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# Artificial Ground Plane Based on Electromagnetic Bandgap for Stripline Transmission Line

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**Abstract**

This paper presents a study of the interaction between mushroom-type electromagnetic bandgap (EBG) surfaces replaced the conventional electric conductor ground plane of a stripline. The proposed EBG surface has both artificial magnetic conductor (AMC) and stopband performances. Compared to the conventional stripline, the EBG as artificial ground plane exhibits bandstop behavior which unlike all-pass behavior of the conventional stripline with electric conductor ground plane. The rejected frequency range is resulted from 6.76 to 10.08 GHz (3.32 GHz), which has fractional bandwidth of 40%. Promising results give future possibilities for practical suppression noises and interferences of systems.

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*Keywords:* EBG, stripline, artificial ground plane, noise suppression;

## 1. Introduction

Electromagnetic noises and interferences (EMI) in semi-conducting electronics and integrated circuits continue to be problematic as the operational frequency and degree of integration of electronic devices increase continuously. So far, several methods have been proposed for suppressing noise and EMI [1]-[4]. Among these methods, electromagnetic bandgap (EBG) as filter has become one of most promising techniques for suppression of noises [5]. EBG structures are usually realized by periodic arrangement of dielectric materials and metallic conductor or mechanically drill hole into the host substrate. Generally, EBG exhibits two unusual properties including forbids the

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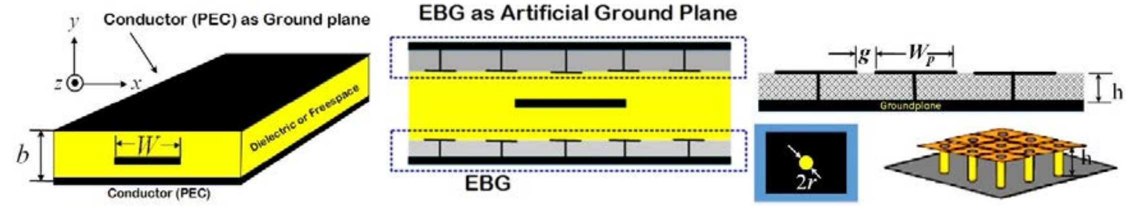


(a) (b) (c)

Fig. 1. Suspended stripline (a) conventional ground plane; (b) replaced EBG as a artificial ground plane; (c) configuration of the mushroom type structure

propagation of surface wave when used as stopband or EBG and in-phase reflection of incident-waves which behaves like an artificial magnetic conductor (AMC). Due to these attractive properties, various EBGs have been designed [5]-[7]. In this paper, we propose a different approach to instead the conventional electric conductor ground plane of stripline with the EBG surface. The mushroom-like EBG is used, which is made up of metal patches, dielectric substrate, and vias connected with patches and ground plane, as shown in Fig. 1 (c). The stopband and reflection phase properties are used to characterize the performance of the proposed EBG. The stopband characteristic can suppress noises and EMI in desired bands.

## 2. Construction and Characteristics of the EBG

The conventional stripline consists of a stripline between two reference conductor ground planes as shown in Fig. 1(a). In order to have a characteristic impedance of 50-Ω, the stripline is designed with width (*W*) of 10 mm and air thickness (*b*) of 7 mm. While, the configuration of the EBG integrated with stripline is shown in Fig. 1 (b). Compared to the conventional stripline, the ground planes are replaced with the EBG surface using mushroom type structure. Fig. 1 (c) shows the cross-sectional and 3D view of the mushroom type structure. The substrate material of the EBG is RT5880 with $\varepsilon_r$ of 2.2 and thickness (h) of 1.575 mm. Each unit cell consists of a square patch of $0.2\lambda_g \times 0.2\lambda_g$ ($6\times6$ $mm^2$) and via has a diameter of 0.01 $\lambda_g$ (*r*= 0.3 mm).The patches are separated from each other by a distance 0.025 $\lambda_g$ (*g*= 0.75 mm).

The EBG is characterized by using CST MicroWave Studio simulator [8]. Two unique properties commonly used to characterize EBG structure are the reflection phase and the surface wave stop-band. The simulated model for the reflection phase calculation is shown in Fig. 2(a). In order to model and analysis the infinite surface, the periodic boundary conditions (PBC) is applied EBG with the CST simulator. The top boundary is assigned as a Floquet port, which excites a plane wave with controllable angle and polarization modes (TE and TM). The EBG surface is chosen as the phase reference plane, and the zero degree reflection phase defines the frequency of the in-phase reflection for each case. The AMC bandwidth is defined as the frequency range of the ±90 reflection phase. Simulation of the structure is carried out with the wide range of frequency from 10 MHz to 25 GHz. The reflection phase shows that the proposed mushroom-like EBG has the zero degree reflection phase at 10.25 GHz as shown in Fig. 2(b). In order to generate dispersion relation of surface waves, a mushroom described the irreducible Brillouin zone is defined [3] using the Eigenmode solver. The Floquet port is replaced by a perfect matched layer (PML) for dispersion diagram analysis. The PML is positioned a half-wavelength above surface to absorb the reflected wave. Fig. 2 (c) shows the dispersion diagram of the first to third modes. It can be seen that the surface wave suppression band gap between the first two modes ($1^{st}$ TM mode and $2^{nd}$ TE mode respectively) is obtained. The forbidden band is from 9.91-11.92 GHz and it is clear that the zero degree reflection phase of 10.25 GHz is in this band.