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E, H and J field Variation in H-Plane Horn Antenna when EBG unit Cell is placed inside the Wave Guide

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***Abstract*— In this paper we design H-plane horn antenna working in ionization band. The idea is to analyze the E,H and J-field distribution in the wave guide and then the same is conducted by making the H-plane part unchanged we place three 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 the wave guide . here the surface waves from EBG cells will affect the space waves or propagating wave in antenna thus it will change EM wave propagation in the horn antenna. To illustrate this in this paper the E,H and J-field distributions are analyzed. Results are compared and presented in this paper.**

***Index Terms*— Energy band gap surfaces, TE and TM modes, phase shift in wave propagation, Field distributions.**

I. INTRODUCTION

In recent years the artificial magnetic conductors are very much used in communication engineering. Due to the capability of them we can use them as replacement of ground plane or reflectors [5]. They can be used to enhance the radiation or absorb unwanted radiation leakage [1,3]. Originally they are implemented for surface wave suppression but later on they are extended to several applications. In this research paper explains the effect on field distribution of the H-plane Horn antenna when EBG unit cells are placed inside its wave guide. Generally the H-Plane horn antenna will have E, H, and J field distribution throughout its inner area. Now we will explain how this will be restricted by the unit cells of EBG. These EBGS are also called as High impedance surfaces, mushroom like structures, Frequency selective surfaces, Artificial Magnetic conductors and also referred as meta-materials. These meta-materials are well used in now a day's research in antenna and communication systems.

II. DESIGN OF ANTENNA

For the analysis purpose we have used a H-plane horn antenna with a wave guide part of 10×4.7×2.2 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 0.5 inch was connected to the inner wave guide and to the square patch of 1×1×0.05 inch is shown in figure 1[b].

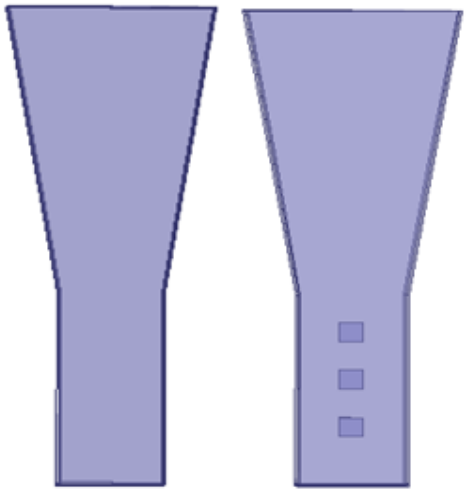

Figure [1]. A) H-plane Horn Antenna B) H-plane Horn Antenna with two EBG unit cells inside the wave Guide

III. 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

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

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

Where the capacitance C is provided by the proximity of the metal plates,

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

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

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

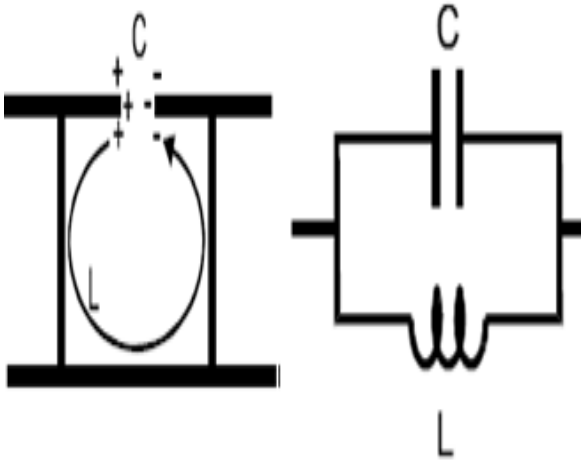

Fig [2] EBG Unit cell, its equivalent

IV. SIMULATION RESULTS

A) 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].

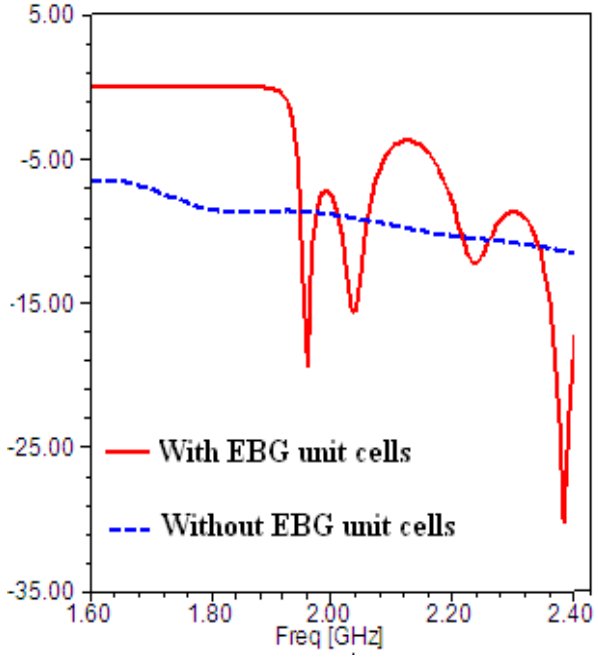

Figure [3] Return loss curves

B) Total Gain in 2D

This graph will explain the radiation phase shift in the antenna when the EBG cells are placed. If we observe the following figure [4] we can see that the three unit cells are causing 180° phase shift between phi=0° curves for conventional antenna and antenna with EBG cells and for phi=90° curves also there is 180° phase shift.

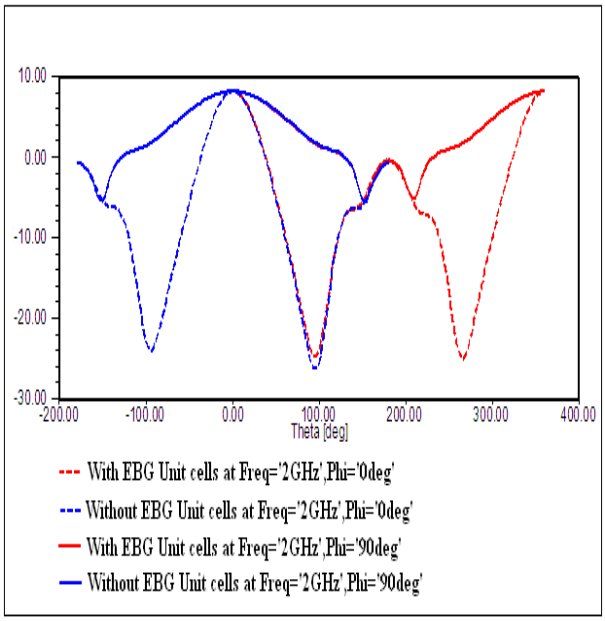

Figure [4] Gain(dB) in 2D

C) Total Gain in 3D

The Gain in 3D is illustrated in the following figure [5].

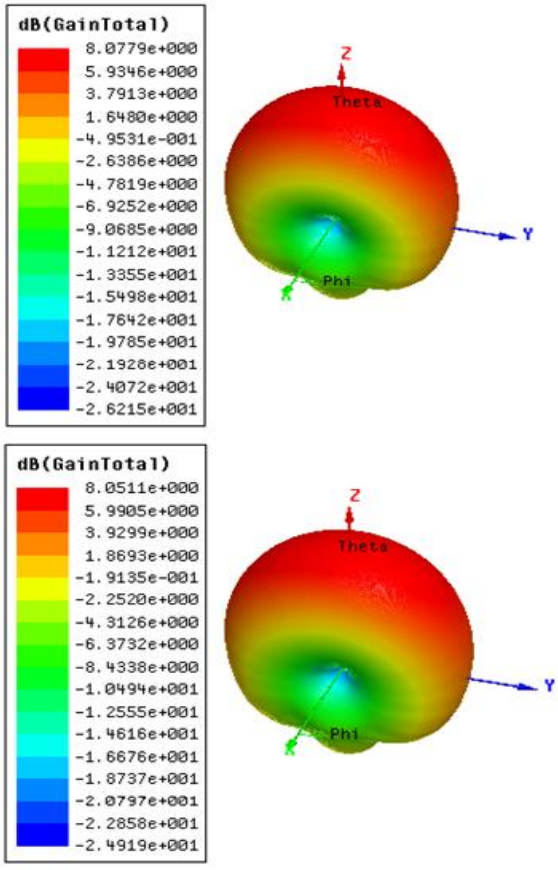

Figure [5]. Gain in 3D curves A) H-plane Horn Antenna B) H-plane Horn Antenna with two EBG unit cells inside the wave Guide

D) Impedance curves

The impedance curves comparision is shown in the following figure [6].

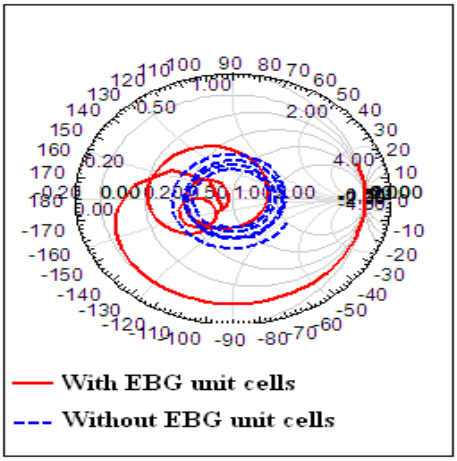

Figure [6]. Impedance curves

E) E- Field analysis

The below figure [7] shows the E- field distribution in H-plane horn antenna comparing when EBG is placed.

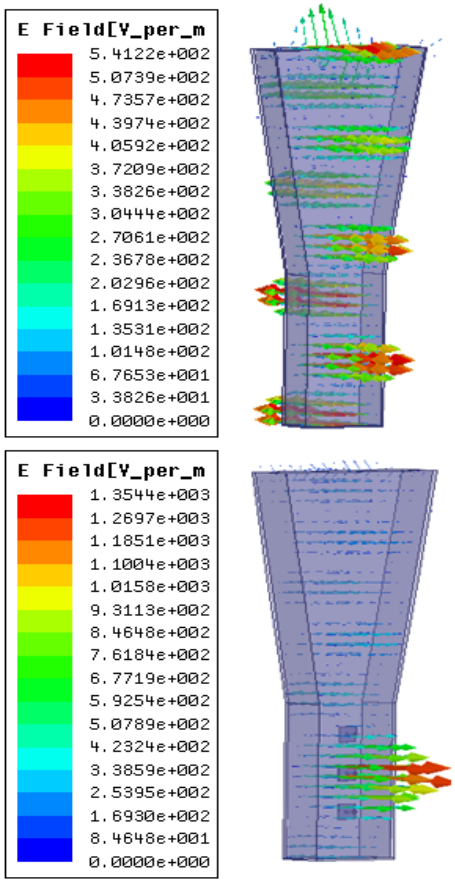

Figure [7]. E- field analysis comparision for antenna without and with EBG

Generally for EBG planes in TE mode it is in the direction of via like passing through inductance and it is bound at one cell and emitts at next successive cell and the above figure depicts the same.

F) H- Field analysis

The below figure [8] shows the H- field distribution in H-plane horn antenna comparing when EBG is placed.

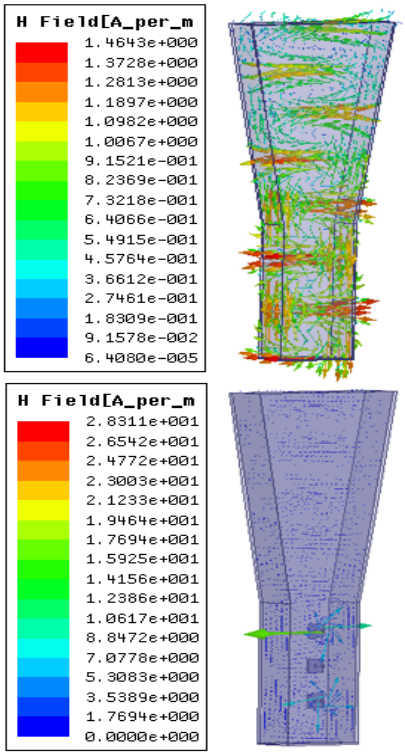

Figure [8]. H- field analysis comparision for antenna without and with EBG

In EBGS the TM mode is in the direction of wave propagation in the surface of EBG patch tangential to the via.

G) J- Field analysis

The below figure [9] shows the J- field distribution in H-plane horn antenna comparing when EBG is placed.

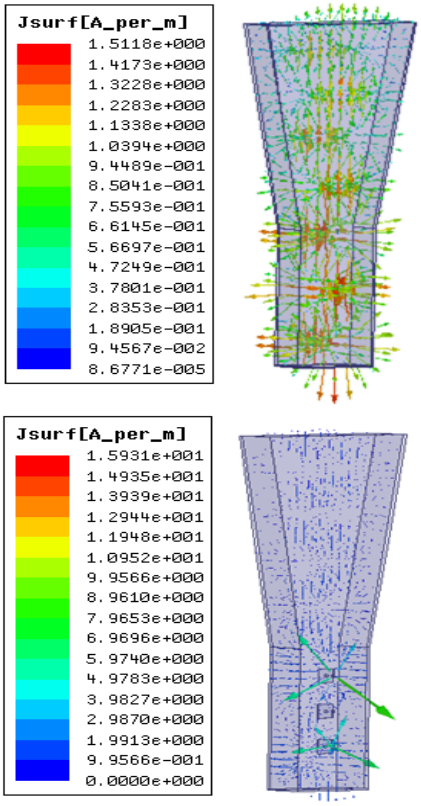

Figure [9]. H- field analysis comparision for antenna without and with EBG

V. ANTENNA PARAMETERS

the general antenna parameters are presented in the following table [1]. The table compares the parameters like gain, directivity, efficiency etc. between the conventional antenna and the antenna with EBGS.

Table [1] Antenna parameters comparison

Quantity	Value	
Max U	0.44383(W/sr)	0.419806(W/sr)
Peak Directivity	6.35069	6.2762
Peak Gain	6.42378	6.38422
Peak Realized Gain	5.57747	5.27556
Radiated Power	0.878246(W)	0.840567(W)
Accepted Power	0.868253(W)	0.826344(W)
Incident Power	1(W)	1(W)
Radiation Efficiency	1.01151	1.01721
Front to Back Ratio	7.65987	7.20151

VI. CONCLUSION

The paper will conclude the analysis of the E,H and J filed analysis when EBG cell in the wave guide of H-plane horn antenna. And also the TE and TM modes in EBG cells when they are subjected to antenna radiation. So that wave propagation is changed due to this EBG cells and the phase shift in the wave occurs.

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