English

Research Express@NCKU Volume 9 Issue 2 - June 5, 2009
[http://research.ncku.edu.tw/re/articles/e/20090605/2.html]

Simultaneous Switching Noise Mitigation Capability with Low Parasitic Effect Using Aperiodic High-Impedance Structure

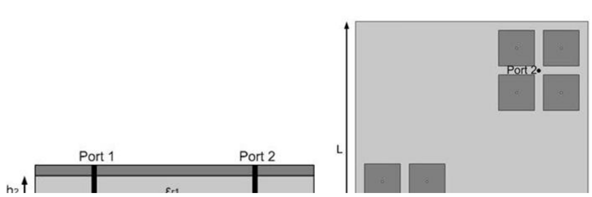
Mau-Phon Houng*, Chin-Sheng Chang

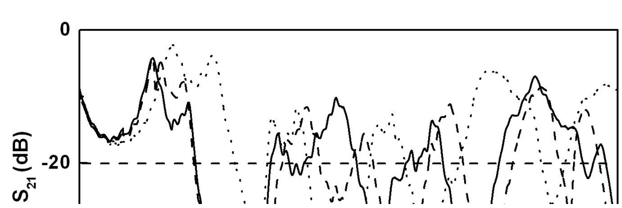
Institute of Microelectronics, College of Electrical Engineering and Computer Science, National Cheng Kung University
mphoung@eembox.ncku.edu.tw

Progress In Electromagnetics Research Letters, Vol. 4, 149–158, 2008

With rapid growth of wireless local area network (WLAN), the trends of high video/sound/data transmission and internet everywhere are increased day by day. Thus, the requirements of compact size, light weight and high performance are necessary; in addition, the trends of the multi-function and multi-band operations in a module are also important in communication products design. Four metal layers assemble technology is widely used in high-speed digital circuits. The top and bottom metal layers are used to mount the active and passive components, the others are used to be power and ground planes. With fast edge rates, high clock frequencies, and low voltage levels, simultaneous switching noise (SSN), on the power/ground planes has become one of major concerns in printed circuit boards (PCBs). The cavity modes among the power and ground planes excited by the SSN causes serious signal integrity (SI) or power integrity (PI) problems for the high-speed circuits. While the clock frequencies increasing, the suppression of the switching noise is becoming important.

Suppressions of the nonlinear effects have been proposed by using the concept of the photonic bandgap (PBG), including the electromagnetic bandgap (EBG) and defected ground bandgap (DGS). Their dominate function is filter behavior. Period of EBG structures would cause the stopband or bandpass in specific frequency. Therefore, The EBG structures are widely used in components and systems. In our study, the EBG structures are embedded in the substrate. Each EBG and ground plane was connected with via to form the high-impedance surface structure. Figure 1 shows the aperiodic high-impedance surface structure. The eliminated cells were placed around the excited and received port. The high-impedance surface structure not only supports an efficient suppression behavior, but also induces undesired modes in lower frequency. Figure 2 shows the suppression results between period and aperiodic high-impedance surface structures. It can be found that the -20 dB stopband of two structures are from 1.3 GHz to 1.9 GHz, the stopband width is 600 MHz. These results were demonstrated that the aperiodic high-impedance surface structure has efficient SSN suppression.





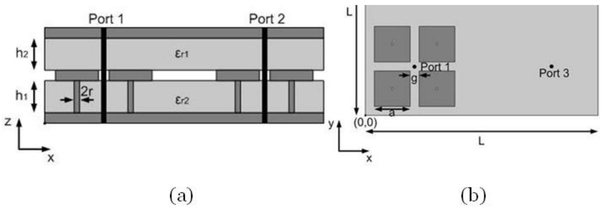


Figure 1. The schematic of the aperiodic high-impedance surface (a) side view, (b) top view.

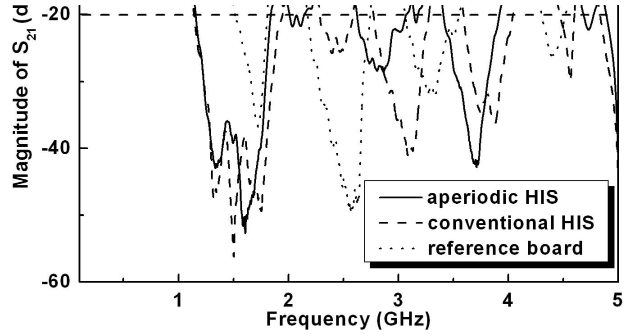


Figure 2. Compared with the suppression results between period and aperiodic high-impedance surface structure.

Figure 3 shows the comparison the suppression results between period and aperiodic high-impedance surface structure in lower frequency. It can be found that there are three modes higher than -10 dB in period structure. The undesired modes could be caused by the parasitic effect of the high-impedance surface. These peaks will be propagated to other modules by cavity modes. Uses of the aperiodic structures not only have efficient suppression performance, but also produce less parasitic effect in lower frequency. In other words, the proposed structure has good EMI and SI problem.

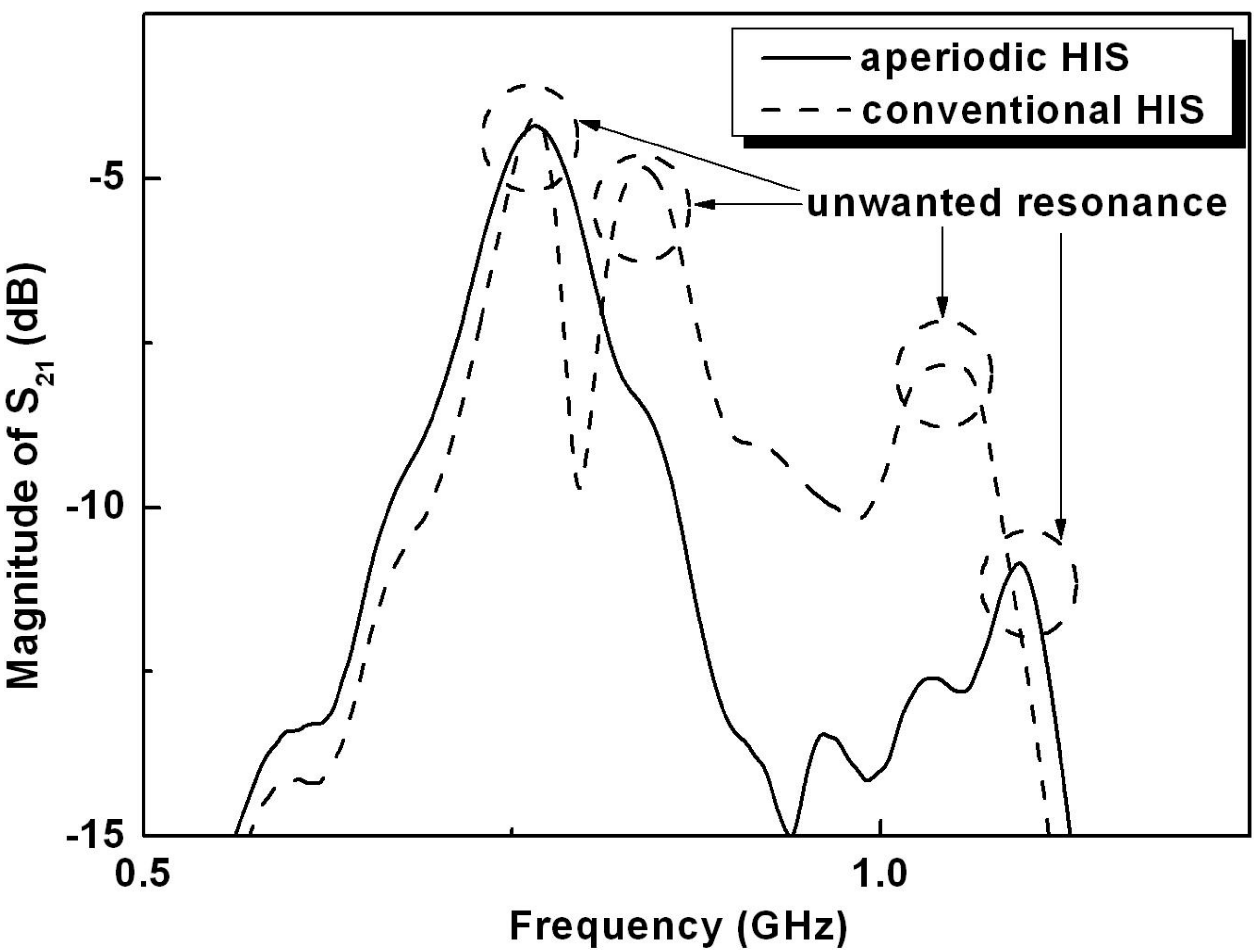
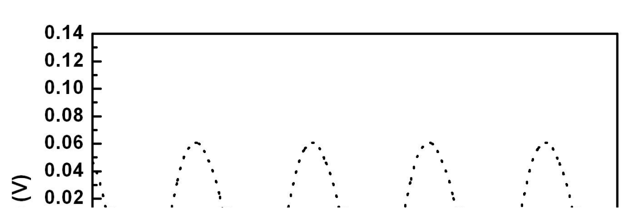


Figure 3. Compared with the suppression results in lower frequency range.

A time-domain digital current source with data rate of 2.5 Gbps and amplitude of 125 mV is generated and then transformed into a frequency domain response by applying Fourier transform. Figure 4



shows the time domain analysis results of the two high-impedance surface structures. It is clearly seen that the peak coupling noise is eliminated from 60 mV to 10 mV for the period and aperiodic structures. Compared with the reference board, the coupling noise can be reduced approximately 83% for two high-impedance surface structures. The phase difference between two structures is generated by the amount of the high-impedance surface cell.

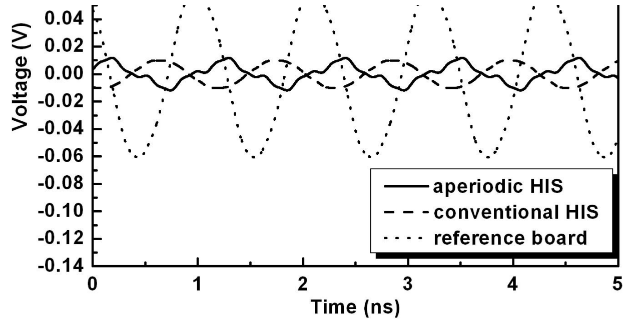


Figure 4. Time domain analysis for two high-impedance surface structures.

Finally, the signal integrity analysis is based on the maximum eye open (MEO) and the maximum eye width (MEW). Figure 5(a) shows five layer PCB structure with signal traces through the proposed aperiodic structure. The top and bottom signal layers are connected by via. The input signal is 2.5 Gpbs with the rise time of 319 ps and the amplitude of 500 mV. The simulated results for the reference board, period and aperiodic high-impedance structures are shown in Figure 5(b)-(d). To compare with the reference board, the MEO and MEW is lightly attenuated by using the period and aperiodic structures. In other words, the aperiodic high-impedance surface structure is able to keep the signal integrity.

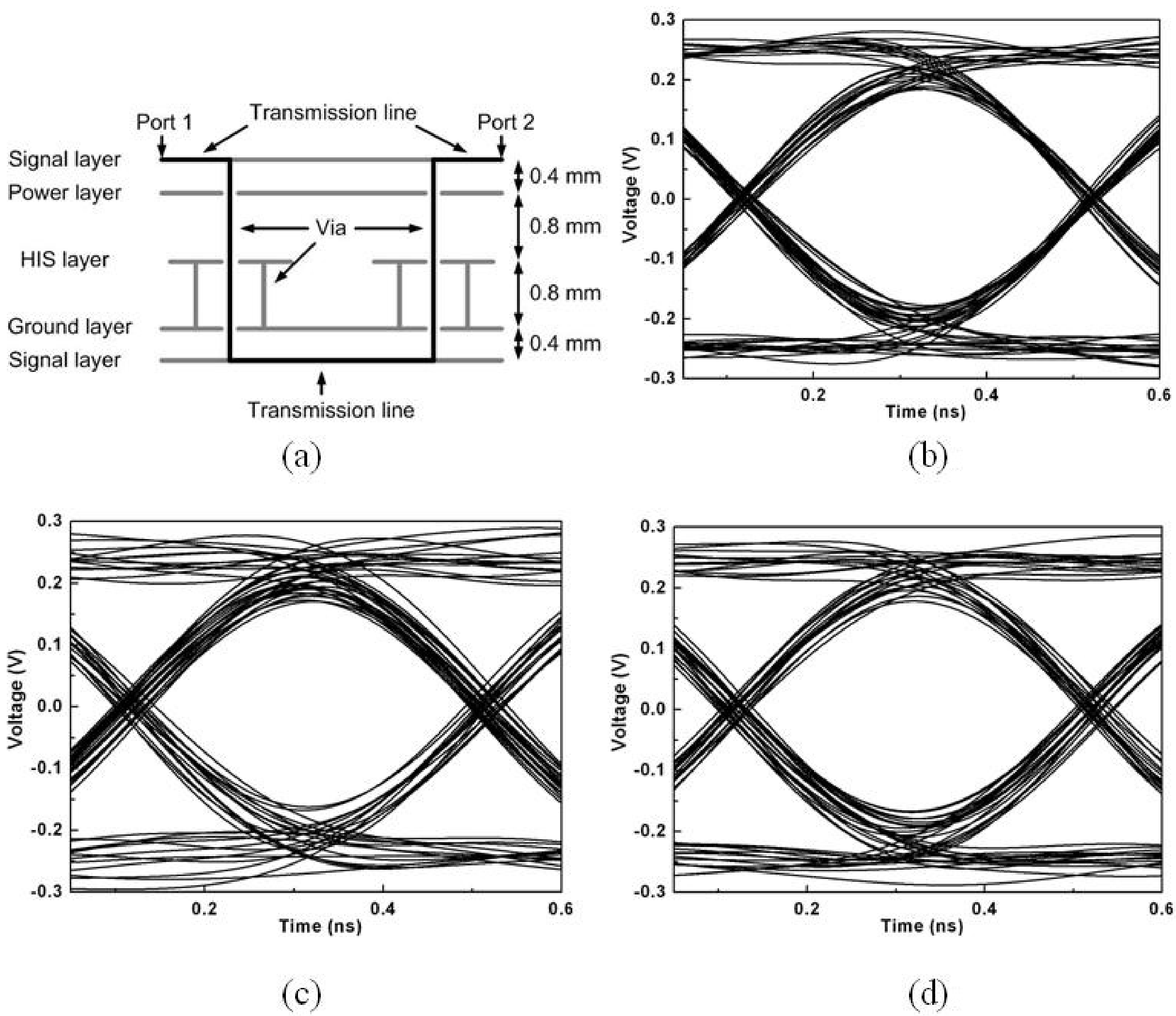


Figure 5. The eye diagram results. (a) Five layer structure for single-ended trace. (b) The reference board. (c) The conventional period structure. (d) The proposed aperiodic structure.