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Square Microstrip Patch Antenna For Wireless Communication Using EBG Structure.

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Abstract

Application of Electromagnetic Band Gap (EBG) structures and their utilization in the design of microstrip antenna and embedded microwave circuits is becoming more popular. The integration of EBG structure method is capturing more importance in antenna design because of its uniqueness characteristics to prevent the propagation of surface waves in patch antenna. In this paper a square microstrip antenna is designed and its performance parameters are compared with having EBG structure. The square antenna of 29 mm x29 mm size is designed at 2.455 GHz ad analysis is done using IE3D simulation software. The proposed work mainly focuses on modification of antenna electronic band gap structure (EBG). The antenna performance parameters such as Gain , VSWR, Return loss and Bandwidth, with and without EBG are measured using IE3D simulation tool. The present work focuses on to improve gain and bandwidth so that microstrip patch can used for multi band applications and study effect of EBG on antenna parameters. The Electromagnetic band-gap structures have been used to enhance the performance of the gain of the antennas and antenna radiation pattern [1]. One of the main benefit of electromagnetic band-gap structure is its ability to minimize the surface wave current present in the microstrip antenna. Combining the square microstrip antenna with EBG structure, the frequency bandwidth of the patch antenna has been enhanced by 34.66%, and attained gain of 44.44% at resonant frequency around 2.4 GHz as compared to the microstrip antenna without EBG. The required return loss S11 also attained at -10 dB cut off.

The proposed microstrip antenna exhibits multi band, simple structure with low cost dielectric material. The proposed designed micro strip antenna may find wide applications in ISM, Wimax and Wi-Fi wireless communication systems.

Keywords— *IE3D, electronic band gap structure (EBG), Return Loss, Microstrip Patch Antenna , VSWR, Multiband.*

I. INTRODUCTION

In the present competitive changing global market there has been a tremendous ever-growing demand, for microstrip antenna designs and fabrications for consumer and defense applications because of very thin, having small size, conformal and operating in multi-band or broad band. Conventional antennas generally operates at a single band of frequency, where a variety of antennas are mandatory for diverse communication applications. Therefore the need of requirement of large space for different antenna exists. In order to surmount this drawback, multi frequency range of operation of microstrip antenna can be used where a single antenna can function at several frequency bands. Now a day's microstrip patch antennas are more extensively used due to its various advantages and merits such as compact in size,light in weight, low-profile, less space occupation, conformal, compatibility with microwave integrated circuits, easy to mount on the stiff surface of patch antenna and cost effective. Therefore microstrip antennas are designed to operate in double band or multi-band for wireless applications.

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There are a number of tactics and methods designed and developed over the previous years that could be used to attain one or more of these design goals [2]. Since conventional micro strip antennas have a conducting patch generally fabricated on a grounded dielectric material and operates as resonant cavity elements therefore its operation leads naturally to a limited impedance bandwidth which is a drawback for micro strip antenna applications in wireless telecommunications system also the radiation of electromagnetic energy in different directions from the radiating element of the antenna and excitation of surface waves that are generated in the dielectric substrate layer. Because of this when a patch antenna radiates the undesired surface waves traps a fraction of whole available radiated power down the surface of the substrate, due to this reason i.e. origination of surface waves lowers the efficiency of antenna and degrades the antenna radiation pattern [3-4].

In order to maximize the antenna radiation characteristics the Electromagnetic Band Gap (EBG) framework method is employed on microstrip antenna. Due to possession of it periodic lattices, the electromagnetic band gap structure can provide efficient and adaptable control over the propagation of the electromagnetic waves within a particular frequency band. The electromagnetic band gap structures exhibit multiband, increases impedance bandwidth and improves the input return loss of the patch antenna by suppressing the unwanted surface waves as exposed in figure 1[5]. The integration of electromagnetic band gap slots in microstrip patch antenna design allows enhancement of gain, increased directivity, widening of impedance bandwidth occurs [6].

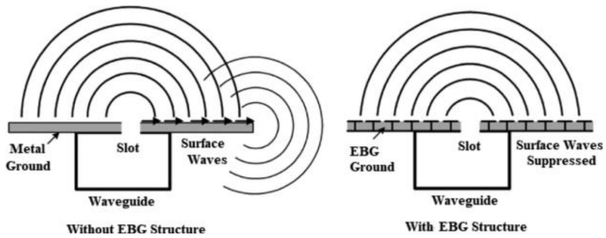

Figure 1:The surface waves cancellation of by the application of EBG

In this work, a bandwidth and gain and multi frequency to be achievable by EBG structure.The simulation results demonstrate that the presented square microstrip antenna with EBG slots operates at multiband frequencies with improved impedance bandwidth, better return loss, and enhanced antenna gain. Therefore, the achievement of the bandwidth, the accomplishment of multi frequency and enhancement of gain of square patch antenna is proposed by EBG

II ANTENNA DESIGN

A. Antenna 1, square microstrip without EBG structure

The microstrip antenna adopted probe feed and a square microstrip antenna size is related to the center frequency fr.
In the proposed design of square microstrip antenna without EBG, the Length “L” and width “W” of the patch antenna performs a significant role in calculating the resonant frequency of operation of the patch antenna. For square Microstrip antennas, the length (L) and width (W) of the radiating patch antenna maintained at 29 mm and the effective dielectric permittivity of the microstrip patch antenna (εr) at the requisite resonant frequency as it support the operation of patch or (λ0= wavelength of free-space) can be designed using the antenna design equations 1 to 5 as given below[7-15]

$$W = \left(\frac{c}{2fr}\right) \left(\frac{\sqrt{2}}{\sqrt{\varepsilon r + 1}}\right) \text{--------------} 1$$

$$\varepsilon r_{eff} = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\sqrt{1 + 12h/w} \text{------} 2$$

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$$L = \frac{c}{2fr\sqrt{\varepsilon r_{eff}}} ----------------3$$

$$\Delta L = L - 2\Delta L -------------4$$

$$\Delta L = 0.412h\frac{(\varepsilon r_{eff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon r_{eff} - 0.258)(\frac{w}{h} + 0.8)} --5$$

where
εreff = Effective dielectric constant
εr = Dielectric constant of substrate
h = Height of dielectric substrate
W = Width of the patch
ΔL= Extension of patch Length

In the formula, c is speed of light, h is the thickness of dielectric substrate, εr is permittivity of dielectric substrate. The patch antenna is simulated using IE3D simulation software Version 15. The antenna 1 is designed using substrate FR-4 with εr = 4.4 as the dielectric constant, thickness 1.6 mm, and the loss factor 0.02. The antenna designed values are optimized with IE3D antenna simulation software tool. The optimization was performed with number of iterations for the best impedance bandwidth, gain and for multiband operation. Diagram 2 demonstrates the geometry of the proposed antenna. The overall measurement of the patch antenna is 29 mm x 29 mm.

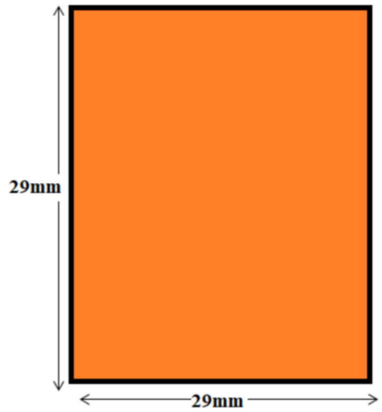

Figure2. Basic Square Microstrip Antenna

B. Antenna 2, square microstrip with EBG structure

Figure 3 shows the configuration of the proposed square antenna with electronic band gap structure of square of 6.5mm size with 1mm gap between them. This structure is compact which has good potential to give high efficiency antenna surface and to build low profile. The antenna is simulated using IE3D simulation software Ver 15. The antenna 2 is designed using substrate FR-4 with εr = 4.4 as the dielectric constant , thickness 1.6 mm, and a loss tangent of 0.02. The antenna designed values are optimized with IE3D antenna simulation software tool. The optimization was performed with number of iterations for the best impedance bandwidth, gain and for multiband operation. Diagram 2 illustrates the basic geometry of the proposed antenna. The probe feeding technique is being used. The overall ground dimension with EBG structures is 44 mm x 44 mm.

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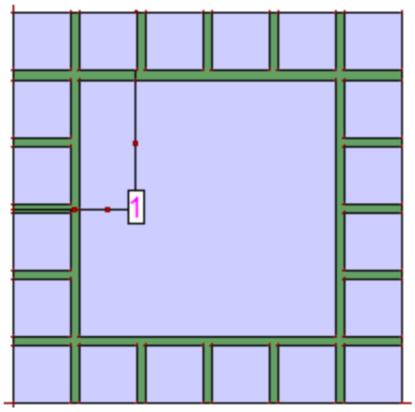

Figure 3.Square Microstrip Antenna with EBG structure

III. RESULTS AND DISCUSSION

Methods to boost the antenna gain can be obtained by replacing the material or by utilization of substrate; however by utilizing simple design and by incorporating EBG structure on microstrip patch a good desired gain as well bandwidth can be attained. Many optimizations are carried out by altering the EBG shape and size to get better results of the antenna radiation characteristics as shown in Table 1. The simulated readings obtained chosen to act as a good antenna radiator which is enlightened in Table 1. Diagram 4 shows the comparative analysis of return loss S11 for the proposed antenna 1 and 2. The figures 5 and 6 shows the 2D radiation pattern of the proposed patch antennas 1and 2.

Table 1. DESIGN SPECIFICATION

Type of Antenna	Resonant Frequency In GHz	Return Loss(S11) In dB	BW In MHz	Gain db
Without EBG	2.44914	-23.4234	49.0927	-3.239
	4.49829	-14.0018	111.0170	-2.807
	5.51057	-11.4546	60.4930	-8.310
	7.28298	-25.1392	172.1380	0.401
	8.97482	-27.6555	176.1940	-7.782
With EBG	2.3957	-16.9489	75.511	2.590
	4.7432	-17.4004	131.794	2.540
	5.46828	-24.2630	178.797	0.581

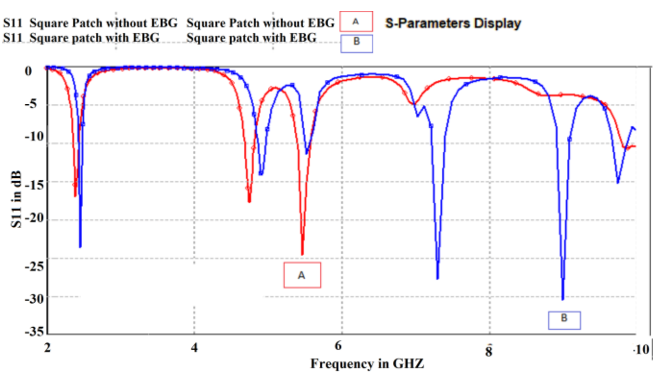

Figure 4 . Square microstrip antenna comparison of S11 with and without EBG

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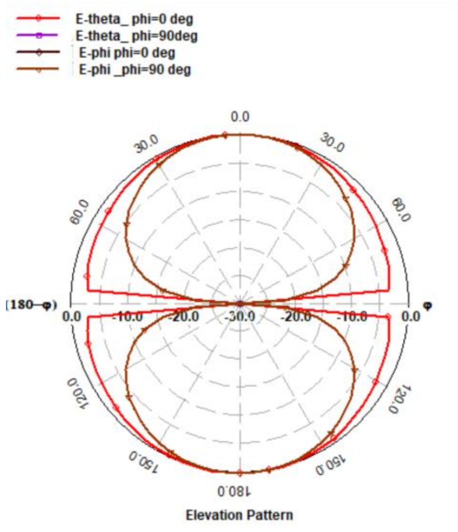

Figure 5 . Simulated square microstrip antenna without EBG, 2D Radiation Pattern (Phi = 90 degrees).

The result shows that the antenna 1 square patch without EBG has omnidirectional radiation pattern at 2.44GHz as shown in figure 5. The simulated antenna gain is -3.2dbi at 2.44GHz. The antenna 1 operates at multiband having good return loss resonanance frequencies 2.44914 GHz, 4.49829 GHz & 5.51057 GHz, 7.28298 8.97482 12.3907 with BW of 49.0927 MHz, 111.0170 MHz ,60.4930 MHz, 172.1380 MHz , 176.1940 MHz & 165.112MHz with gain of -3.239 dB, -2.807 dB, -8.310 dB, 0.287dB, and -7.782dB respectively which are well suited for ISM and Bluetooth.The antenna radiation pattern shows omnidirectional characteristic.

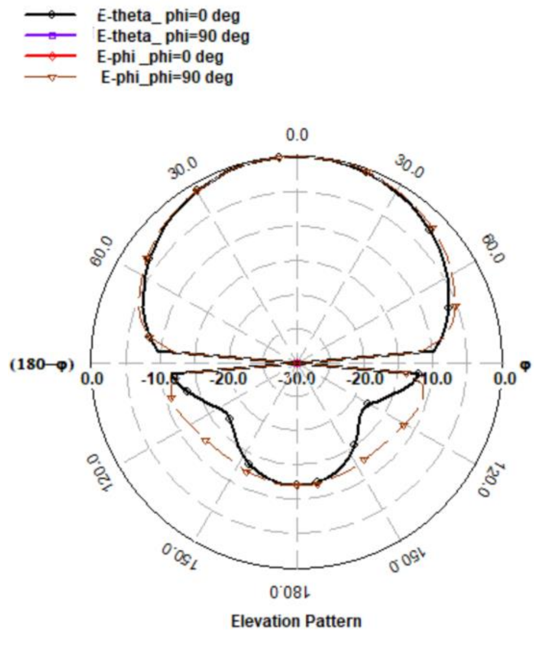

Figure 6 Simulated square microstrip antenna with EBG 2D Radiation Pattern (Phi = 90degrees).

The antenna 2 (square microstrip antenna with EBG)) operates at multiband having good return loss of 16.9489 dB , 17.4004 dB & 24.2630dB at resonant frequencies 2.3957 GHz, 4.7432 GHz & 5.46828GHz with BW of 75.511 MHz, 131.794 MHz & 178.797 MHz and gain of 2.590dB, 2.540 dB & 0.581dB respectively which are well suited for ISM, Bluetooth, Wifi and Wimax applications.The antenna radiation pattern shows omnidirectional characteristic at 2.3957GHz. The

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diagram 6 depicts that antenna 2 (square microstrip antenna with EBG) is much more directional and has enhanced gain and Bandwidth as compared to antenna 1.

IV.CONCLUSION

Square shaped patch antenna with EBG slot has been studied and investigated. The investigated antenna geometry shows overall optimum results compared to the conventional squarer microstrip antenna. From the proposed antenna design and analysis done here, it can be concluded that the square microstrip patch antenna with EBG slots exhibits improved results over the traditional square microstrip patch. The operating frequencies obtained with optimum results are 2.3957GHz with the BW of 75.511MHz and 5.46828GHz with BW of 178.797MHz. These frequencies are useful for applications in S band (unlicensed applications) like Wi-Fi, ISM, LTE, and Blue tooth modules. The third frequency is obtained at 4.7432 GHz frequency with a bandwidth of 131.794 MHz and Gain of 2.540dB. The proposed antenna geometry results are suitable in WIMAX applications.

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