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Unit Cell of EBG Analysis in Inside the Wave Guide of E-Plane Horn Antenna

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Abstract: ***In this paper we design and analyze a EBG based E-plane horn antenna. The idea is to analyze. The E-field distribution in the wave guide and the E-plane part in normal case and then we place a one or two unit cells of EBG's in the wave guide part. And the unit cell consists of cylinder pin organized in a two-dimensional lattice pin have inner side of wave guide at one side and the square patch at other side which is inside of wave guide . The E-field distribution analysis is analyzed and presented in this paper.***

Keywords: Energy Band gap structures, Fringing fields, E-field, H- Field.

1. INTRODUCTION

This research paper demonstrates an EBG effect on field distribution of the wave guide. Generally the E-Plane horn antenna will have E1H1J field distribution throughout its inner area. Now we will explain how this will be restricted by a unit cell of EBG. This EBG is an artificial material called as Meta material which obtains its properties from its structure instead of directly from its composition in general this EBGS is synthesized by embedding different and special inclusions, like periodic structures, in a host medium. So far different varieties of Meta materials were invented. Researches [1] used the grid structure as a highly directive super state suspended over a patch antenna and demonstrated its operation , and a high gain and low profile electromagnetic band gap antennas based on frequency selective surface FSS type meta materials are studied [2] . A review of the high gain antenna design using periodic structures was explained [16].

2. DESIGNING OF ANTENNA

For the analysis purpose we have used a E-plane horn antenna with a wave guide part of 5×4.5×1 inch size and a horn part as shown in the following figure 1[a] and for EBGS Based design two unit cells with pillar size 0.1 inch radius and height 0.4 inch was connected to the inner wave guide and to the square patch of 1×1×0.1 inch is shown in figure 1[b].

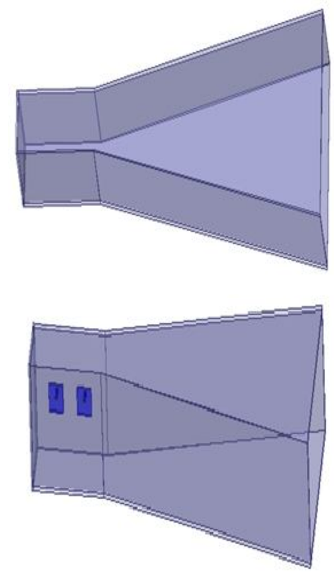

Figure [1]. A)E-plane Horn Antenna B) E-plane Horn Antenna with two EBG unit cells inside the wave Guide

Here in the figure 1(B) we can see that how the unit cells of EBGS are inserted inside the Wave guide part of the E-plane Horn Antenna here both were spaced equivalently the design is for analyzing how the EBG will change the EM waves propagation in the antenna indirectly this idea will enable us to know the working of EBG as in the references the EBG's patch will exhibits the capacitance and pillar will exhibits the inductance together they form a High Impedance Structure and pillar will have current flow through it when the design is subjected to excitation. For that analysis we will check how the E,H and J filed distributions in conventional type E-plane horn antenna 1(A) and then for 1(B). And compare the results to know the effect of EBG on EM wave propagation when it is in the path of its propagation area.

3. EBG UNIT CELL

The behavior of this structure is similar to an LC circuit in Figure [2] Below the resonance frequency, the surface is inductive, while above resonance frequency, the surface is capacitive. Consider

$$\omega_0 = \frac{1}{\sqrt{LC}}. \quad ,(1)$$

Nearby $\omega 0$, the surface impedance (*Zs*) is much higher than the impedance of free space, as (2) depicts. Therefore, no vertical or horizontal propagation modes are allowed. Consider

$$Z_s = \frac{j\omega L}{1-\omega^2 LC}, \quad ,(2)$$

Where the capacitance *C* is provided by the proximity of the metal plates, according to (3) [19] as follows:

$$C = \left[\frac{w\varepsilon_0(\varepsilon_{\mathrm{eff}})}{\pi}\right]\cosh^{-1}\left(\frac{2w}{g_0}\right) \quad ,(3)$$

and the inductance *L* (4) is related to the thickness of the structure, because its value is due to the length of the via as follows:

$$L = \mu_0 t. \quad ,(4)$$

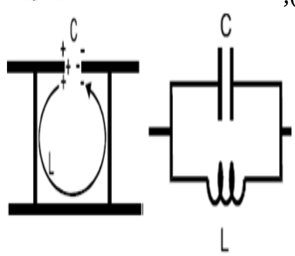

Fig [2] EBG Unit cell, its equivalent

4. SIMULATION RESULTS

4.1 Return loss

Return loss of the horn antenna may decrease when an obstacle as EBG cell is inserted in wave guide but it will enhance the BW of the antenna the comparison of return loss curves were illustrated in the following figure [3].

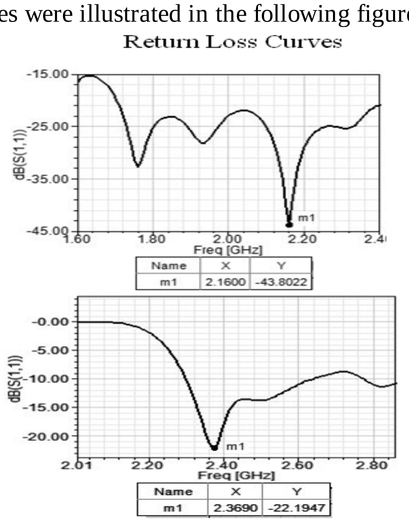

Figure [3] Return loss curves a) without EBG b)with EBG

4.2 Total Gain in 2D

This graph will explain the radiation improvement in the antenna the EBG cell will affect the operating frequency of the antenna and also results in increasing the gain of the antenna. This is shown in the following figure [4].

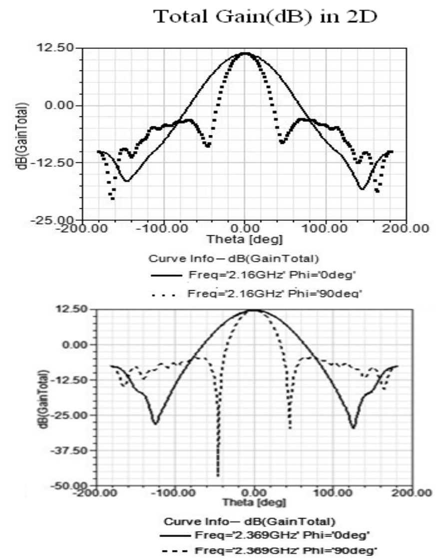

Figure [4] Gain(dB) in 2D a)without EBG b)with EBG

4.3 Total Gain in 3D

Here by the view of 3D gain curves we can see that the radiation can be minimized but we can maintain the coverage of the antenna as gain also indirectly indicates radiation from antenna this will be seen in the following figure [5]. Where the maximum value dropped from 9.20 to 8.51dB. But the Gain lobe in 5[b] is wider than 5[a].

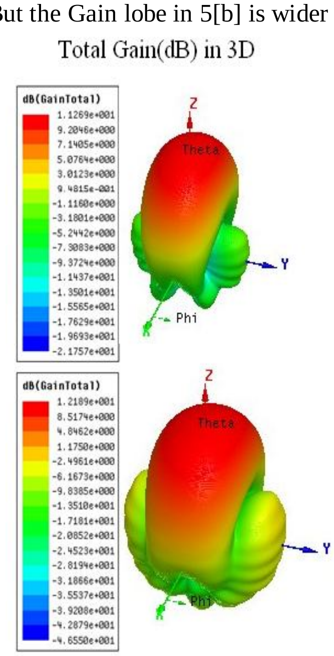

Figure [5]. Gain in 3D curves a) without EBG b) with EBG

4.4 E, H and J field Distribution

The Electric, Magnetic and Current distribution in the wave guide in normal condition and the variation when EBG is inserted is explained by the Figure [6]. The EBG will affect the EM waves that are propagating in the wave guide.

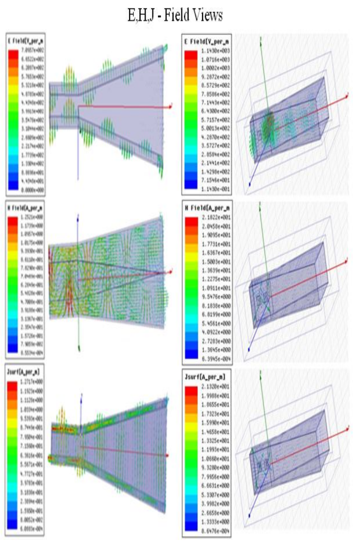

Figure [6]. E, H and J filed distribution comparison in E-plane Horn Antenna

The analysis can be easily explained when we see this Fields variation where we have placed the EBG for the easy understanding it is clearly shown in the Following figure [7].

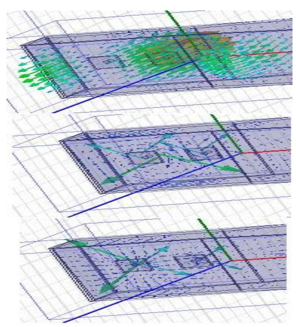

Figure [7] E, H and J field variation at EBG cells

From the above figure [7] we can see that these fields' variations manly concentrated at the EBG cells

5. ANTENNA PARAMETERS

The general parameters of the antenna are illustrated in the following table [1]. To compare the antenna parameters in the cases of normal antenna and after EBG is placed.

Quantity	Value	
Max U	1.06568(W/sr)	1.30925(W/sr)
Peak Directivity	13.0423	16.2145
Peak Gain	13.3928	16.5523
Peak Realized Gain	13.392	16.4529
Radiated Power	1.02681(W)	1.0147(W)
Accepted Power	0.99994(W)	0.993993(W)
Incident Power	1(W)	1(W)
Radiation Efficiency	1.02688	1.02083
Front to Back Ratio	136.14	96.727

Table [1] Antenna parameters comparison

By the table we can see that all the parameters of the horn antenna were enhanced but only the front to back ratio was reduced when the EBG is inserted.

CONCLUSION

The paper will conclude the analysis of the EBG cell under the wave guide and the EBG will definitely have current passing through its via and Fields emitting through them and in results this EBG cells will enhance the antenna parameters but the reverse also possible that the radiation may be decreased or reduced from the antenna this will help us preventing the extra radiation coming out of the antenna

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