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Surface wave suppression band, In phase reflection band and High Impedance region of 3DEBG Characterization

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ABSTRACT

A three dimensional electromagnetic band gap (3DEBG) structure is designed to operate at 3.95GHz. It's surface properties are analyzed using FEM based HFSS software so as to define (i) Surface band gap (ii) In phase Reflection band gap (iii) High impedance regions. A transmission response was calculated using both suspended strip line method and simulation method, from obtained results a band gap of 310MHz (i.e from 3.91GHz to 4.22GHz) is considered as surface band gap. In phase reflection band gap of 50MHz (i.e from 3.92GHz to 3.97GHz) measured between -90^0 to $+90^0$ of reflection phase curve of 3DEBG unit cell. The advantage of each property of 3DEBG is in microwave antenna environment is described in detail.

Keywords: Surface Wave (SW), In Phase Reflection, High impedance, 3DEBG unit cell,

1. Introduction:

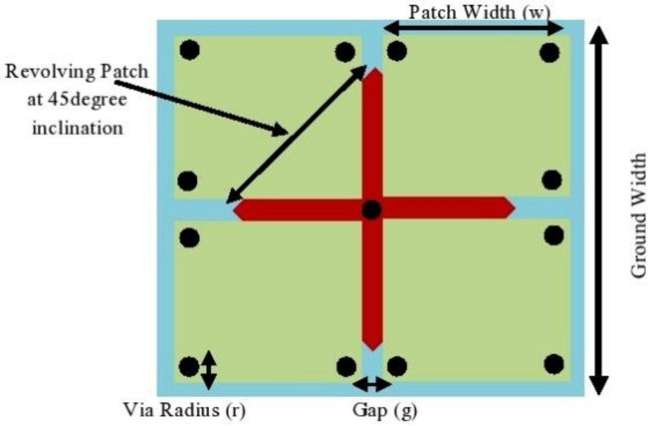
In the late 1990s, new forms of artificially fabricated metallo-dielectric electromagnetic structures were proposed for radio frequencies and microwaves [1]. Since then, these periodic lattices are have become known as Electromagnetic Band Gap (EBG) structures, which are categorized as a class of Metamaterials [2]. These EBG structures exhibits an electromagnetic properties such as in-phase reflection and surface wave suppression [3] and thus they have attracted increasing interest in the electromagnetic and antenna community. Their designs have flourished, and a wide variety of materials and geometries have been investigated [4-7]. In present paper, a 3DEBG (three dimensional electromagnetic band gap) structure is developed. This has ability to produce universal band gap unlike 2DEBG. This 3DEBG exhibits high surface impedance for both transverse electric (TE) and transverse magnetic (TM) polarisations and can suppress surface wave propagation at certain frequency ranges. This property helps to increase the antenna band width, minimize backward radiation, and reduce mutual coupling. Hence, they can play an important role in developments of new applications in wireless radio communications, antenna engineering and beam steering.

2. 3DEBG Unit Cell Modeling:

The architecture of 3D EBG, contains an optically planar ground plane, dielectric substrates (FR4 with a permittivity 4.4, loss tangent 0.02 and Air with permittivity 1, zero loss tangent) arranged in ascending order by making patch as reference. Square metal patches (protrusions) are arranged in three dimensional (The gap that exist between adjacent metal protrusions produces the capacitance due to fringing fields and parallel plate capacitance, develops in between the overlapping area that exist between metal protrusions of upper and lower layer, lower layer and ground). The square metal protrusions on both the upper and lower layer are shorted to ground plane with the help of via. The top view and side view of 3D EBG arrangement is shown in Figure 1. The proposal can be fabricated with the help of multi-layer PCB technology. The dimensions are listed in table 1.

Table 1. 3D-EBG Parameters

Parameter	Representation	Size	Units
Top patch width	W_a	43	Mm
Top patch length	W_b	43	Mm
Gap	G	1.5	Mm
Revolving patch width	Wh_a	56	Mm
Revolving patch length	Wh_b	56	Mm
Via radius	R	1.05	Mm
Height of 3DEBG	H	62	Mil
Thickness of substrate	T	31	Mil



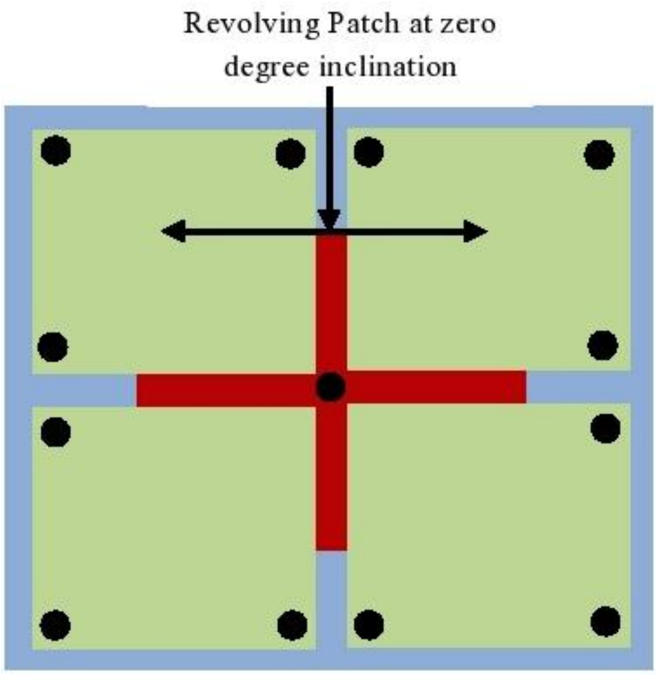


Fig.1. 3D EBG Unit cell top view

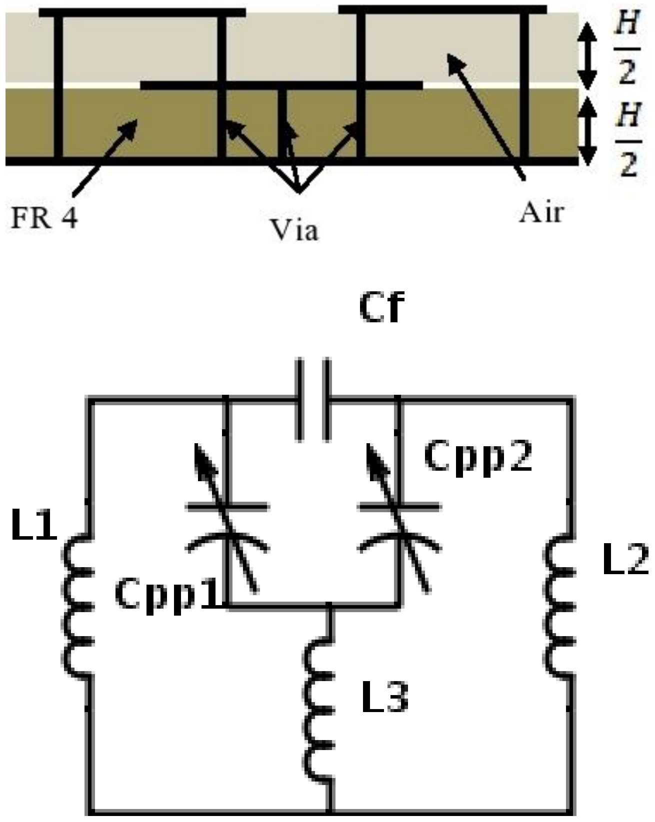


Fig. 2. 3D EBG Unit cell side view and its electrical equivalent

3. Analysis of 3DEBG Unit Cell

3.1. Effective Medium Model

Initially the structure is analyzed and It's operating frequency derived with the help of effective medium model (EMM) technique. The electrical equivalent of 3D EBG is shown in bellow figure 2. Its surface is filled with lumped parameters. The propagation of surface waves will introduce currents and causes charges to accumulate at the edges of patches. Thus, capacitance is introduced. The inductance is provided due to thin conducting via.

The C_{pp1}, $C_{pp2,}$ C_{pp3} and C_{pp4} are the parallel plate capacitances, that are developed in between the over lapping areas of revolving patch and patches of top layer, The substrate used here is air with a thickness of 31mil. C_f represents the fringing capacitance between the neighboring patches of top layer at its edges. In the proposed structure C_{pp1}, $C_{pp2,}$ C_{pp3} and C_{pp4} are variable during process. The equivalent capacitance at top layer is

C_{u-pp1} =Parallel plate capacitance in upper layer $\frac{\varepsilon_0 \varepsilon_r}{d} A$

equation 1

The C_{pp} is the parallel plate capacitance in lower layer, between ground plate and revolving patch. The cascaded arrangement of 3D-EBGs, develops fringing capacitance in lower layer also but the distance between these patches is very large, hence the capacitance that developed is very small so is neglected, hence this capacitance is not included in effective medium model diagram shown in above figure. The equivalent capacitance at lower layer is

C_{l-pp}=Lower capacitance $\frac{\varepsilon_0 \varepsilon_r}{d} A$

equation 2

The resultant capacitance due to engineered structure 3D EBG unit cell is

The equivalent capacitance $C_{eq} = \frac{4C_{up1}XC_fXC_{lp}}{4(C_{up1}XC_f)+C_{lp}(C_{up1}+C_f)}$

equation 4

The total capacitance with correction factor F which is equal to 3.09

$C_T = C_{eq}$XF

equation 5

L_{eq1}, $L_{eq2,}$ L_{eq3} and L_{eq4} are the Inductances, that are developed at each protrusion. That can be given as where N indicates number of via.

Inductance due to one via in upper layer

$$L_{up\_pill1} = \left[\frac{(\mu_0\mu_r)_{air}H}{2} + \frac{(\mu_0\mu_r)_{fr4}H}{2}\right]$$

equation 6

$L_{up_pill1} = \mu_0$H

Where,

L_{up_pill1} = Inductance due to piller1

H = Height of Pillar =64mil,

$(\mu_0\mu_r)_{air}$ = Permeability of air,

$(\mu_0\mu_r)_{fr4}$ = Permeability of FR4 material.

Total inductance in upper layer

$L_{UT}=\frac{\mu_o H}{12}$ i.e $L_{UT}=\frac{L_{up\_pill1}}{12}$

equation 7

Where, L_{UT}=Total inductance of upper patch.

The L_5 is inductance developed due to via which connecting lower layer of revolving patch to ground plane.
The resultant inductance is

Inductance in Lower layer $L_{LP}=\frac{(\mu_0\mu_r)_{fr4}H}{2}$

equation 8

$where,\ L_{LP}$ =Inductance of lower patch

Total inductance in 3DEBG $L_T=\frac{L_{UT}.L_{LP}}{L_{UT}+L_{LP}}$

equation 9

$where,\ L_T$=Total inductance

The inductance depends on permeability of dielectric substrate and height of via. In our proposed structure the dielectric substrates and its thickness is always unchanged. So the inductances that developed are remain constant in all stages of presentation.
To calculate inductance of n number of pillars below formula used

$L_N=\frac{\mu_o H}{4N}$,where N=1,3,5--------------(2n-1)

equation 10

Where, $L_N = N^{tn}$ pillar inductance

After substituting design parameters the capacitance and inductance obtained are

C_T=1.16x$10^{-11}F$, L_T=1.4135x$10^{-10}H$

Under tuning, the revolving plate is made to orient along its axis either in clock wise or anti clock wise with respect to upper patches. This changes the overlapping area in between the revolving patch and upper patches of top layer, that effects the proportional change in parallel plate capacitance in C_{pp1}, C_{pp2}, C_{pp3}, C_{pp4} and C_{pp}.
Now the 3D EBG is resembling as parallel LC resonating structure. The center frequency of it can be calculated as

F_r=resultant frequency $=\frac{1}{2\pi\sqrt{L_T C_T}}$=3.93GHz

equation 11

Characteristic impedance is

Surface Impedance (Z_s) $Z_s=\frac{jw\,L_T}{1-w^2 L_T C_T}$=1.285kΩ

equation 12

Summary of EMM

(i) To characterize the EM behavior of EBG, Effective Medium Model is used

(ii) “The periodicity of individual elements must be less than wavelength” this condition must satisfy in order to apply EMM

(iii) Lumped parameters are used to describe the behavior of the model

(iv) It summarizes the properties of surface into single parameter

(v) It correctly predicts reflection properties of HIS

(vi) It fails to predict actual band gaps

(vii) It roughly predicts High impedance region

(viii) The radiative regions also predicts approximately

3.2 Structural Model (using HFSS software)

This method considers the whole cell as a unit and start analyzing it with the help of numerical techniques such as MOM, FDTD and FEM. Since it is computer simulation technique, so it considers the periodicity of individual elements in 3DEBG and also the material properties used in design. With this method complete electromagnetic behavior of 3DEBG can be predicted exactly.

Summary of Structural Model

(iii) In this approach the periodicity of structure need not to be infinitesimally smaller than wavelength

(iv) This technique can give an accurate description of the surface wave bands by explicitly including the geometry of the metal and dielectric regions, as well as the periodicity.

(v) This also predicts higher order modes (i.e Multi band environment)

(vi) This method is more suitable for more complex structures like 3D EBG

(vii) Present proposal is executed and analysed using Finite Element Method Analysis of 3DEBG using Effective Medium Model Vs FEM based HFSS Software

Because of above mentioned advantages in structural (software simulation) model than effective medium model, in present paper 3DEBG is designed and it's surface properties are characterized with the help of FEM based 3D electromagnetic simulation software HFSS.

4. Characterization of Bands in 3DEBG

4.1 Determination of Surface wave Band gap

4.1.1 Introduction of Surface waves

The surface waves usually generate at the junction of dissimilar materials, such as (i)metal, free space and (ii) metal, dielectric. They exist at radio frequencies, where they are treated as surface currents. The surface waves start exciting when the substrate relative permittivity is greater than unity($\epsilon_r > 1$) and propagate up to boundaries with multiple reflections. At the edges they get diffracted results end-fire radiation
In array environment, these surface waves are coupled to nearby antenna. These waves decay inversely with distance (1/√r). The coupling also decreases away from the point of excitation and are exist in both TM and TE modes. The substrate height and relative permittivity are the key parameters in effecting phase velocity of surface waves. The surface wave propagation has effects, such as reduce antenna efficiency, gain, limit bandwidth, increase end-fire radiation,

increase cross-polarization levels, and limit the applicable frequency range of antennas

The surface wave band gap feature of EBG structures has found useful applications in suppressing the surface waves in various antenna designs. The surface wave band gap can be characterized with the help of two popular techniques. First one is Analysis of 3D-EBG in full wave electromagnetic simulation software that uses FEM numerical technique, this is known as indirect method. Second one is conventional suspended strip line method, this is known as direct method. We start our presentation initially with direct method, and in later section the results obtained in indirect method are compared with direct method.

4.1.2 Direct Method

The direct method is giving more accurate band gap characteristics when compared with conventional monopole and microstrip methods. More over this method has strong coupling of EM waves and eradicate the effect of other parasitic propagation modes.

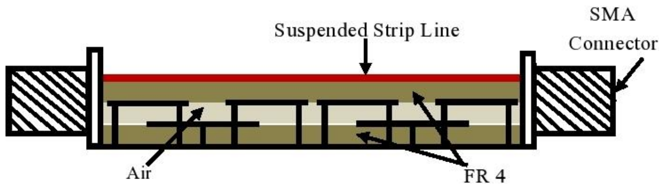


Figure 3: suspended strip line over MEBG

In a construction, a microstrip transmission line having a 50 ohm characteristics impedance, it's both the ends are connected to excitation ports and suspended over 3DEBG. The complete arrangement is shown in figure zz. Here power that transfer and reflect between two ports is measured with the help of scattering parameters. In order to define the lower and upper corner frequencies, the attenuation level is considered at -20dB, which indicates 3dB line or the power is half. The simulated results showing a forbidden band of 340.6MHz (i.e from 3.9GHz to 4.2GHz) presented in figure 4. During this region 3DEBG doesn't support propagation of any EM (neither TE nor TM) waves. The Center frequency, band width and fractional band width can be obtain with following equations

$$f_0 = \frac{f_H + f_L}{2}$$

equation 13

$$BW = f_H - f_L$$

equation 14

$$\Delta BW = \frac{BW}{f_0} = \frac{2(f_H - f_L)}{(f_H + f_L)}$$

equation 15

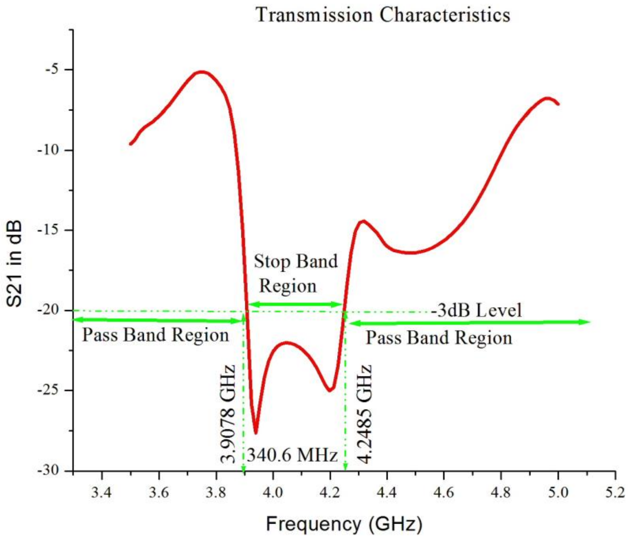


Figure 4: Surface wave band gap of 3DEBG using direct method

4.1.3 Indirect Method:

Indirect method the dispersion or beta-w or k-w diagram is computed for a unit cell. this extracts the frequency band gap of 3D EBG. In order to obtain it, two dimensional eigenmode solutions for Maxwell's equations are obtained for the restricted unit cell (or Brillouin zone) under periodic boundary conditions. Algorithms for solving Maxwell equations under periodic boundary conditions have been implemented using both the Green's function based method of moments [8] and the finite element method. A perfectly matched layer (PML) proposed by [9] is used to model perfect absorbing or open boundary conditions.

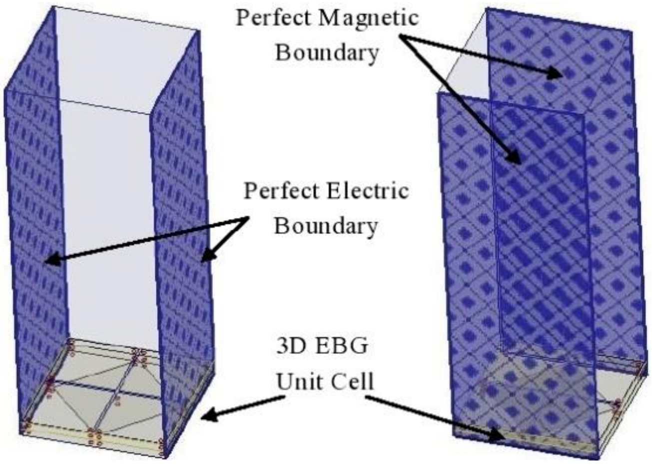


Figure 5:3D EBG Unit Cell with periodic boundary conditions of four walls

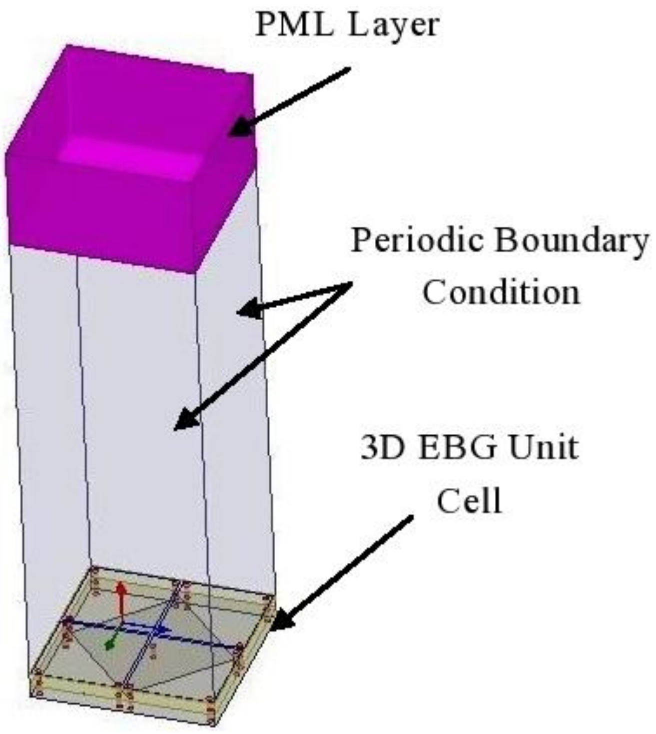


Figure 6: Unit Cell with PML on top boundary

This method has been fully illustrated in [10], [11]. The basic idea is to analyze the performance of the structure along the main sides of an irreducible Brillouin Zone instead of analyzing all possible propagation directions

This involves three main stages.

Stage one, the phase constant named as phase2 is applied between two sides of unit cell, in parallel to the section MX which is made 0 and other phase constant named as phase1is also applied between the two sides of unit cell, in parallel to the section Γ-X is starts at 0 and progressed up to 180 degrees, during the period Maxwell's equations are solved for the first N Eigen mode frequencies. This addresses 1-D wave propagation and the propagation direction is lying orthogonal to section Γ-X.

Second stage, phase1 is set to 180 degrees and phase2 is starts at 0 and progressed up to 180 degrees, during the period Maxwell's equations are being solved for the first N Eigen mode frequencies. This addresses 1-D wave propagation and the propagation direction is perpendicular to the section X-M.

In third stage, both phase1 and phase2 are made to vary all together from 180 to 0 degrees, which addresses to 2-D wave propagation and propagation direction is diagonal to the pattern. According to Floquets theorem for the periodic boundary condition, The change in phase represents the proportional change in k and/or β.

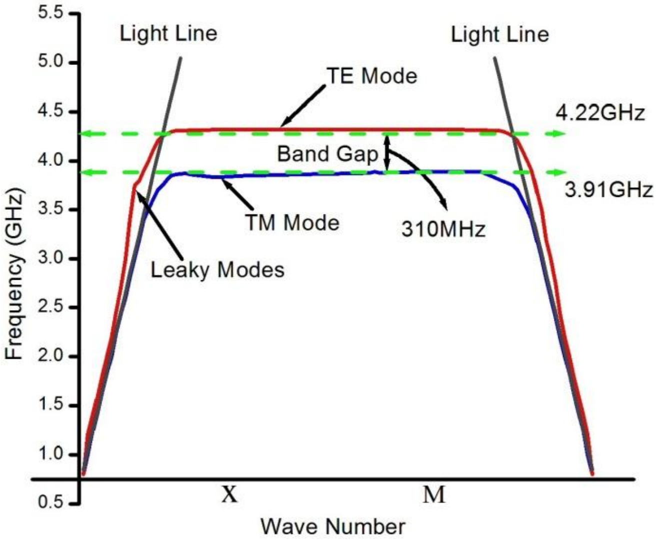
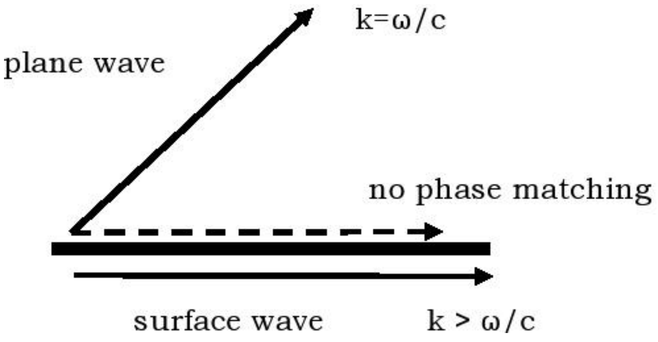


Figure 7: Dispersion Diagram

Figure 7, is showing dispersion characteristics of 3D EBG. A band gap region is spread over 310MHz. It was observed that, 3DEBG permits TM surface waves to propagate slower than the speed of light. Whereas TE surface waves are bound to surface at some frequencies, and radiate at other frequencies. In present proposal TM and TE bands never combine. So band gap can be defined as, the range that spam's from TM band edge to the point of intersection TE band with light line. This band gap is approximately distributed on either side of resonance frequency.

4.1.3.1 Leaky Waves:

In the dispersion diagram shown in figure 7, surface wave that is lying left to light line are radiative leaky modes, which are indicated with the complex frequencies. Usually TE modes lies left to light line hence considered as radiative at some regions, where as TM modes lies entirely below the light line. If these leaky waves has to radiate into free space they need to be couple with a plane wave in free space, in that case there must exist a phase matching between leaky wave and plane wave along the interface.



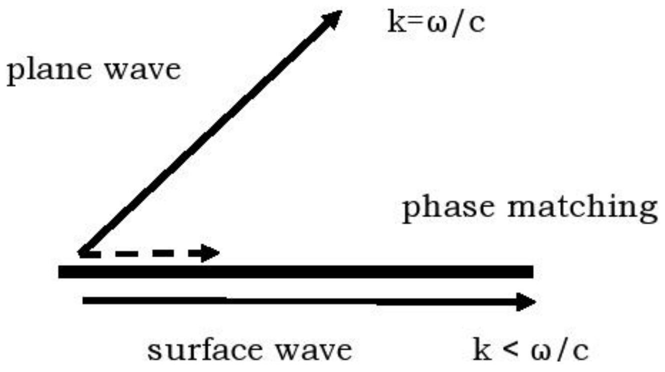


Figure 8:A Leaky wave propagation when surface wave phase match with radiative wave.

For better understanding of concept, the wave vector of surface wave is indicated with distractive line. If it is longer (this condition exist for TM case i.e surface waves that are lying bellow the light line) than external plane wave of same frequency, so there exists no phase matching hence the surface wave is prevented from radiating, and is therefore stable. If it is short (this condition exist for TE case i.e any surface waves that are lying above the light line) then they match with external plane wave of the same frequency. So the surface wave radiate energy away by coupling to external plane waves and is therefore radiatively unstable, leaky waves. Thus, they have an imaginary frequency component, shown in figure 8(a) and (b).

Both direct and indirect methods are showing a common region of 310MHz (i.e from 3.91GHz to 4.22GHz) is considered as surface band gap. Where both the techniques are forbidding the surface EM wave propagation.

4.2 Determination of Reflection band gap:

Figure 9 is showing reflection phase characteristics measurement setup. Where a Floquet port is assigned at the top boundary to generate incident waves normally illuminate to the surface and receive reflected waves, In addition to the periodic boundary conditions, that are applied to 3DEBG unit cell.

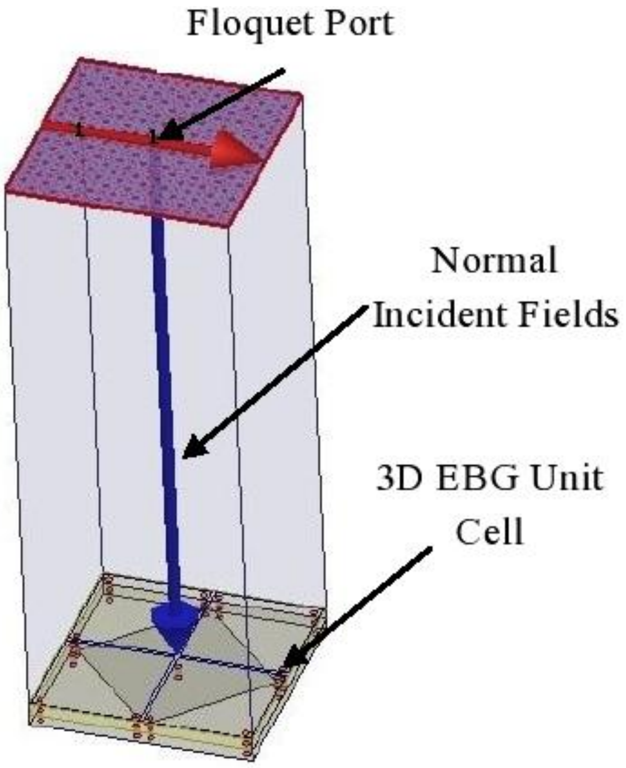


Figure 9: Measurement setup for reflection phase measurement.

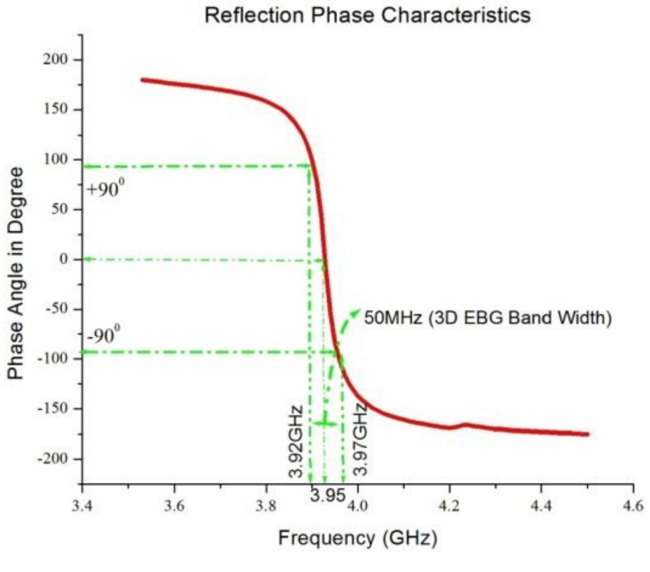


Figure 10: Reflection Characteristics

Figure 10 is depicting the reflection phase characteristics of 3D EBG. The reflection phase characteristics varies from +180 degree to -180 degree as frequency progresses. At lower and higher frequency regions, this structure exhibiting similar reflection phase characteristics as like PEC surface. At frequency of resonance multi layer EBG has zero degree of reflection phase, and exhibits the property of artificial magnetic conductor (AMC). Proposed design is exhibiting high impedance at location of 3.95GHZ, and a band width is measured between +90 degree to -90 degree region, i.e 50MHz (from 3.92GHz to 3.97GHz). The complete process is explained in detailed by considering incident and reflected waves over 3DEBG. The high impedance region of 3DEBG reflects inward wave into backward, results formation of standing wave. The wave is reflected from the surface, and the backward-running wave has a similar form, as indicated in figure 11.

$E_f = E_f e^{-jkx}$
$H_f = H_f e^{-jkx}$

equation 16

$E_b = E_b e^{jkx}$
$H_b = -H_b e^{jkx}$

equation 17

The negative sign on the magnetic field is due to the convention of the right hand rule.

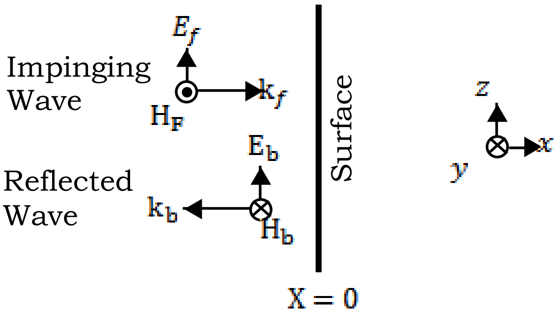


Figure 11: Waves impinging on, and reflected by a surface

The standing waves formed by the forward and reflected waves are of form.

$$E(X) = E_f e^{-JkX} + E_b\, e^{JkX}$$
$$H(X) = H_f\, e^{-JkX} + H_b\, e^{JkX}$$

equatiron 18

The expression for surface impedance is

$$Z_s = \frac{E_{total}}{H_{total}}$$

equation 19

The forward and reflected, fields of electric and magnetic can be relate with intrinsic impedance as

$$\left|\frac{E_f(x)}{H_f(x)}\right| = \left|\frac{E_b(x)}{H_b(x)}\right| = \sqrt{\frac{\mu_0}{\varepsilon_0}} = \eta$$

equation 20

The reflection phase can be described as phase difference between the forward and reflected waves.

$$\Phi = Im\left\{\ln\left(\frac{E_b}{E_f}\right)\right\}$$

equation 21

Combining this with Equation 20 and Equation 21 gives the reflection phase in the form of a surface impedance Zs.

$$\Phi = Im\left\{\ln\left(\frac{Z_s - \eta}{Z_s + \eta}\right)\right\}$$

equation 22

When the surface impedance of 3DEBG is low, then the reflection phase is ± π. When surface impedance reaches to high, the reflection phase is zero. When surface impedance and reflection phase both are equal then phase crosses through ± $\pi/2$.

5. Impedance Characteristics:

The surface impedance can be represented as the boundary due to which standing waves are formed. The general expression for surface impedance is $Z_s = \frac{E}{H}$ For good conductors, the surface impedance is very low because the ratio of electric field to magnetic field is very small. For EBGs the surface impedance is very high, because the tangential magnetic field at the surface is zero. Same surface some time called as “magnetic conductor”. The magnitude of impedance where its value is high, is considered as operating point of the structure. This value always lies within the band gap region. Our structure has high impedance at 3.95GHz.

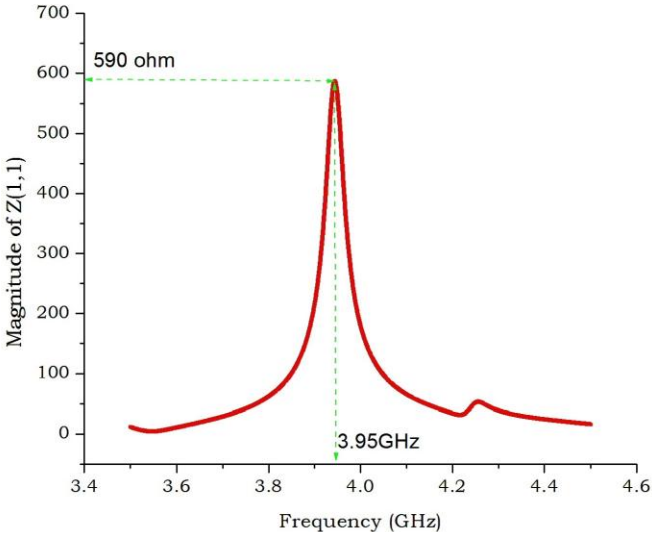


Figure 12: Magnitude of Impedance Characteristics

One thing we understood that at operating frequency 3DEBG exhibits high surface impedance. Then question arises; at other than operating frequency what is the nature and impedance characteristics of 3DEBG ?. That can be predicted by relating the surface impedance with reflection phase.

$$\frac{E_{(x)}}{H_{(x)}} = \frac{E_f(x)+E_b(x)}{H_f(x)+H_b(x)} = \eta\,\frac{e^{-jkx} + e^{jkx+j\emptyset}}{e^{-jkx} - e^{jkx+j\emptyset}} = j\eta\cot\left(kx + \frac{\emptyset}{2}\right)$$

equation 23

The frequencies which are far below resonance, the node of electric field and antinode of the magnetic field are in contact with 3DEBG surface, as shown in figure 13. This resembles the reflection from ordinary metal surface. Here the electric and magnetic fields of a standing wave are the vector sums of the two running wave fields. The solid vertical line indicating the position of 3DEBG surface. The arrow indicating the field direction of an incoming wave. This convention ensures that the 3DEBG surface has positive, real impedance, while a radiating surface has negative, real impedance.

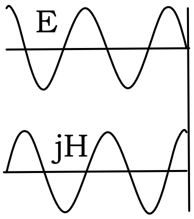


Figure 13: Standing wave fields at a frequency far below resonance

When the frequency increases (The frequency considered here is just below the resonance frequency and near to the TM band edge), the phase slopes downward, shown in figure 10. At this stage the surface just has higher impedance, so the electric field no longer has a node at the surface. As if the effective reflection point of the surface were receding, the standing wave shifts forward, toward the surface, as indicated by the arrows in figure 14.

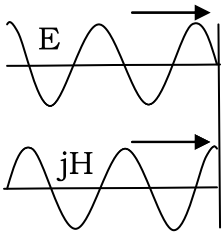


Figure 14:Standing wave pattern just below resonance

At this stage, the surface impedance is positive imaginary, or inductive, but its value is much higher than that of a conventional metal surface.

At the resonance frequency, the surface impedance is very large, so the node of electric field and antinode of magnetic field are at the surface. Shown in figure 15. The surface at this stage functions like high impedance surface.

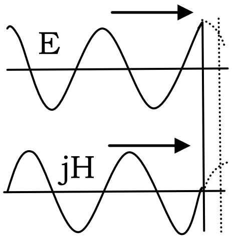


Figure 15: Standing wave pattern at resonance frequency

When frequency increases further (frequency considered here is just above the resonance frequency and near to the TE band edge), the phase slopes farther downward towards -180 degree. The standing wave continues to shift toward the surface. The impedance has switched sign, and the surface is now capacitive. This is indicated in figure 16, in which the magnetic field is now negative.

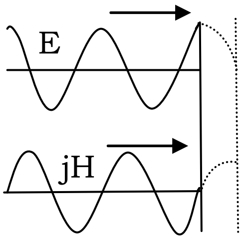


Figure 16:Standing wave pattern just above resonance

At frequencies that are much higher than resonance, the surface impedance has returned to near zero. The reflection phase has returned to the same point where it started, but it has gone through one complete cycle. Shown in Figure 17. As the frequency is increased through the resonance, it is as if the effective reflection plane has slipped into the surface by one-half wavelength.

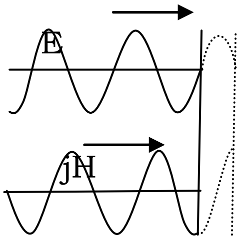


Figure 17: Standing wave pattern for a frequency far above resonance

5. Advantages of 3DEBG Characteristics

The characteristics of 3DEBG discussed above has following applications in the field of microwave antennas.

5.1. Smoother Radiation Pattern and Isolation of Array Antennas

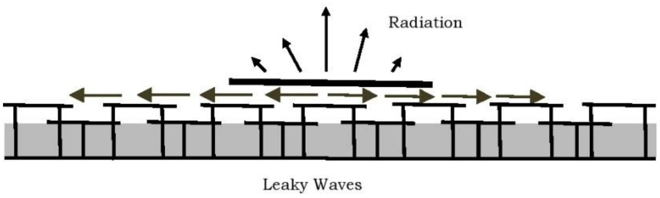


Figure 18: Radiating element lying over 3DEBG

Figure 18 showing a radiating element operating within the surface wave band gap region is placed over 3D EBG parallel to its surface. The gap between patches functions like destructive surface and shorting via develops slow wave nature in 3DEBG. The surface currents that are developed, never reaches to edges, even leaky TE mode that exist within the band gap will radiate much of their power before reaching the edge of a large ground plane. So this avoids the interference of surface waves with radiated waves in the far field results elimination of distortion or produce smoother radiation pattern. In array antenna environment due to suppression of surface waves will avoid the mutual coupling between elements hence can minimize the blind spots.

5.2. Substrate Integrated Phase Shifter

3DEBG has a characteristics of reflecting EM wave with zero degree phase. Present 3DEBG has provision to tune it's surface properties by revolving a patch that is present at lower layer around its axis either in clock wise or anti clock wise direction with a small PCB motor. This comes under category of passive tuning. For our explanation let us consider only anti-clock wise rotation of patch. Initially the position of patch is at -45 degree (reference position) and possible to extend the rotation up to zero degree with a step size of -15degree (Here minus sign indicates the rotation is in anti clock direction). As the orientation of hidden patch is in progress causes to change the overlapping area between the patches of upper and lower layers. Results change in reactive capacitance, in-turn varies the operating frequency. The change in reactive capacitance alters the impedance characteristics of structure. Hence the reflection phase can be varied. This structure, when incorporated in an antenna structure can steer main beam without any involvement of active elements. The SIP's processes low cost of fabrication and lower complexity and highly compatible. The reflection phase characteristics at -45, -30, -15 and 0 degree are presented in bellow figure.

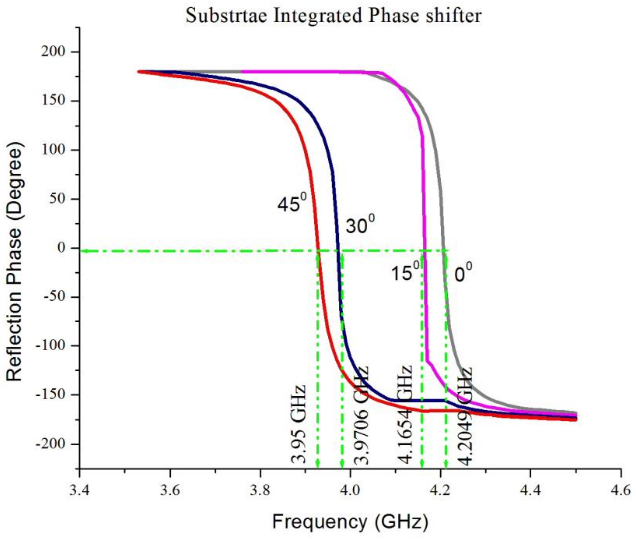


Figure 19: Substrate Integrated Phase shifter

6.3 Miniaturization of Radiating Antenna

The high impedance nature of 3DEBG has great advantages in the field of microwave antenna environment. A low profile antenna when placed directly over the 3DEBG reflecting surface, experiences a free space impedance on one of its face and 3DEBG impedance on the other face. Here two points arises that is,

1. When mounted antenna is operating with a frequency which is far away from resonating frequency of 3DEBG.

At this range the 3DEBG surface exhibiting low surface impedance as like conventional metal reflector. The surface currents in 3DEBG are in equal and opposite to the currents propagating in an antenna so the antenna get shorted out with nearby conductors. This is going to effect the radiation characteristics of mounted antenna results poor radiation efficiency.

2. When mounted antenna is operating with a frequency which is nearer to the resonating frequency of 3DEBG

At this range the 3DEBG surface exhibiting Very high surface impedance which is quite opposite to conventional metal reflector. The surface currents in 3DEBG are equal in phase with the currents propagating in an antenna so the antenna will not shorted out with nearby conductors. Because of high impedance region the operating frequency is shifted to lower side, to bring the operating frequency to within band gap region the aperture of antenna need to be minimized. A miniaturization of 70% can achieved with this technique.

6.4 Body Area Network or Hand held Communications

Portable devices have more interaction with human body. which oftenly consists of compact devices such as antennas. The interaction between antenna and user can have significant impact on antenna performance. When 3DEBG is used as ground plane in designing compact antenna, due to it's in-phase reflection nature, the power is redirect into free space. This will increases the antenna radiation efficiency, longer battery life in BAN applications. To study antenna performance near human body, we should first understand the electromagnetic properties of body tissues, which vary significantly with frequency and tissue types.

Conclusion:

In current paper, a 3DEBG structure is designed in FEM based HFSS simulation software. Its key characteristics such as surface band gap, in-phase reflection band gap and high impedance of 3DEBG is determined. This 3DEBG is producing universal band gaps and doesn't allow any surface EM waves with in surface band gap region of 310MHz (i.e from 3.91GHz to 4.22GHz). It reflects the EM waves with zero degree reflection phase within a region of 50MHz (i.e from 3.92GHz to 3.97GHz). It is producing high impedance region at 3.95GHz, this property helps to minimize the antennas placed and operating over it. In this paper the complete characteristics of 3DEBG is determined and It's applicability in microwave antenna environment is determined.

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