유도성 주기 대역 저지구조를 이용한 적층구조 전원공급면의 불요공진 억제

Removing the Resonance due to the Power-Bus Structure using EBG Inductive Sheets

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Abstract

This paper investigates a method to remove the undesirable resonance of the rectangular power-bus structure(PBS) using an inductive layer. The equivalent surface impedance of the proposed loading is calculated for characterizing the proposed EBG geometry. The effects of the strips and the immediate surroundings are illustrated by a number of numerical experiments.

Keywords : Power-Bus, Resonance, Strip loaded sheets

I. Introduction

PCBs are frequently used in the electric or electronic systems and equipment. In PCBs there are a number of layers stacked and configured in various ways, dependent upon the circuit performance, the flow of signals, grounding, etc. With the rising clock-speed and number of components, PCBs tend to have denser population, which ends up with complicating noise phenomena. Particularly, the power-bus structure of the power- and ground planes is found out to cause the noise in PCBs[1-4].

In this paper, the surface of the PBS winds up with the change in material's characteristics and stratification where PEC strips are assumed to periodically sit on a very thin slab backed by one of the two metal planes in the PBS. The slab will be ordinary lossy dielectric or magnetic material, but very thin enough to be replaced by a sheet. And the sheet has strips on its top and is expressed as the surface impedance[5]. The analysis is rigorously carried out, regarding the way the sheet affects the properties of the PBS as the EBG geometry for having a stopband against the unwanted resonant field propagation, to find out the solution to damp the spurious resonance modes.

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II. Theory

The power-bus structure can be modeled as a cavity having the PEC power- and ground planes and the PMC walls. Fig. 1 is the top-view of the power-bus structure with a current feeding line which is placed in the upper region, and passes the intermediate region through the hole on the planes whose center is (X_S, Y_S), and leaves the ground plane and goes down to the lower region. And the output port is located at (X_f, Y_f). A lumped element is loaded at (X_{Lu}, Y_{Lu}).

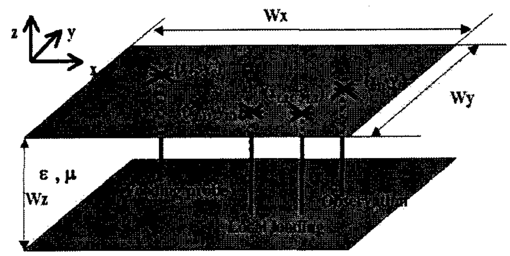

Figure 1. Power-Bus structure with 1 feed.

The size of the rectangular power-bus is $W_x \times W_y \times W_z$. The PCB's substrate fills the intermediate region between the metal planes, and W_z, 4.2 and 0.02 are given as its thickness, relative dielectric constant and loss tangent, which is confined within the PEC and PMC boundaries.

The governing conditions are solved by the modal analysis method using the double sum is adopted to evaluate the field and impedance on the rectangular power-bus structure accurately[1]. The double sum in [1] is good enough for the calculation of unloaded rectangular power-bus problems.

$$Z_{1d}(f,X_f,Y_f)=\sum_{m=0}^{\infty}\sum_{n=0}^{\infty}\frac{\gamma_{mn}\cdot c_{mn}(X_s,Y_s)\cdot c_{mn}(X_f,Y_f)\cdot W_z/(W_xW_y)}{\varepsilon\omega/Q+j(\varepsilon\omega-\frac{k_{xm}^2+k_{yn}^2}{\omega\mu})} \quad (1)$$

where

$$c_{mn}(X_i,Y_i)=cos(k_{xm}X_i)\times\cos(k_{yn}Y_i)\times sinc(k_{xm}P_{xi}/2)\ \times sinc(k_{yn}P_{yi}/2)$$

$$k_{xm}=mp/W_x,\quad k_{yn}=np/W_y,\quad w=2p\ f$$

$$Q=[\tan\delta+\sqrt{2/\omega\mu_0\kappa W_z^2}\,]^{-1} \quad (2)$$

γ_{mn} is 1 and 4 for (m =0, n =0) and ($m\neq0$, $n\neq0$) each. When ($m\neq0$, n=0) or (m=0,$n\neq0$), γ_{mn} takes 2. $tan\delta$, ε, μ, f, P_i and j denote loss-tangent, permittivity, permeability, frequency, port's width and $\sqrt{-1}$,respectively. This has been about the original geometry. Now the PBS with the strips loaded on the PEC backed slab is illustrated.

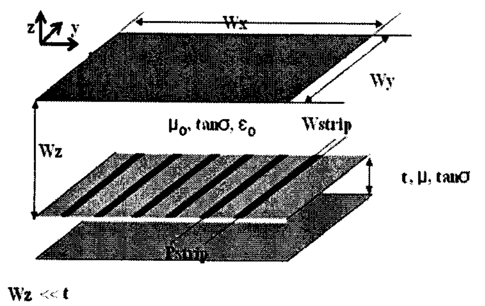

Figure 2. PBS loaded with periodic metal strips on the founded sheet.

The impedance observed at the strip array surface into the slab is represented as

$$Z_S = Z_{inSlab}\ ||\ Z_{Pstrip} \quad (3)$$

where

$$Z_{Pstrip} = j0.5Z_{0Slab}k_0P_{Strip}\log(2P_{Strip}/\pi W_{Strip})/\pi$$

and

$$Z_{inSlab}=Z_{0Slab}\frac{Z_{GND}+Z_{0Slab}\tanh(\gamma_{Slab}t)}{Z_{0Slab}+Z_{GND}\tanh(\gamma_{Slab}t)} \quad (4)$$

The combination of the impedance expressions considers the parallel connection between them.

III. Validation

Firstly, the accuracy of the calculation method adopted in this paper here is tested by being compared to the measurement with respect to the basic PBS of Figure 1. Eqn. (1) is evaluated with the 160000 mode numbers(with the truncation number for both $m$and$n$setto400). The geometry of interest takes 156mm×106 mm×508 μm with X_S = X_f= 117mm and Y_S= Y_f = 79.5

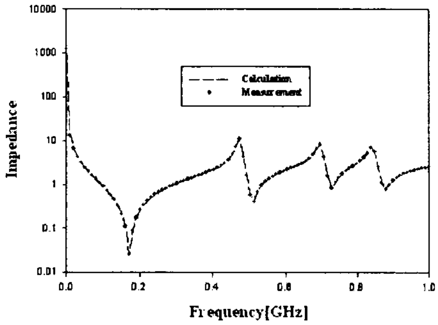

Figure 3. Comparison between the calculation and measurement results with regard to the basic PBS.

As shown in the figure, the calculation scheme turns out robust to have reliable accuracy, agreeing with the counterpart. Also, it is noticed that the resonance modes appear as the peaks in the impedance profile, which are believed to cause the radiated emission as well as the ground-bounce. So it is clear to try to avoid the aftermath in the wake of the unwanted EMI problems by suppressing the impedance levels of the resonance modes. Here a simple but natural need arises like targeting a specific resonance mode frequency to remove or more in an extended frequency band. This leads us to the practice that circumvents the dominant resonance mode, say, TE10 at 475 MHz in a couple of ways such as suppressing only the target resonance frequency without affecting the rest of the entire band of interest or perturbing the overall impedance profile. If a local element is employed, only one specified resonance mode can be selectively damped. However, this paper suggests the variation in the surface boundary condition of the PBS which influences the impedance behavior in the whole frequency range. To see what happens in details, we define a number of cases of parametric differences for engineered sheets: material-wise, there will be lossy dielectric slabs or magnetic slabs on which PEC periodic strips reside, and the slabs will have different thickness numbers. Geometry-wise, strips' period will be varied.

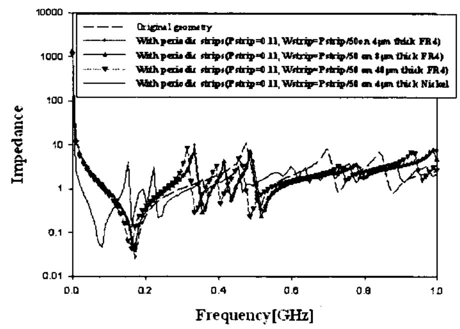

Figure 4. The dominant resonance mode at 475MHz move away by adopting the strips on the FR4 or Nickel slabs.

Periodic strip loaded FR 4 sheets with Pstrip = Wx/5.2and Wstrip= Pstrip/50 make influence on the whole frequency in Figure 4, splitting the original TE10 mode peak and reducing the impedance level at 475 MHz by 9 Ω. However, there are three peaks occurring lower than 475 MHz, while higher resonance frequencies are much suppressed. Things totally change with a magnetic material Nickel(μr=250) of the unchanged thickness. It brings the remarkable mitigation effect in a much wider band.

IV. Conclusion

In this paper, we examined a method to attack the resonance problems of the rectangular power-bus structure(PBS) using thin sheets loaded with periodic metal strips. The equivalent surface impedance of the proposed loading is calculated and involved in the expression of the impedance that accounts for in the PBS, in order to improve the resonance behavior of the original structure.

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