Coupling Effects According to PCB Orientations

Jin-Kyoung Du, Se-Young Hyun,
and Jong-Gwan Yook
Dept. of Electrical and Electronic Engineering
Yonsei University
Seoul, Republic of Korea
jgyook@yonsei.ac.kr

Jongwon Lee and Jin Soo Choi
Agency of Defense Development
Daejeon, Republic of Korea
jwlee@add.re.kr
jschoi@add.re.kr

***Abstract*— Electromagnetic pulse penetrates into electronic devices and makes influences to PCBs finally. The incident fields generate parallel-plate waveguide resonances of PCB itself and the resonances are coupled through via-hole inducing critic damages. In this paper, the coupling effects are measured according to PCB orientations. Both of vertically and horizontally polarized plane waves are found to generate high coupling effects to PCB at the resonance frequency regardless of the incident angle, except for a front propagation of the horizontally polarized plane wave, which hardly generate resonance modes. Based on this result, PCBs can be located properly inside enclosures considering field distributions nearby to decrease the coupling effects.**

Keywords-Electromagnetic pulse; printed circuit boards; couplings; orientations; polarizations; resonances

I. INTRODUCTION

Electromagnetic pulse (EMP) can make malfunctions or destructions of electric devices which usually have printed circuit boards (PCBs) inside. The penetrated fields may generate different coupling effects to a target PCB according to its orientations, therefore investigation of these coupling phenomena can be helpful to decrease the coupling effects and protect the target PCB against penetrated fields.

Coupling effects to perpendicular and parallel modules of daughter boards from a mother board were studied [1] but EMP is not propagated from adjacent circuit boards but from outside in the form of plane waves. The incident plane wave penetrates to dielectric materials of PCBs and generates parallel-plate waveguide (PPW) resonance modes between reference planes. PCBs generally include lots of via-holes and the resonances are coupled through the via-holes [2]. Influences from plane waves to PCBs with different dielectric materials were researched [3] but effects by PCB resonances were not considered. Hence, in this paper, the coupling effects from plane wave to a target PCB including a via-hole are analyzed by measurements according to PCB orientations.

II. MEASUREMENT RESULTS

A target PCB having a signal trace as well as a via-hole is fabricated (size = 36 mm × 24 mm × 3.04 mm, $\varepsilon_r = 3.5$), and measured using vector network analyzer (VNA) to assure a resonance mode generation. A transmission characteristic (S_{21}) of an ideal trace should be almost 0 dB but when noise couplings are occurred at some frequencies, it becomes below 0 dB at those frequencies. The dominant resonance mode of the fabricated PCB is TM_{10} at 2.4 GHz and it is clearly observed using VNA as shown in Fig. 1.

Coupling effects from plane wave according to PCB orientations are measured using VNA and a dual ridged horn at an anechoic chamber. Fig. 2 represents a configuration of the measurement system. VNA is connected between DRH and one port of the signal trace using RF cables, and a 50 Ohm terminated load is connected to another port of trace. Fig. 3(a) and Fig. 3(b) describe measured coupling effects from vertically and horizontally polarized plane waves, respectively. High level of coupling effects are measured around 2.4 GHz regardless of polarizations and the incident angle, except for a front propagation (theta = 90°) of the horizontally polarized plane wave because it hardly generates resonance modes between reference planes of the target PCB.

This work was supported by Agency for Defense Development, Daejeon, Republic of Korea.

III. SUMMARY AND CONCLUSION

The incident fields generate the PPW resonance modes which are coupled through via-holes of traces at PCBs. Vertically and horizontally plane waves are excited toward a target PCB to measure coupling effects according to its orientations and it found that high coupling effects are occurred by both of plane waves regardless of the incident angle, except for a front propagation of the horizontally polarized plane wave. PCBs are usually located in metal enclosure then its orientation can be adjusted properly to decrease coupling effects if field distributions inside enclosures are well analyzed.

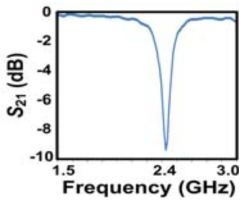


Figure 1.
Transmission characteristic
of the signal trace.

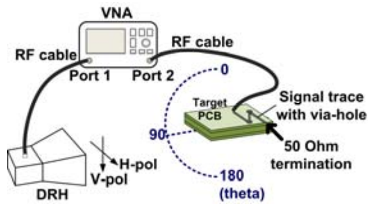
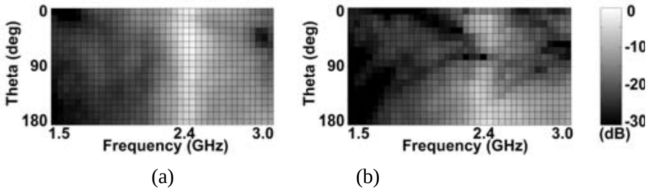


Figure 2.
Measurement configuration
at the anechoic chamber.



(a) (b)

Figure 3. PCB coupling effects from (a) vertically polarized plane wave and (b) horizontally polarized plane wave

.REFERENCES

[1] D. Hockanson and S. Radu, "An investigation of the effects of PCB module orientation on radiated EMI," in *Proc. IEEE Int. Electromagn. Compat. Symp.*, Aug. 1999, vol. 1, pp. 399–404.

[2] H.-D. Kang, H. Kim, S.-G. Kim, and J.-G. Yook, "A localized enhanced power plane topology for wideband suppression of simultaneous switching noise," *IEEE Trans. Electromagn. Compat.*, vol. 52, no. 2, pp. 373–380, May 2010.

[3] F. Brauer, C. Klunder, and J. L. Haseborg, "The influence of different PCB materials on the coupling behavior of high power electromagnetics," in *Proc. IEEE Int. Electromagn. Compat. Europe Symp.*, Jun. 2009, vol. 1, pp. 1–4.