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Band Width Variation and Surface Wave Suppression by Using Mushroom like Meta Materials

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ABSTRACT: This paper investigated the variations occurring in band width of the antenna when mushroom like structured meta-materials are used. Generally the operating frequency may vary according to the tuning of band of meta-material to the band of antenna. Here the tuning may vary according to via size or the gap between metal plates of the meta-materials. Here the analysis is done to verify the return loss and the band width variations according to the meta-materials placed. And the comparative analysis is produced for a simple monopole antenna and a patch antenna for various via lengths in meta-materials.

KEYWORDS: Tuning, Energy Band gap, Frequency selectivity, Band width, Return loss

I. INTRODUCTION

The meta-materials have several research features for various applications; the main purpose of their invention is to mitigate the surface waves [1]. In the last years they are used to design the tuneable and steerable antennas for communication systems [6]. To design capable adaptive antennas to achieve selectivity in frequency. Generally these meta-materials do not allow surface waves to propagate for a certain band of frequency this is called forbidden band [3], meta-materials have very high surface impedance within a specific limited frequency range [4]. Due to these abilities recently they are used in achieving tuneable and steerable antennas where the patches are inter connected with variable diode to change C value therefore the tuning band of EBG structure[2]. Now in this paper we concentrate on changing the L value to tune the band of meta-materials and check the variations in actual antenna. Generally the tuning can be done either by changing C or L of the meta-materials. The meta-materials unit cell is explained in the following figure [1].

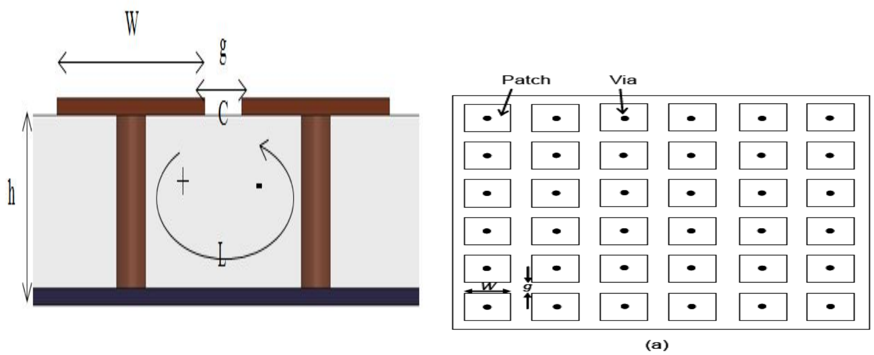

Figure [1] Meta-materials front View and Top View

II. BACK GROUND OF THE WORK

Generally the meta-materials are used to replace the ground planes or it can also be used as the reflecting planes. When they are used we can get zero phase reversal of the reflecting waves [4]. In general when antennas are excited the radiation occurred is space waves and the energy propagated through the antenna is surface waves when these to interfere with each other causes the interference and results in losses. To avoid these meta-materials are used the surface energy will be rooted with zero phase reversal to add to the space waves results in good radiation efficiency. In this aspect the tuning should be perfect to have better results. It is done by varying the Capacitance and Inductance of the meta-materials. Here capacitance occurs due to the fringing fields at the edges of the metal plates of the MM and

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inductance id due to current passing through the vias of the meta-materials [4]. So L can be changed by varying the length of the via and C can be changed by varying the gap between the plates.
The L and C are determined by the following equations

$$L=\mu_o h \quad (1)$$

$$C=W\varepsilon_o(1+\varepsilon_r)\cosh^{-1}((2W+g)/g)/\Pi \quad (2)$$

Where μ_o is the permeability of free space, εo is the permittivity of free space. *W* is patching width*; g* is gap between patches, *h* substrate thickness and ε_r is dielectric Constant.

III. PROPOSED MODEL AND DESIGNING

The analysis is done for a simple monopole antenna and a patch antenna. First the monopole antenna is designed at 2GHz and after that it is exited with meta-material is used as reflector. And then similarly a patch antenna is designed at 2GHz and then the analysis is done by replacing the ground plane with high impedance mushroom like meta-materials of 2×2 array and 4×4 arrays and the comparative analysis is illustrated in the simulation results. The design models are shown in the following figure [2] & [3]. And the design considerations were tabled in table [1] & [2].

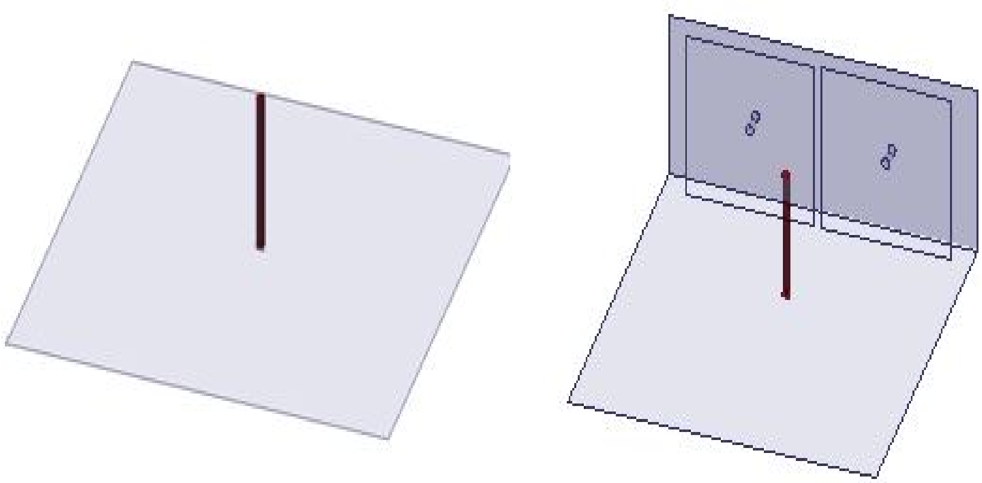

Figure [2] a) monopole antenna b) monopole antenna with meta-material as reflecting plane

Table-1 Design considerations for monopole antenna and meta-material in figure [2]

Title	Value
Monopole material	Pec
Via material	Pec
Arm length	2.636 cm
Arm radius	0.084
Ground plane dimensions	8.37×8.37cm
Meta-material base plane dimensions	8.37×3.5 cm
Metal plate dimensions	3.5×3.5 cm
Via length	0.5 cm
Via radius	0.1 cm
Gap between metal plates	0.2 cm
No of unit cells of MM	2

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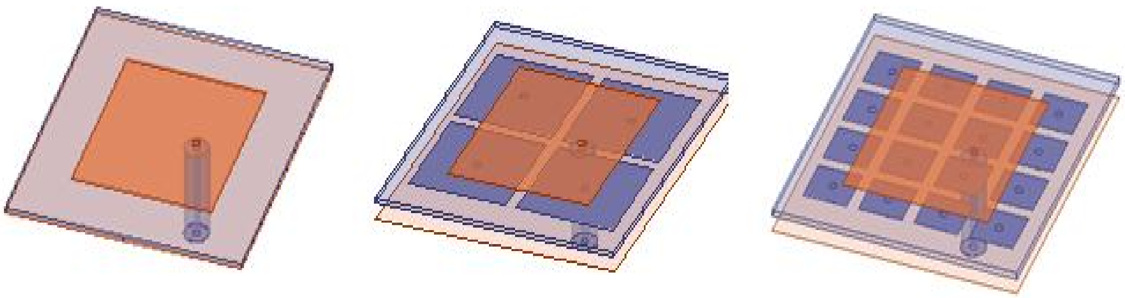

Figure [3] a) Rectangular patch antenna b) with 2×2 MM as Ground plane c) with 4×4 MM as Ground plane

Table-2 Design considerations for patch antenna and meta-material in figure [3]

Title	Value
Substrate material	Duroid(tm)
Via material	Copper
Patch dimensions	5.93×4.94 cm
Substrate dimensions	9.8×8.4 cm
Ground plane dimensions	9.8×8.4 cm
Meta-material base plane dimensions	9.8×8.4 cm
Metal plate dimensions (2×2)	3.4×3.4 cm
Metal plate dimensions (4×4)	1.5×1.5 cm
Via length (2×2)	0.4,0.5,0.6 cm
Via length (4×4)	0.4 cm
Via radius(2×2), (4×4)	0.125 cm
Gap between metal plates (fixed)	0.2 cm
No of unit cells of MM (2×2)	4
No of unit cells of MM (4×4)	16

IV. SIMULATION RESULTS

The Proposed model is designed and analysed by using the HFSS software and comparative results are presented.

Return loss curves comparison for monopole antenna

The return loss curves are presented in the following figure [4]. Where figure [4] a) indicates the return loss curve for a conventional monopole antenna as we know that monopole antennas are isotropic antennas and are very much used in communication applications but they suffer the low Band width problems. Figure [4] b) represents the return loss curves when designed meta-material is used as reflecting plane.

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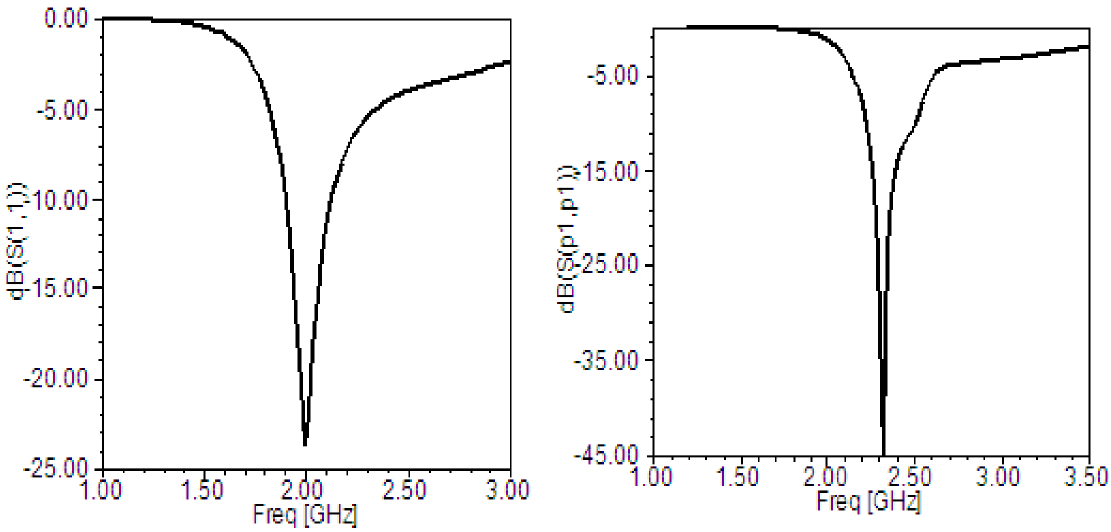

Figure [4] a) Return loss curves for conventional monopole antenna b) Monopole antenna with MM as reflecting plane

By the above figure [4] we can see that at normal case the monopole antenna workd at 1.9899GHz frequncy and the return loss here is -23.6636dB. where as once it is excited with MM as reflctor at one side it operates at 2.3152GHz with better band width than the conventional type and the resturn loss also decreased to -44.9390dB. this is the improvement that can be acihved by MMs reflecting planes and the radiation also enhnaces in the opposite direction of the reflecting plane in this case.

Return loss curves comparison for Patch antenna

The return loss curves comparision for the Patch antenna with conventional type to patch antenna having 2×2 MM as ground plane with varying via lengths 0.4,0.5 and 0.6cms is shown in the figure [5].and also comparision for conventional and 2×2 MM and 4×4 MM is presnted in figure [6]. Here the main point is for figure [6] the 2×2 meta-material have metal plate of 3.4cm where as 4×4 MM have metal plate of 1.5cm here the gap between the plates and the via length is same for both. The variation in metal plate dimension indiactes the changes in C value. Variation in via length for figure [5] indicates changes in inductance L.

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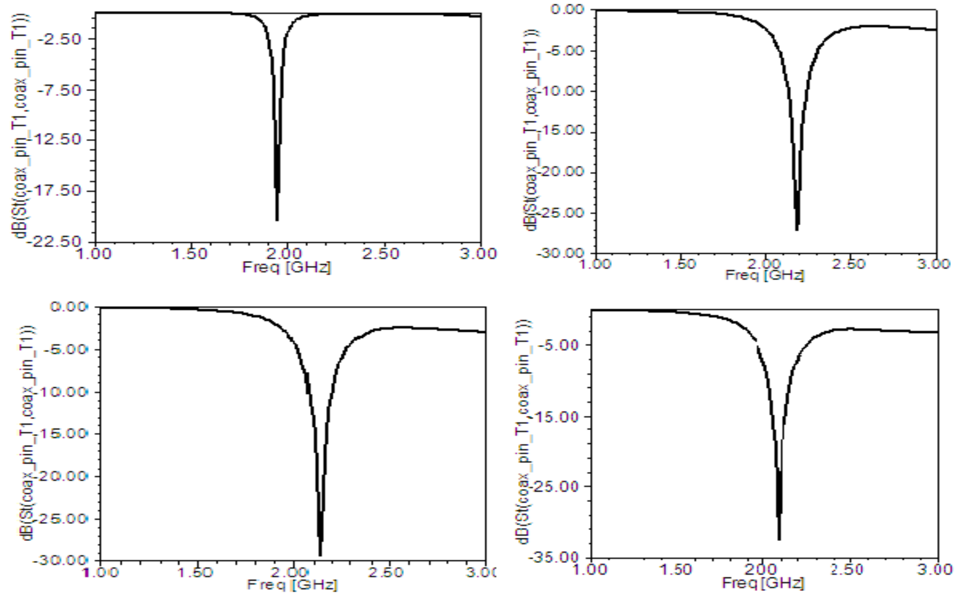

Figure [5] a) Return loss curves for conventional Patch antenna b) Patch antenna with 2×2MM as Ground plane (via length 0.4cm) c) Patch antenna with 2×2 MM as Ground plane (via length 0.5cm) d) Patch antenna with 2×2 MM as Ground plane (via length 0.6cm)

from the above figure [5] we can see that 5.a) represnts the return loss curve for conventional antenna and b,c &d represnts the return loss curves for 2×2 meta-material or varying via lengths of 0.4,0.5 & 0.6cm respectively when comparing the b,c & d curves have better band width and return loss than the conventinal type. And the comparision is illustrates in the table [3].

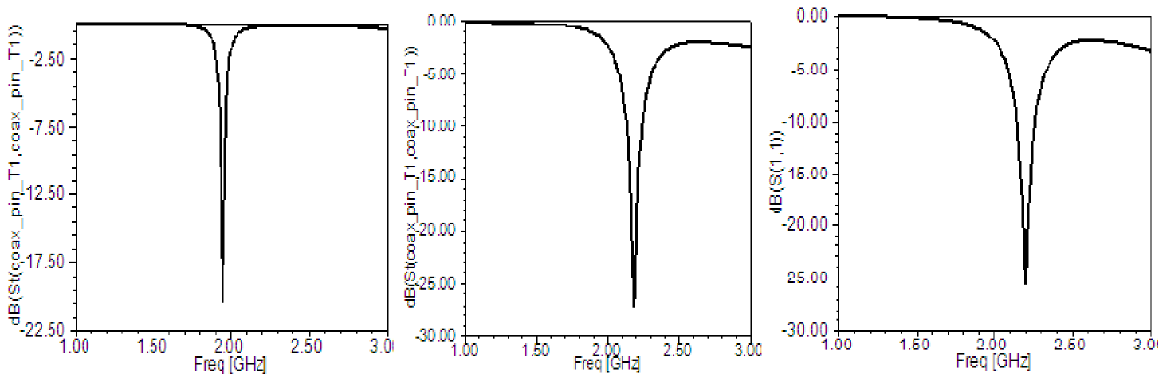

Figure [6] a) Return loss curves for conventional patch antenna b) Patch antenna with 2×2MM as Ground plane c) Patch antenna with 4×4MM as Ground plane

By the above figure [6] we can see that the changes in figure [5] are differ in figure [6] especially when we see 6 .c) the return loss should be better than 6.b) if we keep the same metal plate dimension but we changed the metal plate dimension for 4×4 MM to 1.5×1.5cm here the change in C acts to effect the operating frequency and BW of the antenna. Comparison can be seen in table [3].

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Table-3 Comparison of operating freq and return loss

Title	Operating Frequency(GHz)	Return loss(dB)
Patch antenna	1.9447	-20.3435
Patch antenna with 2×2 MM Ground plane (0.4cm)	2.1759	-27.0853
Patch antenna with 2×2 MM Ground plane (0.5cm)	2.1357	-29.3292
Patch antenna with 2×2 MM Ground plane (0.6cm)	2.0854	-32.4180
Patch antenna with 4×4 MM Ground plane (0.4cm)	2.1960	-25.5603

From the above table [3] we can see that when the via length increase from 0.4 to 0.6cm for 2×2 MM the operating frequency drops and the return loss improves on the contrast we can also say with low via length we get enhanced band width shown in figure [5]. We can also see that in figure [6] the band width is improved from conventional to 2×2 MM and then to 4×4 MM but the return loss is not improved in 4×4 MM over 2×2 MM because the metal plate length reduced to 1.5cm from 3.4cm the change in C value effects here.

V. CONCLUSION

The met-materials can tune the antenna to work with different frequencies over a selected band. Instead of changing the antenna physically we can alter its working with these materials placed either as reflectors or in general as the ground planes. The band width can be enhanced by tuning the meta-material to new band it can be accomplished by varying via length or by changing the metal plate dimensions and we can also change it by providing the different gaps between the metal plates.

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BIOGRAPHY

Saleem Akram was born in India, A.P in 1984. He received M.Tech (Communication Engg) from VIT University, Vellore, India. He is a research scholar of GITAM University, Visakhapatnam. In the field of Antennas. Presently working as Associate. Professor, in Dept of ECE, Nalanda Institute of Engineering & Technology, Sattenapalli, A.P, INDIA.

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