgu-Mures, Romania, Procedia Technology 22 (2016) 549 – 555 Authors : Abdelmoumen Kaabala,* , Mustapha El halaouia, Saida Ahyouda, Adel Asselmana