BY HOWARD JOHNSON, PhD

# Hidden schematic

*I've invited my good friend, Bruce Archambeault, PhD, creator of the IBM EMC-rule-checking program "EMSAT," to share his thoughts about ground.*

Your schematic is lying. It shows only the intended flow of signal power. It masks details crucial to the operation of unintentional signal pathways, such as crosstalk and EMI. To understand these factors, you must uncover the hidden schematic operating behind your logic diagram.

The hidden schematic represents, among other things, the flow of physical current in your pc board. Current never flows "one way," as logic diagrams show; it always makes a loop out to the load and returning to the source. For EMI purposes, the returning current path is as important as the intended signal path. As long as you keep the outgoing and returning signal paths closely aligned, the radiation patterns from the two currents cancel. Interruptions to the returning current path have serious negative effects on the EMI/EMC performance of a pc board. Even slight deviations in the returning current path can dramatically increase emissions.

Logic diagrams completely omit the returning signal path. They presuppose a perfect common reference node—ground—for all signals. This idealized node maintains the same voltage at all points of use.

Anybody can make a good ground system at audio frequencies. But no one can make one at 100 MHz, spread out over the area of a typical pc board.

When the size of your pc board exceeds the signal wavelengths, your solid-plane layers operate in distributed fashion. Perturbations slosh across the plane from side to side. The instantaneous voltages at different parts of the plane differ markedly, rendering meaningless the concept of a universal common ground reference.

**Ground is a good place to grow potatoes and carrots.**

When my students ask me how to use ground, I say, "Ground is a good place to grow potatoes and carrots."

I focus my attention not on ground, but on the physical relation of each signal trace to its nearest local-reference plane. That nearest plane, regardless of the dc voltage it carries, forms the main conduit for high-frequency returning signal current.

For example, consider a trace routed next to a power layer. The EMI performance of that trace hinges on the continuity of the power layer. If the trace crosses a chopped-up power region, the boundary of that region interrupts the path of returning signal current on the power layer. In a related way, changing layers within the pc board interrupts the flow of returning signal current.

Remember: Signal current always returns to its source. If you interrupt the natural path of the returning signal current, it will find another way home. The only question is whether the returning signal current remains close to the outbound signal current on a smooth, continuous solid plane or takes a stray path elsewhere that causes EMI problems.

Today's high-speed, complex pc boards have many layers. Who has time to examine each critical signal for a good returning-current path?

I don't, but my computer does. It uses automated EMC-rule-checking tools. These tools uncover the hidden schematic, examining each net in turn, regardless of the pc-board complexity.

If you have not investigated this new class of tool, it's time to do so. Look for a tool that interfaces well with your design process, is easy-to-use, and can display rule violations in a graphical and easy-to-understand manner. EDN

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*Howard Johnson will be back in an upcoming issue. You can reach Bruce Archambeault through www.mossbayeda.com, and you can reach Howard Johnson at www.sigcon.com and howie03@sigcon.com. Comments invited!*