The Truth About Guitar Cable

by Steve Lampen, 01.21.2009

So what does guitar cable have to do with radio broadcasting? Well, not much, except that it's a good example of a system where the cable used can be a *major component* in how that instrument sounds.

Of course, most cable you use is supposed to "disappear" — to have no effect at all.

But you know that's not true. There's resistance and capacitance; and if you get into the megahertz, you have to deal with impedance, and impedance matching, and transmission lines. All of these affect the signal on your cable. But nowhere, in no other equipment, is the effect of the cable as pronounced as it is on a guitar.

The first reason is the nature of the pickup on an electric guitar. It's a magnetic pickup, essentially a coil of wire whose magnetic field is interrupted by the metal string. That's why you can't have an electric guitar with nylon strings, like those used on a classical guitar. And the sounds of metal strings vs. nylon (or, originally, cat gut) are very different. That metal-string response is that sound we instantly recognize as an "electric guitar."

Those magnetic pickups, however, are really wonderful antennas, picking up stray magnetic fields from everywhere.

The first big breakthrough was the "humbucking" pickup invented by Seth Lover at Gibson guitars in the early 1950s. It essentially uses two coils, wired in series. The string passes through both fields and is reproduced. A stray magnetic field is picked up by both coils, but because they are wired in series one signal will be out of phase to the other; when they are connected together, any noise will cancel out. Only the vibrations of the string are heard.

The response of a dual "humbucking" pickup further colors the sound, especially at high frequencies. The wavelength of these high notes approaches the distance between the pickups and begins to cancel out. Guitars with humbucking pickups, therefore, have a "mellow" sound. Those guitars with single pickups are much "brighter." And this effect occurs even though the highest note on a guitar is only around 1300 Hertz.

This noise problem is exacerbated by the fact that the cable attached is unbalanced, just a single shielded conductor. Such a cable has no way to reject electromagnetic interference as a balanced-line twisted pair can. So essentially you have a long antenna feeding EMI and RFI into the pickup and into the guitar amplifier at the other end.

Due to the dimensions of a guitar and the need to keep cost reasonable, hum-bucking pickups are very high impedance, generally around 50 k-ohm or so. If you've been following my columns, you might recall my ranting and raving about "source impedance." At audio frequencies, the source impedance of any device (together with the capacitance of the cable) determines how far you can go before you have measurable loss.

The table shows the "source impedance" chart. But look at that last row. There's the 50 k-ohm guitar pickup. Even if you used flexible digital video cable to hook up the guitar at around 16 pF/ft (and unbelievable overkill in bandwidth) you could only go slightly over 5 feet before you are 1 dB down at 20 kHz. And most cable for guitars is all PVC, around 50 pF/ft, so we're at a foot and a half!

Source Z	15 pF/ft (49 pF/m)	20 pF/ft (66 pF/m)	30 pF/ft (98 pF/m)	50 pF/ft (164 pF/m)
50 ohm	5406 ft (1648 m)	4055 ft (1236 m)	2703 ft (824 m)	1622 ft (495 m)
100 ohm	2707 ft (825 m)	2030 ft (619 m)	1353 ft (413 m)	812 ft (248 m)
150 ohm	1873 ft (571 m)	1352 ft (412 m)	901 ft (275 m)	541 ft (165 m)
600 ohm	451 ft (138 m)	338 ft (103 m)	225 ft (68.6 m)	135 ft (41.2 m)
1 k-ohm	271 ft (82.6 m)	203 ft (61.9 m)	135 ft (41.2 m)	81 ft (24.7 m)
10 k-ohm	27 ft (8.2 m)	20 ft (6.1 m)	14 ft (4.3 m)	8 ft (2.4 m)
50 k-ohm	5.4 ft (165 cm)	4 ft (122 cm)	2.7 ft (82 cm)	1.6 ft (49 cm)

But guitars certainly don't produce notes at 20 kHz or even close. At the highest frequency of the guitar with the most frets (24 frets above E_4) would be a frequency of only 1319 Hz. I calculate those –1 dB distances at that low frequency to be 206 feet with the 16 pF/ft flexible video cable and 25 feet with the cheap 50 pF/ft cable. These calculations ignore any harmonics of the highest note. I'm sure they make a difference in the "tone" although I am unaware of anyone who has done filter tests to see just how these harmonics might add to the sound. As long as the cheap cables aren't longer than 25 feet there isn't much of a problem.

So why don't they simply convert that pickup to low impedance and a balanced line? Well, they did back in the late '60s, XLR connector and all. And the result? Everyone *hated* the sound. I have never heard a "flat response" pickup but I am sure it would sound brighter than a sunrise. Of course, that doesn't mean we couldn't still run a balanced line on an existing guitar except that it would require a 50 k-ohm transformer to balance the line at the guitar end and another at the amp end.

Steve Lampen has worked for Belden for 16 years; he is its multimedia technology manager. His book "The Audio-Video Cable Installer's Pocket Guide" is published by McGraw-Hill. Past articles are archived at radioworld.com *under Columns.*