

Reduction of Power and Ground Noise Coupling in Mixed Signal Modules

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ABSTRACT - By the full-wave electromagnetic field simulation, the effectiveness of certain measures to reduce the power and ground noise coupling in mixed signal modules is investigated. Segmentation of power and ground planes and proper placement of decoupling capacitors for the reduction of noise coupling are evaluated.

With the boom of portable communications industry, challenges in designs of mixed signal modules are becoming increasingly serious. Severe electromagnetic interference may occur in high-density mixed signal electronic modules. Switching currents of output drivers of high-speed digital circuits can generate significant noise in power and ground supply systems. Power and ground supply noise, together with the noise coupled to the analog and digital signal distribution systems, may cause malfunctioning of both digital and analog circuits.

This presentation provides investigations on the effectiveness of some techniques used for the reduction of power and ground noise coupling. As shown in Figure 1, segmentation of power and/or ground planes are often used for the isolation of different parts of circuits [1]. As signal traces pass through split power or ground planes, severe signal integrity issues will appear [2]. Bridges connecting segmented metal planes provide adjacent current return paths for such traces.

Electromagnetic field simulations are used for detailed study of the effectiveness of the configuration shown in Figure 1, as well as other configurations, in reducing noise coupling. With an electromagnetic field solver and a circuit solver integrated together [3], evaluations are performed for different shapes and segmentations of power/ground planes, as well as for various decoupling capacitor placements. In this study, transient electromagnetic wave propagation between adjacent parallel metal planes are computed by a time-domain electromagnetic field solver. Distributed capacitors between edges of split metal planes are computed separately and are implemented in the circuit solver that runs simultaneously with the field solver.

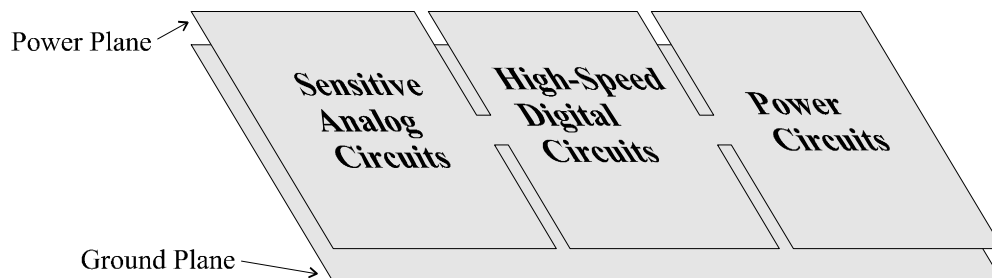


Figure. 1 Segmentation of power and/or ground planes to isolate different parts of circuits.

An example of such simulations is illustrated in Figures 2 and 3. In this example, the power and the ground planes are 12 cm by 8 cm in size, separated by a 0.5 mm thick dielectric medium with a relative dielectric constant of 4. The noise source located at the center of planes in both Figures 2 and 3 is a current source with an internal resistance of 10 ohms. The waveform of the current source is a series of positive and negative pulses, alternating with a period of 4 ns. Each pulse has a 500 ps rise, duration and fall times and 200 mA magnitude. Gaps, at 4 cm and 8 cm from the left edge as shown in Figure 3 (a), is 1 mm wide. The horizontal coordinates of the four test locations, where decoupling capacitors (10 nF each) are placed, are 36, 42, 78 and 84 mm respectively.

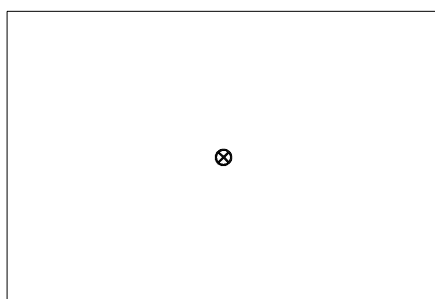
Package resonance along the longer side of the metal planes can be clearly observed from Figure 2 (b) for the solid power plane shown in Figure 2 (a). The noise source at the center causes strong voltage fluctuations near two ends of the metal planes. However, without proper placement of decoupling capacitors, the segmentation of the power plane can actually worsen the situation near the two ends of the metal planes, as shown in Figure 3 (b). Different effects of placing only C_2 and C_3 , or only C_1 and C_4 , or all the four capacitors are shown in Figure 3 (c) to (e).

Acknowledgment

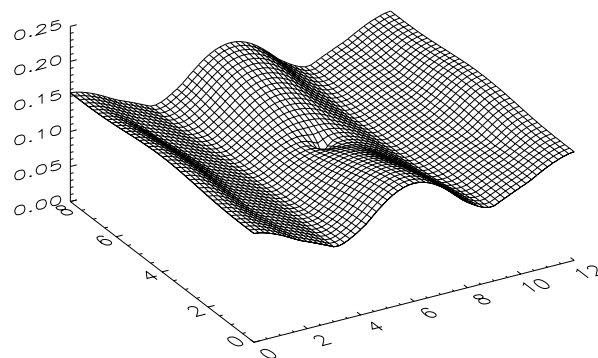
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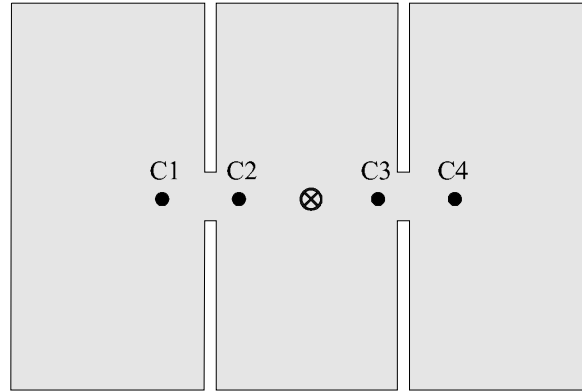


(a)



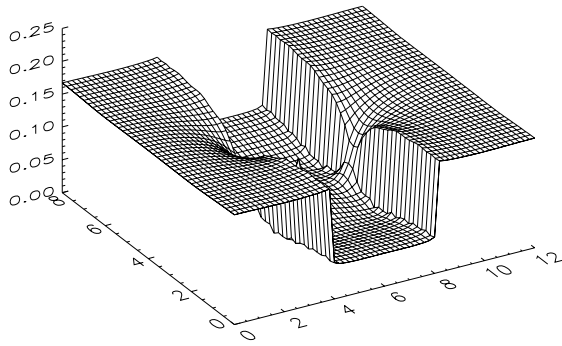
(b)

Figure 2 (a) Top view of the non-segmented power and ground planes with a noise source located at the center. (b) Spatial distribution of the average magnitude of voltage fluctuation between power and ground planes.

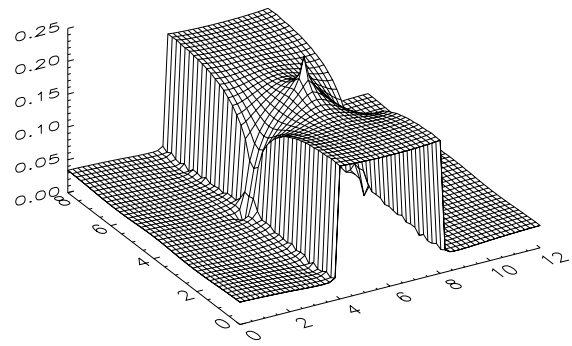


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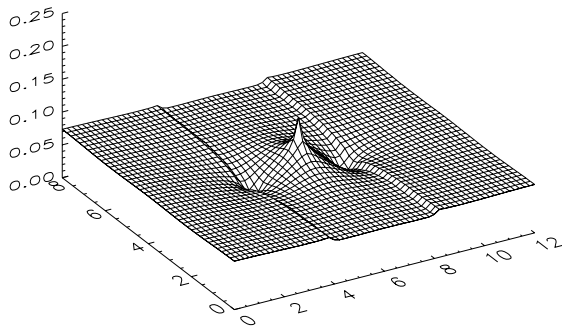
(a)



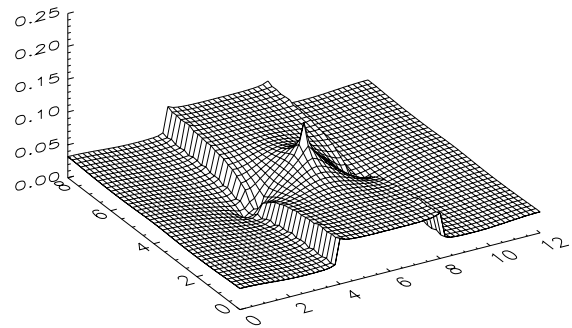
(b)



(c)



(d)



(e)

Figure 3 (a) Top view of the segmented power plane with a noise source located at the center. Also shown are four test locations where decoupling capacitors may be placed. (b)-(e): Spatial distribution of the average magnitude of voltage fluctuation between power and ground planes when there are no capacitors (b), capacitors C_1 and C_4 only (c), capacitors C_2 and C_3 only (d), and all four capacitors (e).