ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization, *Volume3, Special Issue 6, February 2014*

National Conference on Emerging Technology and Applied Sciences-2014 (NCETAS 2014)

On 15th to 16th February, Organized by

Modern Institute of Engineering and Technology, Bandel, Hooghly 712123, West Bengal, India.

A Novel Compact EBG Structure for the Improvement of Microstrip Antenna Parameters

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ABSTRACT: In this paper a new mushroom like electromagnetic band gap arrangement for development in antenna parameters is represented. The represented arrangement also gives an extra degree of liberty to regulate the band gap position, which is useful to design a new reconfigurable multiband EBG construction. The major purpose behind utilizing EBG structures in Microstrip Patch Antenna is to attain enhanced gain, effectiveness and isolations amongst array elements by restraint of surface wave modes.The major concept illustrated in this paper is by drawing numerous correct shapes in the metal surface of the mushroom-like compact EBG cell so as to initiate stop band in electromagnetic band gap arrangement. EBG structures includes two chief configurations, first EBG substrate and second EBG superstrate. In first case, the patch of antenna is enclosed with EBG arrangement that restrain the propagation of surface wave and in second case, layer of EBG structure that call EBG superstrate or metamaterial superstrate set beyond the patch of antenna. Simulated consequences authenticate the development in performance of the antenna array compared to the array antenna without EBG. From the simulated effects it is observable that radiation patterns are unaffected by EBG arrangements that are on the feedline and other antenna functioning parameters are developed by utilizing antenna with EBG arrangements. Ultimately EBG Patterns insertion in Microstrip Antenna increases the bandwidth of the antenna by placing the feedline below the center of the patch.
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KEYWORDS: Microstrip patch antenna, Electronic Band Gap Structure, IE3D

I. INTRODUCTION

With the quick development of wireless markets, Microstrip antennas became more desirable in antenna community. These microstrip antennas are low-profile, low cost and light weight. Nevertheless, surface waves are a main disadvantage for this kind of antenna as they have a tendency to decrease the antenna efficiency. Two methods have been utilised to surface surface wave propagation, that is to say micromachining and utilizing periodic arrangements termed as the electromagnetic band gap (EBG) arrangements [2]. Multiplicity of EBGs have been offered and considered, as the EBGs present a few distinctive features, like forbidden band gap, in- phase reflection, etc. EBG's are classified majorly in three group's according to their formation. The EBG structure always utilized as a part of antenna arrangement in order to develop the functioning of the antenna specially for improvement of the gain and radiation pattern. They are (a) 3-D volumetric arrangements, (b) 2-D planar surfaces and (c) One dimensional transmission lines. The 2-D planar surfaces have the benefits of low profile, light weight, low fabrication cost and are extensively contemplated in antenna engineering. implementation of EBG's arrangements in antenna effects in enlarged radiation effectiveness of device and enhance in antenna directivity. It allows an added control of the behavior of electromagnetic waves other than usual guiding and or filtering structure [3].

II. THEORY OF EBG

Electromagnetic Band Gap (EBG) structures are non periodic arrangements that expose distinctive electromagnetic attributes, like frequency band gap for surface waves and in-phase reflection coefficient for incident plane waves, which makes them advantageous for low-profile antenna designs. The important attribute of EBG arrangements is to demonstrate band gap attribute in the repression of surface-wave propagation. This quality assists in improving the antenna's performance such as to increase the antenna gain and decrease back radiation.[5]. It focused on four major parameters that control the total operation of the antenna design. The design parameters are specifically patch width W, the spacing between mushroom-like EBGs, substrate thickness h and substrate permittivity ε_r. In this paper, the analysis is concentrating not only on W, s and h [4], but also on the spacing between patch element, and the number of rows of the EBG fixed between the patch elements. Mushroom-like EBG include a ground plane, a dielectric substrate, metallic patches using the linking between the patches to the ground plane. The central frequency of the band gap can be expressed as

$$f = \frac{1}{2\pi\sqrt{LC}}$$

III. ANTENNA CONFIGURATION

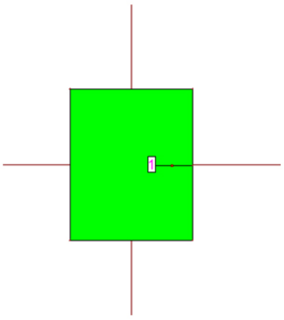

Fig. 1 (a) Geometry of Antenna structure without EBG

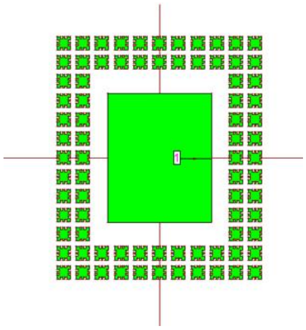

Fig. 1 (b) Antenna Structure with EBG

The antenna geometry demonstrated in Fig.1 (a) without EBG has only one patch, which is simpler than conventional broad-band Microstrip Antennas. Antenna is designed with the help of co-axial feed to resonate at frequency of 3.5 GHz. The patch is accumulated on a glass substrate with comparative permittivity, ε_r= 2.2. Here the patch length ,patch height and patch width are considered as 27.22 mm, 2mm and 33.8 mm respectively. The antenna portrayed above in Fig.1 (b) includes designing of Microstrip Patch Antenna with EBG having resonant frequency of 3.5 GHz. Length and width of EBG patch is 0.5 mm.

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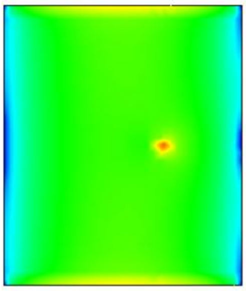

Fig. 1(c) Current Distribution structure without EBG

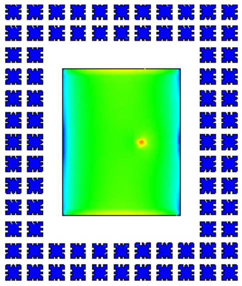

Fig. 1(d) Current Distribution structure with EBG

The figure presented in Fig.1 (c) demonstrates the current distribution performance of Microstrip patch without EBG at 3.5 GHz excitation. The important alterations in radiation pattern of arrays can be attained by altering current distribution array of the antenna, including phase delay between elements, alteration in the radiation uniqueness of individual emitting arrangement in an array, alteration in the geometry of the array and by varying the inter-element spacing. The figure presented in Fig.1 (d) shows the current distribution characteristics of Microstrip patch with EBG at 3.5 GHz excitation. The significant change in radiation pattern of arrays can be obtained by altering current distribution array of the antenna, including phase delay among elements, variation in the radiation features of individual emitting arrangement in an array, alteration in the geometry of the array and by varying the inter-element spacing.

IV. DESIGN SPECIFICATIONS

1. Calculation of patch width (w) computed by the formula

$$w=\frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \tag{1}$$

Where, v_0= speed of light in free space, ε_r =dielectric constant of patch

2. Determination of effective dielectric constant ε_{reff} computed by the formula

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

Here, h and w denote the height of the patch, width of the patch respectively.

3. Determination of increment of patch length (Δl) computed by the formula

$$\Delta l=0.412\frac{(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{w}{h}+0.8)} \tag{3}$$

4. Calculation of patch length (l) computed by the formula

$$l=\frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_0\varepsilon_0}}-2\Delta l$$

(4)

Here, $f_r, \varepsilon_{reff}, \mu_0, \varepsilon_0$ signify the resonant frequency of antenna, effective dielectric constant of antenna, permeability of the substrate, permittivity of the substrate respectively. In this paper we have considered f=3.5GHz, h=2mm, ε_r =2.2, length and width of EBG patch= 0.5mm.Putting the values in the above equations we get the length of patch is 27.22 mm and width of patch is 33.8 mm. We have considered the feed point which is 4.66 mm from centre.

V. PERFORMANCE EVALUATION

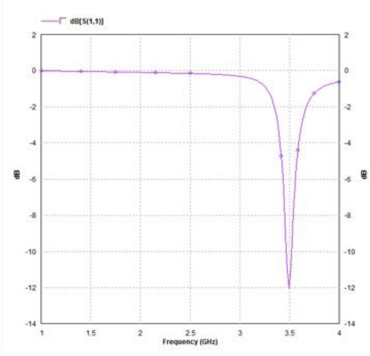

Fig. 2 (a) Return Loss characteristics of antenna without EBG

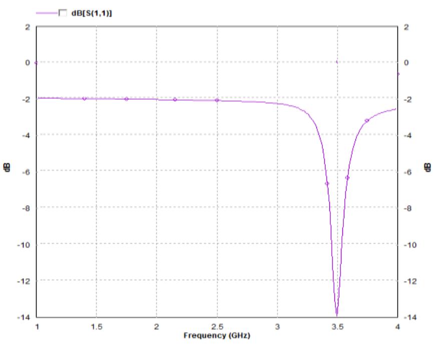

Fig 2(b) Return Loss characteristics of antenna with EBG

The graph in Fig. 2 (a) demonstrates the Return loss without EBG acquired at 3.5 GHz frequency about -12 dB. Return loss is associated to both standing wave ratio (SWR) and reflection coefficient (Γ). It is a calculation of how well devices or transmission lines are corresponded. The graph in Fig. 2 (b) demonstrates the Return loss with EBG attained at 3.5 GHz frequency about -13.75dB. Return loss is associated to both standing wave ratio (SWR) and reflection coefficient (Γ). It is a determination of how well devices or transmission lines are matched.

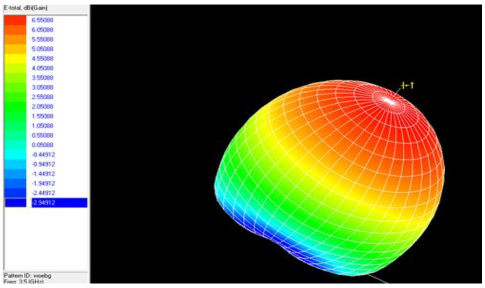

Fig. 2 (c) Gain pattern without EBG

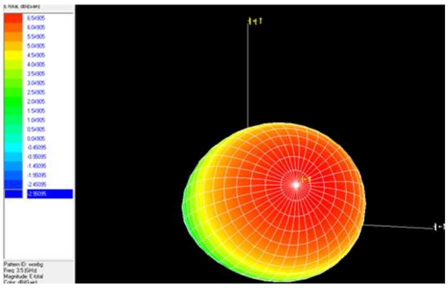

Fig. 2 (d) Gain pattern with EB

Fig. 2 (c) illustrates the three dimensional pattern of gain without EBG in dB scale for the antenna. Gain as a parameter calculates the directionality of a specified antenna. An antenna with a low gain emits radiation in all directions uniformly, while a high-gain antenna will specially emit in specific directions. Fig. 2(d) demonstrates the 3D pattern of gain with EBG in dB scale for the antenna. Gain as a parameter computes the directionality of a specified antenna. An antenna with a low gain discharges radiation in all directions uniformly, while a high-gain antenna will radiate better in specific directions.

VI. DISCUSSION

From simulated study of the designed antenna it can be simply observed that the designed Antenna with EBG has proper return loss less than -10 dB. i.e.-14 db contrasted to return loss of -12 dB without EBG. The best consequences of offered antenna demonstrated and investigated with the help of IE3D SIMULATOR. Finally, EBG arrangements progress return loss, gain and beam shaping of microstrip antenna. When EBG arrangements are utilized as substrates, they aid to minimize surface waves. Nevertheless, the design can be simply extended for the frequency normalized arrangements and the patch antenna of necessitated specifications can be then designed methodically and the present work does not represent a single design, as an alternative of a set of best possible designs utilizing the EBG structures.

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BIOGRAPHY

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