PCB007 ***QuietPower*** *columns*

Comparing Cable Shields

Istvan Novak, Oracle, November 2013

In recent columns we looked at the importance of properly terminating cables even at low frequencies and also showed how much detail we can lose in PDN measurements when we use bad-quality cables [1]. In this column we will analyze a step further the shield in our cables.

As a reminder, *Figure 1* shows the noise pickup through the shield of two different cables. Data was captured with a 1-GHz bandwidth oscilloscope. Both cables had 50-ohm factory-mounted BNC connectors at their ends. The oscilloscope input was switched to 50-ohm input impedance and the cables were attached to a DUT with a BNC connector. The DUT (a small DC-DC converter evaluation board) was turned off, generating no signal on its own. The noise we see on the oscilloscope is the signal pickup of the cable from the air.

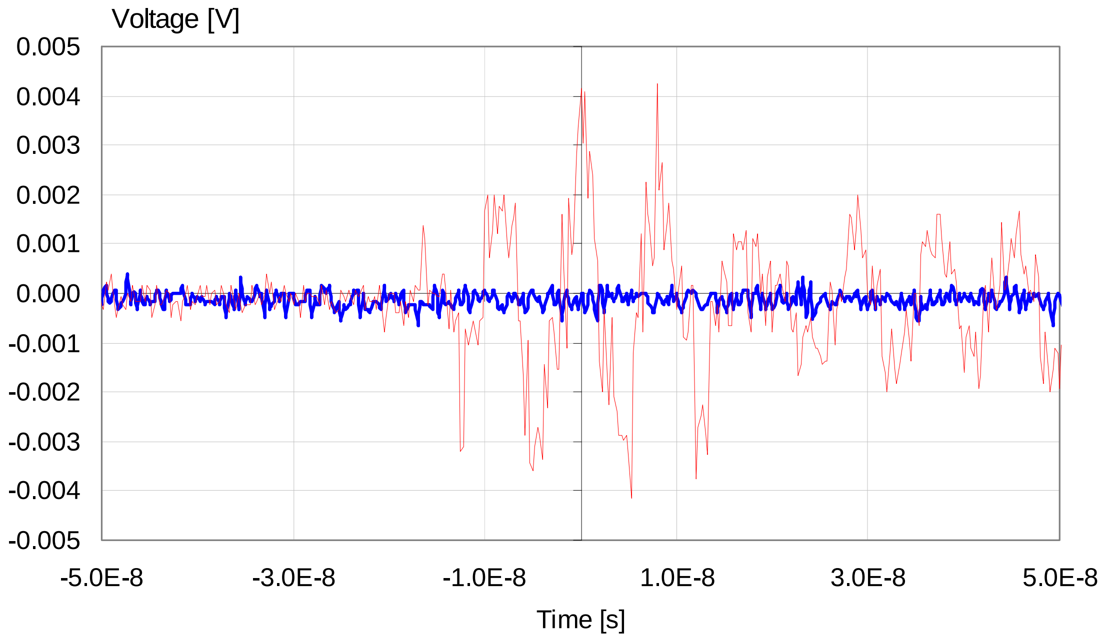

Figure 1: *Voltage measured at the DUT BNC connector with two different cables, with the DUT turned off.*

The more than 8 mVpp signal we see with one of the cables was consistent, not only occasional short bursts. I live in a residential area in the woods, with no visible industrial plant or antenna tower nearby. It might be interesting to track down the source of the noise, but from this column's perspective it is more useful to look at the differences in the cable braid constructions.

Flexible coaxial cables have conductive foil, braided wire or a combination of these serving as the outer conductor, which also serves as shield in single-ended cables. Braided shields come in single or multiple layers of wire mesh. The cables used for *Figure 1* have single-braided shield with no foil. *Figure 2* shows close-up photos of two cable braids, taken with a small USB-powered microscope camera.

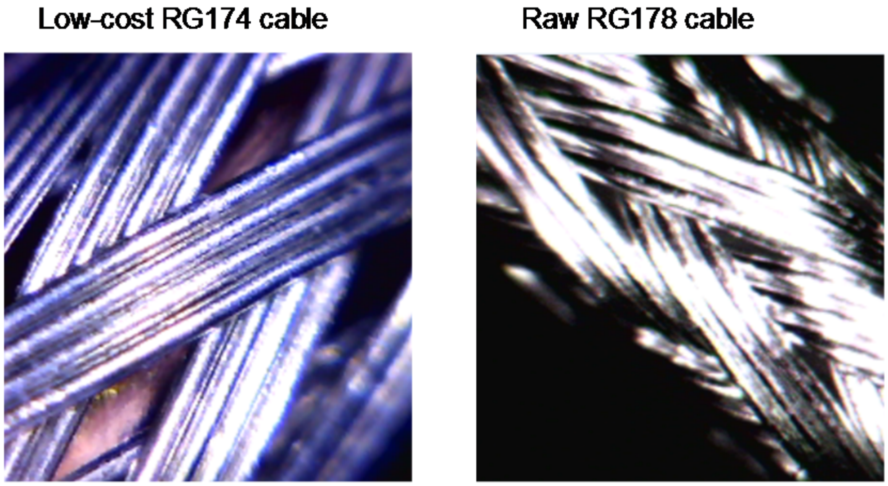

Figure 2: *Close-up photos of different cable braids.*

The photo on the left shows the braid construction of the coaxial cable used for the red trace in *Figure 1*. There are strips of wires, loosely braided around the dielectric insulation surrounding the center conductor. There are rhomboid-shaped openings, where the orange-pink color of the dielectric insulator shows through. To give you a sense of scale: the diameter of the cable, 80 mils or about 2mm, fills the diagonal of the photo. These little openings on the braid create the transparency of the cable at high frequencies, where otherwise the skin depth is less than the braid thickness, so we could expect low surface transfer impedance and therefore good shielding. The photo on the right shows a better-quality braid from a spool of RG178 coaxial cable I bought from a different source. Note that this is not the cable that produced the blue trace in *Figure 1*; that cable was too expensive for me to cut it up. Nevertheless, this photo illustrates that a good quality braid does not exhibit openings of the size we see in the left photo.

To check further the differences in cable braids, I used the signal-generator function of a small pocket-size Vector Network Analyzer (VNA) that was developed by radio amateurs primarily for ham-radio measurements [2]. The unit has a synthesized RF source, with an adjustable frequency in the 0.1 – 200 MHz range. The source has 50-ohm internal impedance, which terminates the cable at the driver side. I attached the cables used for *Figure 1* and measured the leakage through the cable braid by a small pickup loop connected to my Tektronix TDS540 oscilloscope. The setup is shown in *Figure 3*.

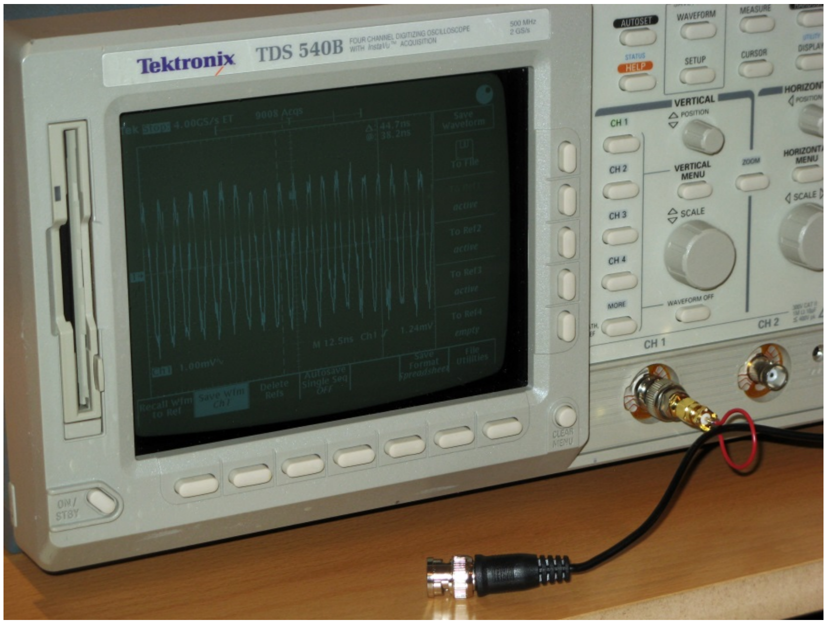

Figure 3: *A small pickup loop (red wire) connected to CH1 of the oscilloscope detects the field leaking through the shield of the coaxial cable.*

The frequency of the source was manually changed to find the peak reading on the oscilloscope. In the case of the cable that produced the red trace in *Figure 1*, this happened to be around 160 MHz.

The drive strength was set to 0 dBm and, to suppress resonances in the detector loop, the oscilloscope input was switched to 50-ohm input impedance. The signals picked up by the loop for the two cables of different shielding quality are shown in *Figure 4*. For the more poorly shielded cable, the resulting waveform (red trace in *Figure 4*) shows a large sinusoidal component way above the noise floor of the oscilloscope. For the better shielded cable (blue trace in *Figure 4*), the maximum signal pickup across a range of frequencies is much smaller: mostly random noise with little sinusoidal component.

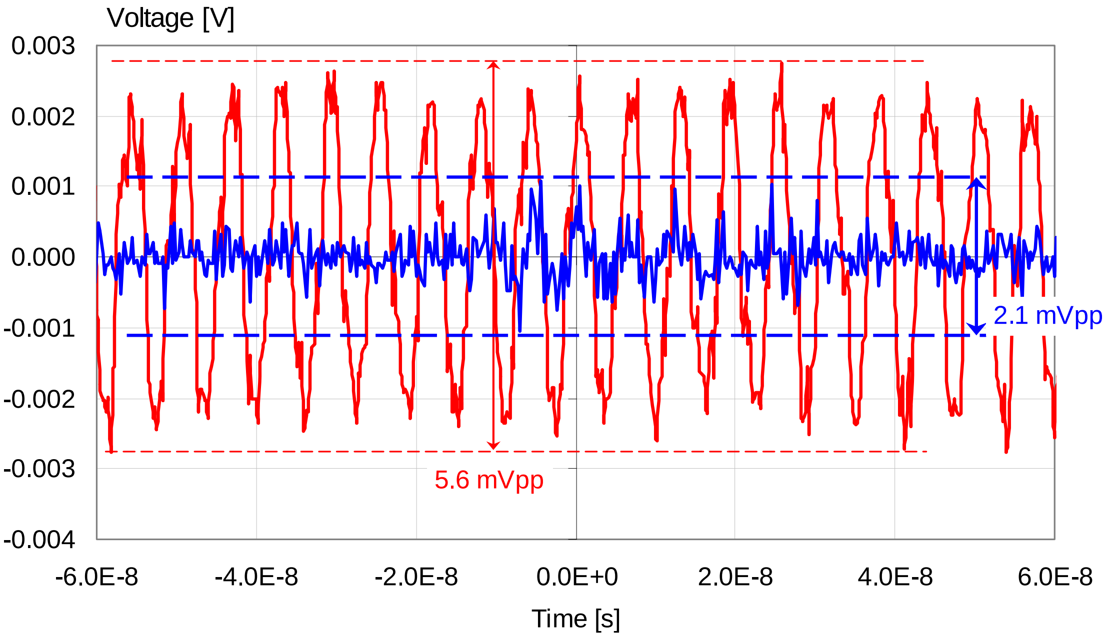

Figure 4: *Signal pickup from a poorly shielded cable (red trace) and well-shielded cable (blue trace) measured with the setup shown in Figure 3.*

Of course this crude illustration does not represent a systematic quality measurement: it is rather a simple comparison showing big differences in the quality of cable shields. In the next column we will use the pocket-size VNA to measure the approximate frequency-dependent transfer function through the cable braids under various conditions. Stay tuned.

References:

[1] "Cable Quality Matters," QuietPower column, http://www.electrical-integrity.com/
[2] MiniVNA-Pro, http://miniradiosolutions.com/minivnapro