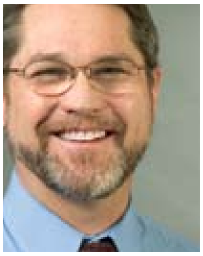

BY HOWARD JOHNSON, PhD

Visualizing differential crosstalk

Figure 1 depicts two 100Ω differential pairs of PCB (printed-circuit-board) traces. A solid-plane layer appears at the bottom of the **figure**. An upper solid plane exists somewhere above the **figure**. This plot shows only a subset of the full stripline cross section.

A pattern of thin, colored lines represents the magnetic field resulting from current in the left-most pair. Technically, the lines prescribe contours of constant 2-D magnetic scaler potential. The magnetic field is most intense where the lines fall closest together and least intense on the right side of the diagram where the lines spread far apart. The field intensity proximate to the conductors appears very intense. Pixelation effects in the **figure** may create what look like moiré interference patterns in the dense region. The moiré patterns are not real. The field patterns proximate to the conductors form a set of concentric curves near the surface of each tiny conductor.

You can estimate the crosstalk picked up by the victim pair, wires A and B, based on the field patterns in this diagram. Your estimate will not be perfect because the mere presence of wires A and B will distort somewhat the high-frequency magnetic-field pattern, but the general principle remains quite useful. Simply count the number of magnetic-field lines that pass between wires A and B to estimate the crosstalk picked up between them.

There are 96 magnetic-field lines between the two conductors on the left side. You can't see those lines, but I know how many there are because I wrote the code that generated this **figure**. There are three lines passing through the flux window between the centerlines of victim traces A and B. Near-end crosstalk is simply the ratio of 3 to 96—about 3%. That's all there is to estimating crosstalk.

Experts in electric- and magnetic-field calculations may recognize that my procedure takes into account only magnetic-field effects, ignoring capacitive coupling. The procedure still works because, in a stripline configuration, inductive- and capacitive-coupling effects are nearly always exactly equal. Compute one, and you have the other.

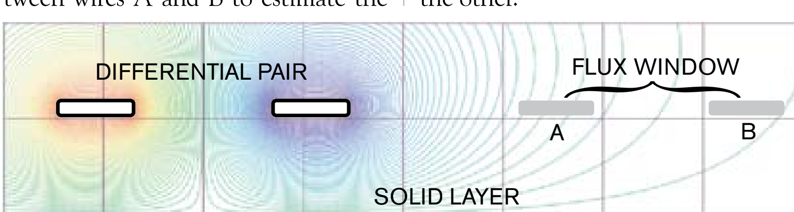

Figure 1 The number of lines of magnetic flux passing between traces A and B indicates crosstalk.

Now, change something. Grab traces A and B and move them both to the left by about one-half a trace width. In response to that action, two new magnetic lines of force now fall within the victim's flux window. Crosstalk increases to 5%, almost double the previous result. The spacing between the aggressor pair and the victim pair greatly affects crosstalk.

Put the traces back to their original positions and try again. This time, leave trace A in its original position while you bring B to the left by one-half a trace width. After you slide B into its new position, three flux lines still penetrate. Crosstalk hardly changes. In a more accurate plot, you would surely observe some small effect, but I think you get the picture. The spacing between the wires of a differential-stripline pair only mildly affects crosstalk.

In this example, the spacing between wires A and B has little effect because the crosstalk effect is not well-balanced. The aggressive field affects wire A much more strongly than it affects wire B. Differential systems can reject only the noise that equally affects both wires. In a nonsymmetric situation, differential-noise cancellation does not occur.

I hope **Figure 1** helps you visualize why differential PCB traces do not significantly reduce crosstalk from other traces. To reduce intertrace crosstalk, you must enforce spacing rules between the aggressor and the victim, much as you would with single-ended signals.EDN

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