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A STATE OF THE ART REVIEW ON MODELING OF ELECTROMAGNETIC BAND GAP (EBG) STRUCTURES

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Abstract

This article provides a systematic overview of the research performed in the last two decades on theoretical and computational methods of modelling electromagnetic band-gap (EBG) structures. The EBG structures have created their separate life in the antenna engineering society due to the unique features of surface wave reduction as well as perfect magnetic conductor (PMC) like action. Such devices are commonly used in the design of multiple planar microwave circuits, including printed antennas, printed microwave filters, etc. The aim of this article is to provide an inclusive analysis of both analytical and numerical approaches in the context of EBG-structure modelling. Such a review process is seldom performed to the best of the experience of writers in open literature. Researchers working on the modelling of EBG structures, as well as EBG standardized printed antennas, microwave planar filters, etc., may benefit from the review exercise.

Keywords: *Antenna, Bandwidth, Filter, Electromagnetic Waves, Electromagnetic Band-Gap (EBG).*

I. INTRODUCTION

Periodic structures have interacted with electromagnetic waves that create exciting features for specific frequency ranges in terms of pass-band, stop-band, and band-gap [1]. In recent years, these structures have been categorized under the broad terminology of "Electromagnetic Band Gap" structures due to unprecedented growth. Generally speaking, EBG structured materials are periodic

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objects for all incident angles and all polarization states to prevent/assist the propagation of a specified bandwidth at a specific frequency band [2].

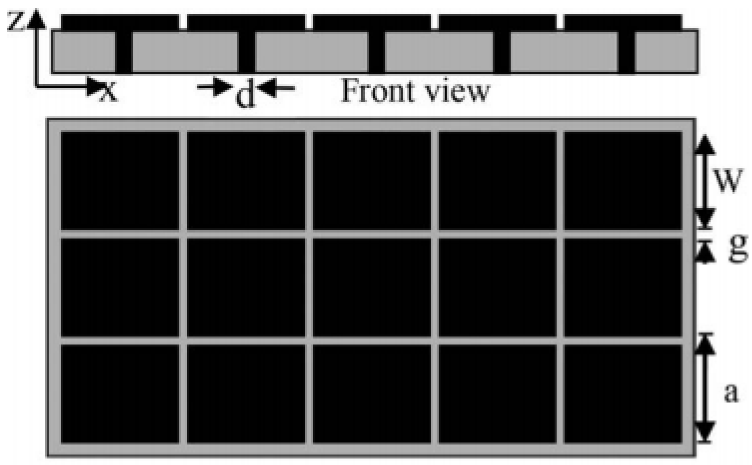

Fig. 1: Illustrates the structure of the mushroom-like EBG [3]

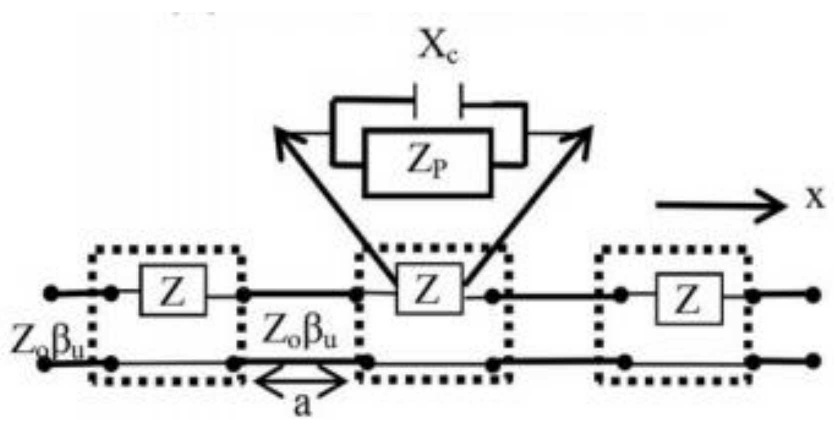

Fig. 2: Illustrates the equivalent circuit [4].

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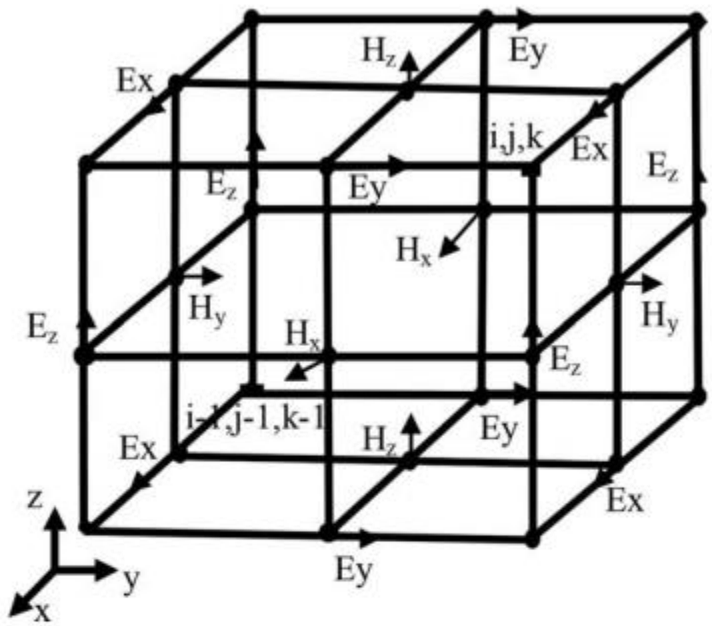

Fig. 3: Illustrates the E-and H-field vectors in Yee's model [3]

The width W of the microstrip patch antenna is calculated by using the following equation [5].

$$w = \frac{c}{2\, f_r \sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Where,

f_r denotes the resonant frequency, and

r represents substrate dielectric constant

The effective dielectric constant (ε_{reff}) of antenna is derived by applying the given equations.

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2} \sqrt{\left(1 + 12\frac{h}{W}\right)}$$

Where h denotes the height of the antenna and W denotes the width.

The length of the antenna may be measured by applying the following equation [6].

$$L = \frac{c}{2\, f_r \sqrt{\varepsilon_{reff}}}$$

The antenna length extension is calculated by applying the equation below.

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$$\Delta L = 0.412\, h\, \frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.246\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)}$$

Here W represents the width and h denotes the height.

The real length (L_{eff}) of the antenna can be calculated by using the following formula[7].

$$L_{eff} = L + 2\Delta L$$

II. LITERATURE REVIEW

A survey on the microstrip patch antenna was performed by Nandan et al. An overview of the microstrip patch antenna and its design techniques is provided in this article. Basically, a microstrip patch antenna consists of a trace of some geometry of copper or some other metal on one side of a regular printed circuit board substratum with another side grounding. Using different feeding methods, such as coaxial, strip line, aperture coupling or proximity coupling techniques, the antenna is fed. The working theory and the mechanism of radiation have been defined as well. In the military, manufacturing and commercial industries, the microstrip patch antenna is commonly used.

III. DISCUSSION AND CONCLUSION

In the literature, the EBG structures have been extensively investigated and the chronicled overview and a summary of the current condition of electromagnetic band-gap (EBG) structures have been highlighted in this review article in the context of mathematical modelling for both analytical methods and numerical methods. In this correspondence, contributions of researchers around the globe have been arranged, evaluated and outlined in a prospective objective. Several significant contributions to EBG modelling, based on theoretical and computational approaches, have been demonstrated in the review process. An illustration of the analytical approach is illustrated and the discretization and simulation of EBG structures based on three numerical methods (FDTD, MOM and FEM) has also been shown in the following sections. For researchers working on EBG structures and their applications in the design of planar microwave filters as well as planar antennas, this review process may be useful.

In addition, it is also concluded that FEM-modelled EBG structures are very constrained in the literature as compared to other approaches. For various types and shapes of EBG structures, the modelling associated with this approach could be further expanded.

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