Display to Main-Board Grounding Design Methodology Through Eigen Simulation

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***Abstract*— This paper discusses the grounding between wireless displays and Main Logic Boards (MLB), when they are aligned in parallel to each other to save space. The MLB accommodates lots of high-speed signals such as DDR, MIPI, etc. High speed signals can exploit the display/MLB parallel arrangement to efficiently radiate EM interferences causing wireless system compliance failures and desensitizing the receiver. RF engineers use conductive posts to short the two at multiple points in order to reduce the unwanted radiation. Often this implementation is done using trial and error approach. This paper describes a systematic method to simulate and design the grounding locations to minimize the interference. A design example is presented using this method to reduce the coupling from the noise sources to the antennas by ~40 dB. Without loss of generality, the method can be equally used in similar metal/metal arrangements.**

I. INTRODUCTION

Consumer electronics are very prevalent nowadays. A big portion of consumer electronics has displays; cellphones, and smart display home assistants are examples. A common strategy for devices with display is to place the MLB parallel to and behind the display, the display back is a full metal stainless-steel sheet and the MLB is mostly copper, this arrangement creates a resonance structure that can amplify unintentional radiation from high speed signals on the MLB.

Unintentional radiation has two major impacts, 1- far field radiation that can cause EMI compliance test failures, 2- near/far emission that can desensitize the wireless receiver.

The resonance structure can be viewed as a patch antenna. While patch antenna study is focused on the fundamental resonance frequency, for unintentional radiation, we are concerned about fundamental and high order resonances. The patch antenna design is also concerned with matching the input, for EMC the coupling to noise power can take many forms and the feeding methods are numerous.

Eigen-Mode solver generates resonance properties of a closed structure without enforcing excitation, for electromagnetics case, the software solves Helmholtz homogeneous wave equation $\frac{1}{c_0^2}\frac{\partial^2 E}{\partial t^2} - \nabla^2 E = 0$ [1].

The Eigen-Mode simulation shows all the resonance frequencies of the display/MLB structure. The paper shows that high amplified radiation is related to those frequencies and that eliminating the resonances will simultaneously reduce radiation and coupling to close by antennas.

II. METHODOLOGY

We will use an example of display/MLB arrangement to illustrate the methodology. The display/MLB has approximate sizes of 6x12 cm and 11x18 cm. Similar devices usually have EMI/desensitization issues at or below 2.5 GHz. Thus the study focusses on eliminate resonances up to 2.5 GHz as a design target.

We used a commercial EM eigen mode simulator, the resonance frequencies were found to be 1.3, 2, and 2.5 GHz. The simulator shows locations for high E-field, grounding posts are added at those locations. Random grounding can create more resonance at lower frequencies, 600 MHz for our example was created when grounding one side.

A step by step design will be presented in details in the full paper. The final design has 6 grounding posts, the smallest number of posts that pushes the resonance frequency higher than 2.5 GHz.

The Eigen-Mode simulation is accompanied by a frequency domain simulation. We simulated the total structure with no simplification, electric and magnetic infinitesimal dipoles are used to represent the noise sources and the antennas. The return loss of the noise dipoles and the coupling from noise to antennas is compared to the resonance modes, and the improvements in coupling as we eliminating resonance modes.

III. RESULTS AND CONCLUSIONS

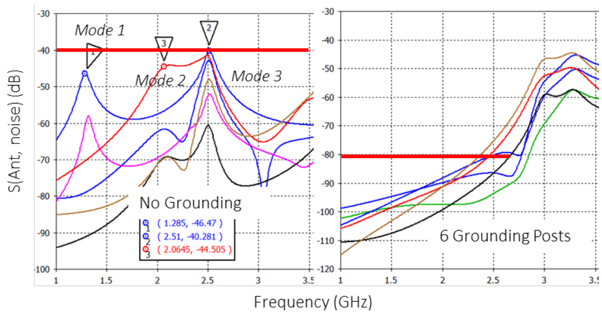

Fig. 1. Improvement of the noise to antenna coupling. No grounding posts has -40 coupling, peaks align with resonance frequencies. For 6 grounding posts, resonances are pushed to higher than 2.5 GHz, maximum coupling is ~ -80 dB at 2.5 GHz.

This paper presents a design method for grounding MLB to display, and similar arrangements, to eliminate amplified coupling and radiation due to resonances. The method has the advantages:1- very fast, it takes couple of minutes on a normal desktop, 2- it shows all the supported resonances and the positions for adding grounding posts, and 3- it provides a solution with minimum number of grounding posts. In one example, the design method resulted in 6 grounding posts to push the smallest resonance frequency up to 3 GHz and reduced noise to antenna coupling by 50 to 35 dBs, Fig. 1. It also showed random grounding can create more resonances and exacerbate the problem, and faster simpler Eigen mode can replace frequency domain simulation for grounding design.

REFERENCES

[1] P. Monk, C. Carstensen, S. Funken, W. Hackbusch, and R. H. W. Hoppe, Eds., *Computational Electromagnetics*, vol. 28. Berlin, Heidelberg: Springer Berlin Heidelberg, 2003.