

Metzler's "Laws" of Signals

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VTC Applications

Many fine circuits have been abandoned or ignored because of 'components' that never appeared on the schematic.

1. Any conductor that carries alternating current is considered to be a transmission line. Energy that fails to appear at the far end went elsewhere. Signals escape by way of capacitance, mutual inductance, common resistances (ground loops), or by radiating as RF. It's a bad idea to just hope the missing stuff turned into heat! This includes power supplies, which must be assumed to be carrying nasty stuff until proven clean...
2. Reciprocity: If stuff can leak out, stuff can leak in!
3. If the conductor is $\ll 1/8$ wavelength (at the highest excitation frequency), the line length MAY be unimportant. In digital work, excitation frequencies (edge rates) are way higher than clock frequencies. In analog work, distortion products are way higher than signal frequency excitations. Is the line still short?
4. If there's a known resistance in range, try to match to it unless there's a very good reason not to. Even a simple series terminator at the source end can help. If you get lucky and condition 5 is met, the line can be ignored... maybe.
5. ALL lines have return paths associated with them. If you don't control them, Murphy will, in which case return will likely be by way of another of your signal lines. Return is by way of the lowest impedance, NOT the lowest resistance path, even at 'audio' frequencies. The smallest area loop will carry the signal current. DC powered amplifiers of ALL kinds work by shunting current between 2 or more 'power rails', which become the actual return points. Have you tied them together? Where, and with what? This includes logic gates.
6. Capacitors have inductance, lots of it. Resistance too. Know how much if you can... People who make capacitors don't like inductance and resistance and don't readily admit to having any!
7. Inductors have capacitance, lots of it. Resistance too. Know how much if you can... People who make inductors don't like capacitance and resistance and don't readily admit to having any!
8. Resistors have capacitance, lots of it. Inductance too. Know how much if you can... People who make resistors don't like capacitance and inductance and don't readily admit to having any!
9. Conductors are usually decent inductors. Their capacitance may be due to lousy dielectric. Make sure yours is good enough. This includes ANY insulator between signal and return.
10. ALL mismatched lines (most lines in general) are resonant somewhere in the spectrum. If they're not resonant they're matched. PERIOD! Sometimes one can get away with matching them only at high frequencies (snubbing). Find or control 'Z' and the frequency (length) rather than blindly trying out a slew of resistor and capacitor values. Never simply assume that where they're resonant isn't hurting your signal in some way.
11. If something isn't working right and the voltages don't tell you why, start looking at the currents.