RSX Technical White Paper:
Balanced Field™ Technology

Introduction

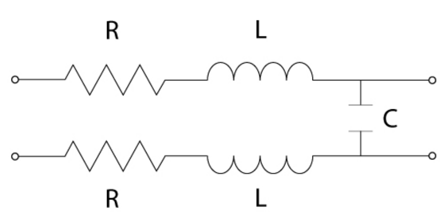
A great deal of information, both highly technical and in language more suited to the layperson, has been written about cables and their design. The great majority of it, whether specifically addressing the issue of cables or as intended to be much broader in scope and more fundamental in application, is (if from a reliable source) correct, and much of it has been drawn from the research of such historical greats as Maxwell[1], Faraday[2], Ampere[3], and other more recent authorities including Malcolm Omar Hawksford[4].

As presented, this information answers many questions. One basic question, though, is seldom, if ever, addressed. This present paper will specifically focus on that question and its answer.

R+C+L

Most of what we read about cables holds that their function is determined by just three factors: Resistance (R), Capacitance (C), and Inductance (L). These, we are told, are defined as follows:

1.) "The *electrical resistance* of an object is a measure of its opposition to the flow of electric current."[5];
2.) "Capacitance is the ability of a component or circuit to collect and store energy in the form of an electrical charge."[6] (This important to cable design because a cable composed of any two or more electrical conductors separated by any non-conductor [its/their insulation] *is* a capacitor.[7,8]); and
3.) "In electromagnetism and electronics, inductance describes the tendency of an electrical conductor, such as [a] coil, to oppose a change in the electric current [passing]through it…(which) induces a reverse electromotive force (voltage)."[9]



1 https://en.wikipedia.org/wiki/James_Clerk_Maxwell
2 https://en.wikipedia.org/wiki/Michael_Faraday
3 https://en.wikipedia.org/wiki/André-Marie_Ampère
4 https://www.stereophile.com/reference/1095cable
5 https://en.wikipedia.org/wiki/Electrical_resistance_and_conductance
6 https://www.fluke.com/en-us/learn/best-practices/measurement-basics/electricity/what-is-capacitance
7 https://en.wikipedia.org/wiki/Capacitor
8 https://en.wikipedia.org/wiki/Capacitance
9 https://en.wikipedia.org/wiki/Inductance

We are told that the interaction of these three factors is the principal determinant of cable performance and that how much of each factor will be present in any cable can be simply calculated: The amount of resistance will depend only on what material the cable's conductors (the parts that actually carry the current) are made of, its shape, and how much of it is used in each conductor[5], and capacitance and inductance will be present in a "seesaw" relationship with each other – the more of either one is present, the less there will be of the other, with both being determined only by the distance between the two conductors making up the cable[8]. (The closer the two conductors ["plates"] are together, the more "C" there will be and the less "L", and the farther they are apart, the less "C" there will be and the more "L".)

The Question

What we seem never to be told, however, is how it comes to be that the two conductors are, and are held at, whatever distance apart they may be.

Questions that are not asked are often the ones hardest to answer, and the question of conductor spacing seems largely to be ignored in the literature. Instead, it seems that, in most cases, simply stating that the distance between conductors is significant obviates the need to tell how that distance comes about.

In fact, though, the answer to that question is crucial to understanding how cables function because the answer, itself, both adds and explains a fourth factor to the classic R+C+L.

The Answer

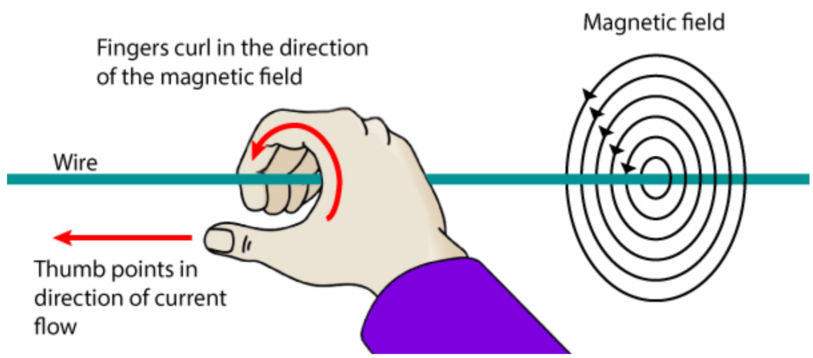
For cables, the answer is so obvious that it's easy to overlook: Every audio or video cable must consist of at least two conductors. These must be separated to keep them from touching and shorting out and creating a fire or safety hazard. The thing that separates them is the insulation and it's the thickness of the insulation around each of the two conductors added together that creates the minimum distance possible between conductors. What the *maximum* distance is may be determined by as little as simply twisting the wires together. If each is wrapped around the other, the twist will prevent the wires from moving any farther apart than their minimum distance. The same could also be accomplished by simply adding an overjacket to the cable, whether the individual wires are twisted or not. This, too, would keep the wires from moving farther apart than their minimum distance.

The Fourth Factor

Once we accept that the wires we're going to be dealing with in an electrical cable are going to be insulated, it becomes apparent that the "fourth factor" mentioned above must have something to do with the insulation or with something related to it.

Here's how that works:

Any time an electrical current is run through a wire, an *electromagnetic field*[10] is formed around that wire, with the field circling around the wire in the same direction as the fingers of your right hand would point if the current were running in the direction pointed to by your right thumb. This is called the "Right Hand Rule"[11] and the strength of the electromagnetic field produced will be determined only by the amount (the amperage) of the current flowing through the wire.



With an insulated wire, another effect of the current flow (or electrical potential) will be the creation of a second field—an electro*static* field[12] — formed around the insulation. This will not be controlled by the amount of current flow, but only by the voltage (the electrical *pressure*, regardless of flow) present in the conductor, and this is where things start to get interesting.

Velocity of Propagation

$$\nu = \frac{c}{\sqrt{\varepsilon_1}}$$

where,

ν = propagation velocity in meter per second in dielectric medium
ε_1 = dielectric constant of the material
c = speed of electromagnetic waves in free space, 3×10^8 meters per second

We are told that electricity and light are both types of electromagnetic radiation ("ER"), and that all ER travels ("propagates") at "the speed of light" (300,000.000 meters [186,000 miles] per second.[13]) In a vacuum like the void of space this is true, but when traveling through a physical medium, like air or a wire, that speed is reduced.[14]

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10 https://en.wikipedia.org/wiki/Electromagnetic_field

11
https://www.bing.com/images/search?view=detailV2&id=BF966576A25E0833443321600757843FE69A3526&thid=OIP.9zs20Y3YDIZZZvNW528FgHaD3&mediaurl=https%3A%2F%2Fi0.wp.com%2F4.bp.blogspot.com%2F-15p1JFHnI2Y%2FV4CHANvY3XI%2FAAAAAAAAAq4%2FGivz8NnAnJwHvc2ft7cHzxkhkvrCGf_ewCLcB%2Fs1600%2FScreen%252BShot%252B2016-07-09%252Bat%252B10.38.08%252Bam.png%3Fssl%3D1&exph=558&expw=1070&q=the+right+hand+rule+of+magnetism&selectedindex=2&ajaxhist=0&vt=0&eim=1,2,3,6

12 https://whatis.techtarget.com/definition/electrostatic-field

13 http://scienceline.ucsb.edu/getkey.php?key=2910 answer #1

14 https://en.wikipedia.org/wiki/Speed_of_electricity

How this becomes significant to the performance of a cable can be demonstrated by a simple example: Let us suppose that we were to cut two wires of the same (any) length off the same spool. Obviously, they would be of the same material, of the same (AWG) gauge, and, if identical electrical charges (signals) were to be sent through them, they would pass through each of the two in exactly the same amount of time, at exactly the same speed (*velocity of propagation*[15]).

Now, two things: First, if we were to take just one of those same wires and coat it with an insulating material (*dielectric*[16]), leaving the other wire unchanged, and we were then to pass the same signal as before through both the insulated and non-insulated wires, we would find, upon measuring, that the velocity of propagation of the insulated wire had changed and that signal now passed through it more slowly than through the uninsulated wire.

Then, as a second step, if we were to insulate the heretofore uninsulated wire with any different dielectric than had been used to insulate the first one and, once again, pass that same signal through both (now insulated) wires and measure the velocity of propagation in each, we would find that the two insulated wires would pass signal at speeds different from each other, and that the velocity of propagation of both would be less, as a percentage of the speed of light, than it had been before the wires were insulated.

From an audio standpoint, the actual velocity of propagation of the signal is of little consequence. What *is* important, though, is the fact of difference: Uninsulated wires pass signal faster than insulated ones, and wires with different insulation pass signal at different rates. Obviously, this must have something to do with the insulation on the wires. But how can it? If it's the wires that actually conduct the electricity, and the insulation is just a non-conductor put there to *prevent* current flow between the wires, how can the insulation affect signal flow?

Field Interactions

The answer lies in the nature of electricity: Most commonly, electricity is described as a flow *of electrons*[17] through a wire, with the electrons, themselves, carrying the signal.[18] Other descriptions treat electrons like a row of billiard balls set-up touching each other, so that motion applied to the first ball in the row moves the second, and then the third, and so on, with the energy communicated through the entire length of the row (however long it might be) even though each individual ball may move very little or seemingly not at all.[19] A third theory says that, while electrons do move, their movement is every small (*electron drift*[20]), and the actual transmission of energy is the result, not of the electrons passing through the wire, but of an *electric field* [21] surrounding the wire, for which the wire acts simply as a *waveguide*[22]. *Free*

15 https://www.techopedia.com/definition/26167/velocity-of-propagation
16 https://en.wikipedia.org/wiki/Dielectric https://whatis.techtarget.com/definition/dielectric-material
17 https://whatis.techtarget.com/definition/electron
18 http://scienceline.ucsb.edu/getkey.php?key=2910 answer #3
19 https://en.wikipedia.org/wiki/Electrical_resistivity_and_conductivity See "Newton's Cradle"
20 https://en.wikipedia.org/wiki/Drift_velocity https://en.wikipedia.org/wiki/Electron_mobility
21 https://en.wikipedia.org/wiki/Electric_field http://www.physicstutorials.org/home/electrostatics/electric-field

electrons[23], in this model, are simply the charged particles upon which the electric field acts.

Even though it's electrons that carry the charge, it's the electric field that's causing the energy transfer, so, once again we find ourselves dealing with field phenomena: Electric, Electromagnetic, and Electrostatic. And it's the interaction of these that are the source of changes, not only to the velocity of propagation in the earlier example, but to other aspects of the signal carried by any wire.

In electronics, though, except as part of the internal wiring of some electronic device or the running of a wire to ground, we're never dealing with just a single wire. Signal flow requires the ability of energy to flow from a source to some destination (from a preamp to an amplifier, for example), *and back again*. In short, a *circuit*[24] must be formed in order for anything to happen. This requires at least *two* wires (or multi-wire signal paths), and constitutes the simplest form of cable. It also creates (increasing factorially with the increasing number of wires in the cable[25]) more and different kinds of field interactions than just a single wire would. If shielding, if used, adds even more than that.

Along with the effects of the materials used to make it (the conductors[26] and dielectrics[27] that it's comprised of) and of the structural and winding geometry that contribute to its R, C, and L[28], the field relationships within a cable are strong determinants of its performance.

Searching for the Optimum

Any cable at all that will pass a desired signal without failing can be used for just about any cable purpose, and it *will* work. A speaker cable, for example, could certainly be used as an interconnect, and, if fitted with the proper connectors, it *would* pass signal. Similarly, so could an interconnect be used (at least at low levels) as a speaker cable. The question is not "would it work?", but "would it be the best possible cable for that application?"

All of the fields and field relationships that affect any cable's design and operation are either electromagnetic or electrostatic in nature; all are either current- or voltage-controlled; and all can be combined in different ways and ratios to achieve a broad range of results. The fact,

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22 https://en.wikipedia.org/wiki/Waveguide
23 http://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/introduction/free-electrons.html
24 https://www.dummies.com/programming/electronics/components/what-is-an-electronic-circuit/
25 http://www.probabilityformula.org/factorial.html
26 See Note #19 "…in a solid, the electron repeatedly scatters off crystal defects, phonons, impurities, etc., so that it loses some energy and changes direction…"
27 See Note #15. Different dielectric materials have different abilities to store energy ("dielectric constant"); different loss rates through dielectric absorption ("dissipation factor"; and different rates at which they release stored energy ("dump rate").
28 See Note #5. "… resistance and conductance are extensive rather than bulk properties, meaning that they also depend on the size and shape of an object. For example, a wire's resistance is higher if it is long and thin, and lower if it is short and thick." Cable performance will also be affected by whether or not its conductors are twisted or coiled, and, for C and L specifically, on how far apart they are from each other.

though, is that there is only one optimum field relationship, and that any other will result in less than the best possible cable performance.

That's NOT to say that the theoretical ideal of a cable that would pass all and only the signal run through it, with nothing added, nothing lost, and no distortion or other changes of any kind is possible at this state of the art. Even if all else were perfect, unless superconducting materials[29] were used for the signal path, even the very best cable now possible would still show a change from the original signal due to resistive losses and the conversion of signal energy to heat. Something very close to optimum performance is possible, however, right now, and that is (and always has been) the goal of RSX's designer.

Balanced Field™ Technology

More than twenty years ago[30], in reviewing another product created by RSX's designer, *Stereophile* magazine's High-End audio reviewer, Jonathon Scull, wrote that it was "…always and totally superb.", and went on to say that it was **"...almost certainly the best cable that will ever be made."** Other reviewers had similar opinions: One month later, in the September, 1998 issue of *Fi, The Magazine of Music and Sound,* Dr. Michael Gindi enthused that "... [As it burned-in,] It just kept getting better and better and better, until it disappeared entirely, and nothing was left but the music." Dr. Gindi came back with more high praise for that same product line in *"Fi magazine"* in February of 1999. And in the Spring of 2000, Myles Astor, after reviewing nine of the world's best cables in *Ultimate Audio magazine*, declared that "Compared to [the product from RSX's designer], other cables sounded muddy and distorted."

In the two decades since that time, new and better materials have become available and better manufacturing techniques have been developed for using them. Most importantly, more knowledge has been gained as to how cables and the signals they carry actually work. As a result, Jonathon Scull's description of that earlier cable as being "…the best…that will ever be made" is no longer true. All RSX cables now combine RSX's exclusive Balanced Field™ Technology with the very best, purest, and most modern materials and manufacturing techniques to produce cables that were, quite literally, never before possible.

Balanced Field Technology is the practical application of the theory that there is only one optimal relationship for the electrostatic and electromagnetic fields underlying a cable's performance. Originally developed by Roger Skoff, RSX's designer, that theory has been developed and perfected over the years, and is why RSX cables not only look different and are constructed differently than other cable brands, but even look different and are constructed differently from each other.

The reason for this is simple: While all cables have both current-controlled electromagnetic fields and voltage-controlled electrostatic fields inherent to their operation; and; while there's only one optimum relationship for those fields; different cable applications call for different ratios of voltage

[29] https://en.wikipedia.org/wiki/Superconductivity

[30] *Stereophile Magazine*, August, 1998

to current. Two extreme examples of this are phono cables, which may carry only the tiniest amounts of current (micro amps) at, sometimes, the tiniest voltages (as little as fractions of a millivolt), and power cords, which carry potentially huge amounts of current (multiple Amps) at (by comparison to other elements of your system) relatively high voltage (120 -240 Volts). The only way to create and maintain even approximately the same field relationships for such extremely different applications is to build the physical structures of the two kinds of cables very differently. This is exactly what RSX has done.

Hear the Music, not the Cables

The only thing any cable is supposed to do is to carry signal from Point A to Point B. That's its only real function. Anything else makes the cable, whether by addition, subtraction, distortion, or phase (time) shift, a contributor to the sound of your system instead of the purely passive "pipeline" component it's intended to be. It also potentially detracts from your enjoyment of your music and from the fidelity of the system that you have put so much time, effort, and money into creating.

Except for its intended purpose, a cable should do nothing at all. That's easy to imagine, but exceedingly difficult or maybe even impossible to achieve in practice. It seems that cables *always* do something to the signal they carry, even if it's just to turn some part into heat and lose it from your musical performance. And usually what they do is far more; acting as filters or "tone controls" or shifting phase and smearing transients, they can have a material effect on what you hear.

By balancing internal field interactions RSX cables can do much to eliminate these problems and get your cables out of the way of your music. Balanced Field technology is one reason why we think RSX cables do better "nothing" than any other brand.