A Review on Microstrip Patch Antenna with Electromagnetic Band Gap Substrate

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Abstract — In this paper, we have reviewed the behavior of electromagnetic substrates to enhance the gain of antenna. In respect of all the research papers gain is improved up to7.92 db using hexagonal electromagnetic substrates that results in fluctuations in the bandwidth which improves the gain of the antenna. Secondly, we observed that for enhancing the gain of return loss should be minimum. Second factor is bandwidth that needs to be discussed.

Keywords: EBG (Electromagnetic Band Gap), PBG (Photonic Band Gap), HFSS (High Frequency Structure Simulator), Coaxial Feed Antenna

I. INTRODUCTION

In the present time, the enhanced technology of wireless communication is increasing day by day as per the requirements. In prospective to security point of view, wireless sensor network are used in automatic organization and company. Wireless communication systems are used to transmit images and videos with higher data rates [1]. Electromagnetic band gaps which works for both transverse electric field and transverse magnetic field can eliminate the surface waves along the same frequency band. Electromagnetic band gaps are the regular manner structure which are used to transmit electromagnetic waves in the space. Electromagnetic band gap structures can be designed in different dimensions and shapes according to the operating frequencies. Popular EBG structures are, rectangular, circular, fractal and mushroom shapes. EBG structures are formed on either substrate or ground, depending on the application of antenna. According to our survey, if we uses mushroom like structure of the electromagnetic band gaps, it will have half wavelength . This half wavelength structure can be used in microwave applications [2].There are two important properties of electromagnetic band gap , one is reflection phase property and second one is surface wave suspension . First property is used for the applications having phase -180* to 180* and other one is used to improve the gain, minimization of backward radiation and reduction of mutual coupling [4]. Electromagnetic band gaps acts as a artificial magnetic ground plane. EBG designe on the substrates so that it can create band gap around the operating frequencies. Due to this property it can avoid the radiations from radiated in the substrate surface. In this paper, we are reviewing the designing and operations of EBGs Structure. The effect of these shapes is much higher in the substrates as compared to the patches. The rest of paper is organized as follows. The overview of patch antenna & EBG is described in section II & III receptively. Performance parameters are defined in section IV. Related literature survey work is described in Section V. Advantages & applications are described in section VI. The overall conclusion of review paper is described in section VII.

II. Overview Of Patch Antenna

Microstrip patch antenna is small in size, light in weight, so preferred over conventional antenna. These are also known as patch antenna. As printed circuit technology is used in microstrip patch antenna, makes it easy to manufacture either as standalone elements or as elements of an array. There are two parts of microstrip patch antenna. One is substrate & other one is patch. The substrate is made of different material and patch is made of copper metal. Different Cad formulas are used to calculate the dimension of patch antennas. There are two types of substrates, thin and thick. For thin substrate, CAD formula is sufficient for final design of antenna [7].On the other hand, for thicker substrates, CAD formula is used for only initial design but full wave simulation tool is used for final design. The patch antenna is easy to analyses using both transmission line and cavity models. These are most accurate thin substrates.

III. Electromagnetic Substrates

In past decades, electromagnetic band gaps comes from the technology photonic band gap . Photonic band gap concept comes from the idea that when material is drilled, then electromagnetic radiation emits from that hole [7] . The energy emitted in the form of photons. These band gap structures are known as photonic band gap and the regular manner of these structures known as electromagnetic band gap. In 80's Photonic band gap are developed. These structures are able to pass the electromagnetic band gap. These structures are called photonic band gap structures. These are widely used in microwave applications. After using in electromagnetic waves, this technology became famous, termed as electromagnetic band gap [8]. There are five types of EBG structures that are discussed

(a) Mushroom (b) Cross Hair (c) Swastika

(d) Hexagonal patch (e) T Shape Above structures can be modified in accordance to microwave applications. The proposed substrates are of dimension 100 × 50 × 1.5. A rectangular patch antenna made of copper is employed on it. The dimension of patch is 30 ×20 (mm). The design of antenna is based on FDTD method where all the feeding process is assigned to the patch. The feeding point is given (0,-3.5, 0) The proposed antenna is given in fig 1

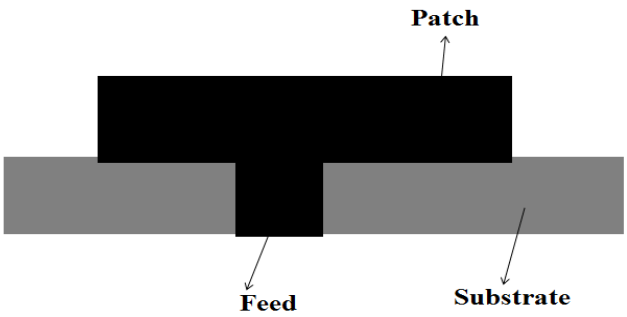

Fig 1 Basic Design of Patch Antenna

The configuration of EBG cells are given in fig 2. EBG cell side 3 mm.& No of EBG Cell: 4× 3

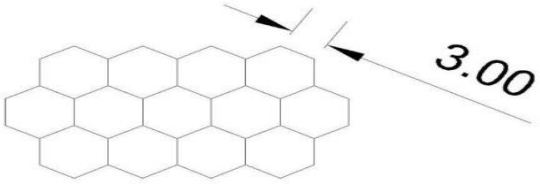

Fig 2. Electromagnetic Band Gap Structure

IV. PERFORMANCE PARAMETER

The other parameter of antenna is to be improve are gain, directivity, bandwidth and return loss [8]. These parameter are as :

1. Directivity is the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. , $D = \frac{4\pi U}{P_{rad}}$

2. Gain of an antennas is the ratio of the intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically.

$$\text{Gain} = 4\pi \frac{Radiation\ Intensity}{Total\ Input\ (accepted) Power}$$

3. The bandwidth of an antenna is defined as the range of frequency within the performance of the antenna. The bandwidth of narrow band and broadband antennas are defined as $B.W = F_h - F_l$

4. Return loss or reflection loss is the reflection of signal power from the insertion of a device in a transmission line or optical fiber. The return loss is given by

$$RL = 10\text{Log}\frac{P_r}{P_i}$$

5. The standing wave ratio (SWR), also known as the voltage standing wave ratio (VSWR), is not strictly an antenna characteristic, but is used to describe the performance of an antenna when attached to a transmission line.

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

V. LITERATURE REVIEW

Authors	Paper title	Research methodology used	Major findings	Research prospects
TahsinFerdousAra Nayna , A. K. M. Baki	Comparative Study of Rectangular and Circular Microstrip Patch Antennas in X Band	Rectangular & Circular patch Design with aperture coupled feed	Return Loss : -18.3 Gain :7.52 B.W : 488 MHz	Used for X-Band Communication
Viorel Ionescu1, MihaelaHnatiuc, Adrian TopaViorel Ionescu1	Optimal Design of Mushroom-like EBG Structures for Antenna Mutual Coupling Reduction in 2.4 GHz ISM Band	Mushroom Shape EBG , specification h = 14.9 mm, g = 4 mm, w = 8 mm , = 4.4 , FR4 Substrate	Return loss : -40.12 db Resonant frequency : 2.42 GHz B.W : 948 MHz	Used for ISM band Communication
KamariahBinti	Fractal Antenna with	circular shaped	Return Loss : - 44.27	Used for WBAN

Ismail NurSyuhadaBinti KhairulShamsudin	Electromagnetic Band Gap (EBG) Structure For Wireless Application	EBG structure , Rogers RT Duroid 5880 substrate , = 2.2 , h = 0.38 , Copper cladding = 0.175	Gain :5.692 B.W : 80.6 MHz	Network
WriddhiBhowmik , Vibha Rani Gupta , ShwetaSrivastava , Laxman Prasad	Gain Enhancement of Butler Matrix Fed Antenna Array System by Using Planar Circular EBG Units	FR4 Substtate 4×4 EBG units , = 4.4 , h = 0.84 16 EBG cells	Return Loss : -48.35 Gain :4.56 B.W : 1.3 GHz	A large no. of beams area available.
Lalithendra Kurra, ,Mahesh P. Abegaonkar, , AnanjanBasu, and Shiban K. Koul	FSS properties of a Uni-planar EBG and its Application in Directivity Enhancement of a Microstrip Antenna	GML 1000 substrate ε_r = 3.2 , h = 0.762 13 × 13 Cells d : 14.5 mm	Return Loss : -29.3 Gain :6.95 B.W : 511MHz	It is used for for aspect transmission as compared to reception.
N.M.Jizat, Yusoff. Z, S.K.A Rahim, M.I.Sabran, M.T.Islam	Exploitation of the Electromagnetic Band Gap (EBG) in 3-dB Multi-Layer Branch-line Coupler	\RO4003 dielectric Rogers substrate having a dielectric constant of = 3.38, a thickness of h = 0.508 mm Cell: 10 × 5	Return Loss : -35.83 B.W : 1.25 GHz	It is used for 5 G Communication
D.Helena Margaret, S.Suba , B. Manimegalai	Band Gap Analysis of a novel C Slot Electromagnetic Band Gap Structure	FR4 Substrate 3×3 EBG units , = 4.4 , h = 2.8 9 EBG cells	Return Loss : -45.3 B.W : 452 MHz	Compactness increases its form fitness for recent wireless devices and the flexibility to hold more EBG cells in available area.

VI. Advantages & Application of Electromagnetic Band Gap

The main advantages of electromagnetic band gap are at the package level and the board level. It includes the reduction of decoupling caps. In discrete system, radiated emission from PCB may be reduced. The data rates of these antennas are fast as compareed to others [9].

The main applications of electromagnetic band gaps are in designing PCB used as Power distribution networks for high speed computer server, laptops , computer etc. On the other hand these are used as ceramic module used as microprocessor chips. Electromagnetic band gaps are used in RF IC Chips for decoupling of RF Amplifiers [10].

VII. Conclusion

In this paper, the studies of microstrip antenna with & without EBGs are defined. The study of effects of Electromagnetic band gap on gain, return loss & bandwidth. The Gain is improved and return loss is minimized with electromagnetic band gap. The net conclusion comes from survey is that EBG substrates are used to eliminate the surface wave and to transmit the transverse electric and magnetic waves

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