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Electromagnetic Bandgap Structure for Antenna Design

Muhammad Abdulhamid[1], M. K. A. Rahim, Umar Musa
[1](Radio Communication Engineering Department (RaCED), Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Skudai, Johor Bahru 81310, Malaysia)
amyas1000@gmail.com

Abstract: *A dual band electromagnetic band gap structure is designed, simulated and measured. This is carried out using CST microwave studio software, the design is carried out on FR-4 substrate by Method of Suspended Transmission Line. The structure posses a dual band gap that effectively suppress surface wave at the dual frequencies. The result from the simulation gives dual band gaps that resonate at 1.8GHz and 4.0GHz and the measured result resonate at 1.8GHz and 4.3GHz, this show there is a good agreement between the two results. The structure is simple and easily incorporated with microwave and wireless devices.*
Keywords: ***Electromagnetic** Band Gap (EBG) Structure, Dual Band, Mushroom Shaped EBG and Symmetrically Distribution.*

I. Introduction

Due to unique characteristics of an Electromagnetic bandgap (EBG) Structure, it enables it to be used in Radio frequency (RF) and microwave application which is considered to be among the significant breakthrough in the EBG technology nowadays [1].

Because of the unique properties produced by the structure, it is widely used in various research fields especially in RF design. Many exciting phenomena appear when periodic structures interact with electromagnetic waves, which include band pass, band stop and also frequency band gap. The periodic structure reviewed previously revealed that varieties of applications like guiding wave, reflector, photonic crystals and photonic bandgap are the typical advantages derived. Others include wave propagation, noise reduction for high speed electronic devices and mutual coupling effect reduction [2][3][4].

Recently there is significant increase in utilizing EBG structures in antenna community. By increasing the coupling area of the adjacent metal patches, loading the lumped parameters [5], prolonging the connected microstrip line between EBG units and moving the position of metal via [6], the size of EBG unit has been reduced in varying degree. However, there remains some disadvantages, such as single-band, narrow bandwidth, integrating difficulties, etc.

II. Electromagnetic Bandgap Structure Design

The EBG is designed with metallic patch and a ground plane of 0.035mm thickness and 13mm width Ws, FR-4 substrate of 1.6mm thickness h, with a relative permittivity of 4.6 and a tangential loss of 0.019, a via that connects the EBG patch with the ground plane of radius r 0.4mm.

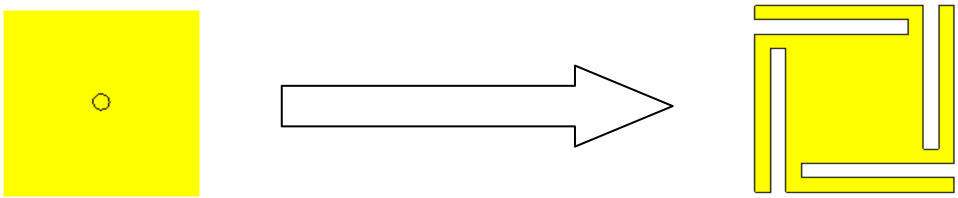
LC filter could be used to explain the operation mode of the EBG. The parameter L (inductance) results from the current that flow through the vias and the C (capacitance) is due to the gap effect between the neighboring patches. The patch width Ws, substrate thickness h, gap width g and dielectric constant ε_r, the inductance L, capacitance C and resonance frequency are related in the equations below [6][7][8].

$$L=\mu_0 h \quad (1)$$

$$C=\frac{Ws\varepsilon 0(1+\varepsilon r)}{\pi}\cosh^{-1}\left(\frac{Ws+g}{g}\right) \quad (2)$$

$$f_0=\frac{1}{2\pi\sqrt{LC}} \quad (3)$$

Where g and Ws are the gap and the width of the EBG, h and εr are the substrate height and the dielectric constant while ε_0 and μ_0 are the relative permittivity and permeability respectively. f_0 is the resonance frequency of the mushroom EBG.



(a) (b)

Figure 1: slotted EBG structure design process

The mushroom EBG structure produces a single band but when four slots of 1mm by 10mm where introduced and distributed symmetrically about the centre on the basis of the mushroom EBG structure, the structure achieves a dual band gap.

It is found that each step extends the equivalent path of the current, with an increase in frequency band, the figure below shows the structure of 3x3 dual band EBG structure. The EBG patches are separated 2mm from each other, the transmission line is placed 1.6mm above the structure. By using the method of suspended transmission line S2,1 value was measured.

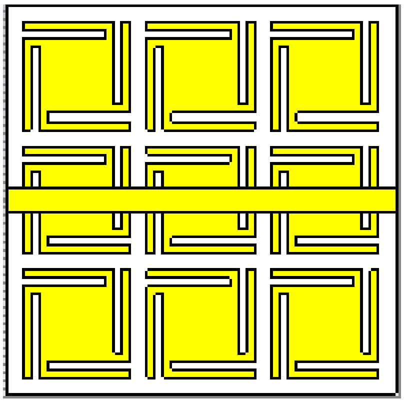


Figure 2: 3 by 3 slotted Electromagnetic bandgap structure

The structure in figure 2 above is design and simulated using Computer Simulation Tool (CST) software. Both the simulated and measured result shows the structure successfully achieves dual band gap frequencies.

The individual bandwidths (≤ -20dB) from the simulated and measured result are 10.50% and 8.9% percentage bandwidth at 1.80GHz and 4GHz are obtained from the simulation while 10.97% and 5% at 1.8GHz and 4.3GHz are obtained from the measurement.

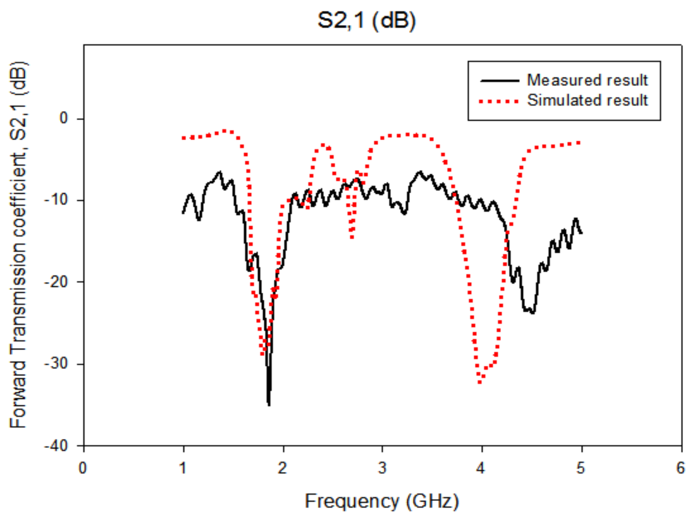
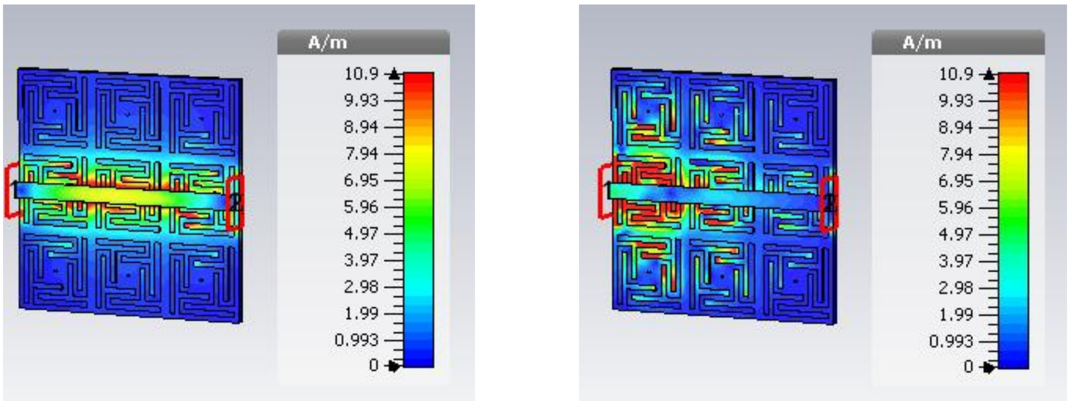


Figure 3: simulation and measured results

III. Current Distribution

Figure below shows the surface current distribution, it can be seen that outside the bandgap the current is uniformly distributed along the suspended transmission line from port 1 to port two for both E-field and H-field. While inside the bandgap the current is focused on the etching slots, it couldn't reach port 2. This shows that the structure can effectively suppress the surface wave in the entire pass band frequency.



(a) (b)

Figure 4: (a) Current distribution outside the bandgap (at 3.5GHz and 1.25GHz) and (b) Current distribution inside the bandgap (at 4GHz and 1.8GHz)

IV. Conclusion

A multi-band Electromagnetic band gap structure using method of Suspended Transmission Line has been designed, simulated, Fabricated and measured. The performance of multi-band microstrip antenna can be increased when incorporated with the EBG structure.

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