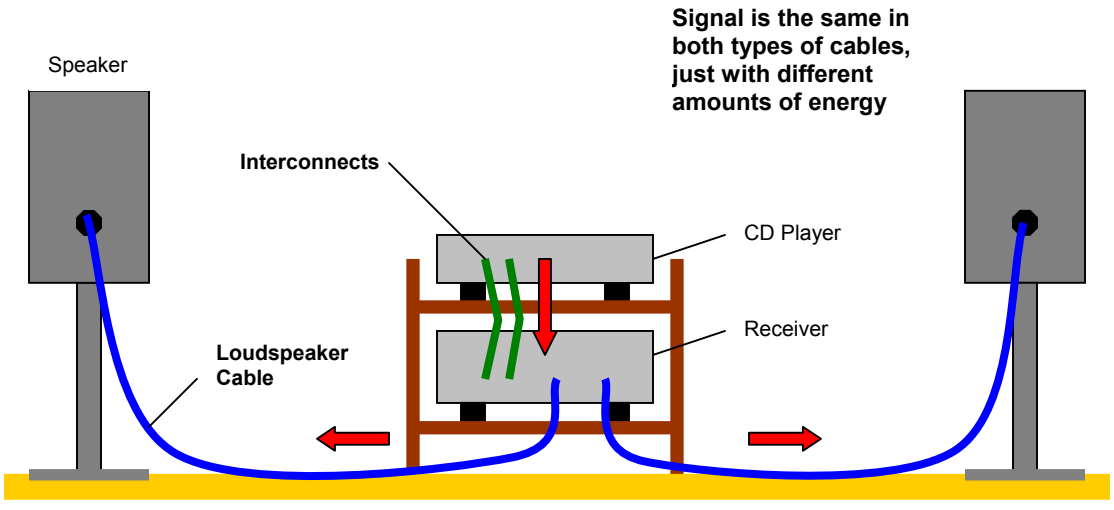
A Technical Introduction to Audio Cables by Pear Cable

What is so important about cables anyway?

One of the most common questions asked by consumers faced with purchasing cables for their audio or home theater system is, "What is so important about cables anyway?" They can cost as much or more than some of the hardware in the system and to many it is difficult to understand why wire isn't just wire.

To begin to understand how audio cables work, we have to start with the two fundamentally different types of audio cables you are likely to have in your system. The first type of cable is called an interconnect, which is used to connect various components together (such as a CD player to a receiver). The second type of cable is called the loudspeaker cable (this is the wire going from the receiver or amplifier to the speakers). It is important to realize that both types of cables are carrying the same information, just with different amounts of energy.

Back view of a simple stereo setup with a CD player and receiver shows the two basic types of cables



Interconnects carry a signal with very little energy. These cables only need just enough energy to convey the information from the source, for example a CD player, to the amplifier. The low energy requirement means that the signal in interconnects has very little current (usually in the range of thousandths of an amp).

Loudspeaker cables on the other hand, carry a large amount of energy. All of the energy required to move the speaker cones and make sound must come through the loudspeaker

cables. Because of the high-energy requirement in these cables the current is relatively high (currents can reach 10 amps or more).

The very basic reason why audio cables are important is because they *change* the signal going through them. There are two different, fundamental ways that an audio cable can change the signal. *The cable itself can change the signal, or the cable can allow outside sources of energy to change the signal.*

In order to understand how these two situations can occur, some basic background electrical knowledge is needed.

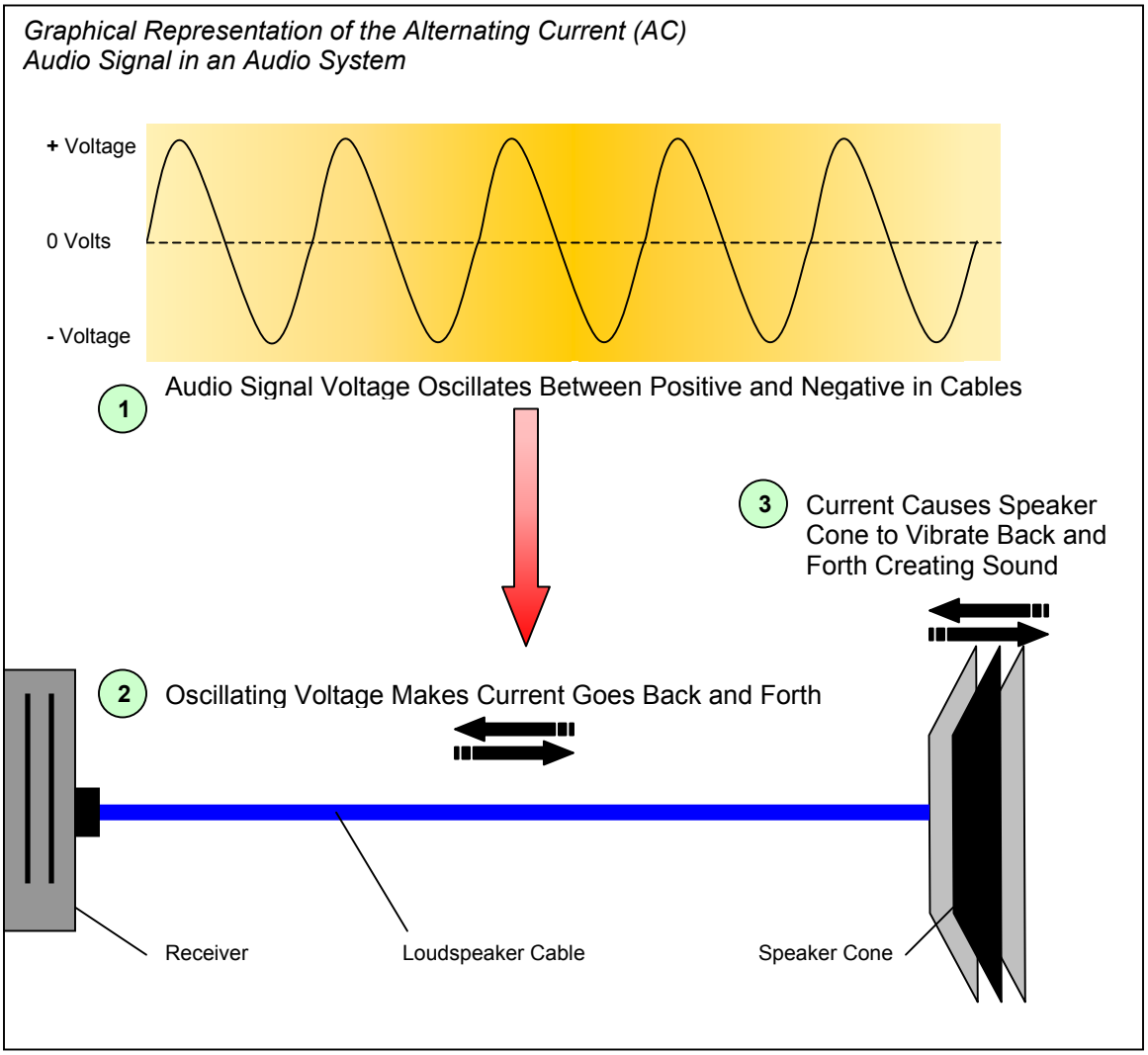
Signals in all types of wires are conveyed by the combination of voltage and current. Every signal has some amount of voltage and some amount of current. The larger the difference in voltage between two places, say the beginning and the end of a cable, the larger the amount of current, and vice-versa. The direct analogy to voltage and current is the flow of water through a hose. The *amount* of water flowing through the hose is analogous to current. The water *pressure* in the hose is analogous to voltage. The higher the amount of water pressure, the more water will flow through the hose. The higher the amount of voltage, the more current will flow through the wire.

Every cable has a set of electrical properties that can be measured using standard electrical testing equipment. The three most basic properties are resistance, capacitance and inductance. While a detailed description of these three different electrical properties is outside the scope of this article, a basic description of the relevant effects of these three properties can be given.

- Resistance opposes current. The higher the resistance the greater the amount of energy that is removed from the current and turned into heat.
- Capacitance opposes *changes* in voltage. If a voltage is increasing, capacitance will cause the voltage to increase more slowly. If a voltage is decreasing, capacitance will cause the voltage to decrease more slowly.
- Inductance opposes *changes* in current. If current is increasing, inductance will cause the current to increase more slowly. If current is decreasing, inductance will cause the current to decrease more slowly.

The final piece of background knowledge that is needed for this article is what the audio signal looks like. If one were to take the speaker cover off a speaker to look at the speaker cone while music is playing, you would see that it is moving *back and forth*. In order to move the speaker cone back and forth, the electrical signal must push and then pull the cone in rapid and repeating fashion. This is accomplished by having an Alternating Current, or AC.

Alternating Current simply means that the voltage oscillates between positive and negative. Because the voltage drives the current, this means that the current also goes positive and negative. In other words, the current is going back and forth in the wire, just like the speaker cone. *The subtle variations in how fast the voltage and current go back and forth creates the different sounds that we hear when listening to music.*



How a cable itself affects the audio signal

Now, going back to the ways that the cable itself can change the signal going through it, let's consider both types of cables separately.

As stated previously, interconnect cables carry a very small amount of current. Relative to the current the voltage is large. Because of that fact, capacitance is important, but inductance is relatively unimportant. *As the voltage oscillates between being positive and negative, the capacitance slows the voltage changes down, and causes delays. This can cause audible distortion in the sound.* Because interconnects have very little current, resistance is not much of a factor. Even an interconnect with extremely high resistance will only remove an infinitesimally small amount of energy.

The signal in loudspeaker cables is essentially the opposite of the signal in interconnects. Both cables have the same information, but in loudspeaker cables, the voltage is small and the current is large, relatively speaking. *Because of the high current, both resistance and inductance are important in loudspeaker cables.* The higher the resistance, the greater the amount of energy that will be absorbed by the cables. The resistance will not cause any distortion, but it will decrease the volume of the sound. The inductance on the other hand, can cause distortion. As the current oscillates between being positive and negative, the inductance slows the current changes down, and causes delays.

How a cable lets outside sources of energy affect the signal

As stated previously, the second fundamental way of altering a signal passing through an audio cable is to introduce outside sources of energy. This outside energy is typically termed “noise”. By definition, if any energy is absorbed by the signal, the signal has been distorted.

There are many potential sources of noise around audio cables. Some of the more common sources of noise, such as radio frequency waves, are familiar to most people. When wiring up a radio, frequently a consumer must attach an antenna. Antennae are intentionally designed to channel radio frequency energy into a stereo. Just like an antenna, it is entirely possible for an audio cable to pick up radio frequency energy. If you are not intending to listen to the radio, this is not a welcome effect.

Electronic components, electrical cords, sound waves, and even the sun, are all capable of creating noise. Electrical cords create electromagnetic fields around them that can transfer energy to a cable. Sound waves create mechanical vibrations that can be transformed into electrical energy that is added to an audio signal. Because there are so many different types of noise, there are many methods used to prevent a cable from picking up noise. Shielding, twisting of conductors, and mechanical damping are all common noise protection methods in cables.

While noise affects both interconnects and loudspeaker cables, generally the effects are far more significant in interconnects. This is because the signals in the interconnects have far less energy. Since most forms of noise are inherently low energy to begin with, this means that it is far easier for them to modify the low energy interconnect signals than the high-energy loudspeaker cable signals.

Macro vs. Micro

The parameters discussed so far have been primarily "macro" effects. These are for the most part the top-level parameters that effect cables. These parameters as well as others not discussed here also exist at a "micro" level. Taking capacitance as an example, a given cable will have an overall capacitance that can be measured. This overall capacitance is a "macro" level parameter. The same cable can also be analyzed as 1000 separate but connected pieces. Each piece will have a local capacitance. These local parameters are "micro" effects and can have their own impact on the signal separate from the "macro" effects.

The impact that the "micro" level parameters have on an audio signal is usually less than the impact of the "macro" level parameters. However, they do still make a difference in the signal transfer. The various ways that audio companies choose to either mitigate or ignore these "micro" level details is, in part, responsible for the vast array of different cable designs. From cryogenic treatments and precious metal wires, to fine silk insulation and fluid filled cable jackets; extreme cable designs abound.

Will I hear the difference?

The fact of the matter is that cables do alter the sound going through them, and that it is audible. You do not need to be an expert, or an audiophile, to hear the difference. To demonstrate this point, simply listen to your stereo. If you close your eyes, does it sound like the music is being played live right in front of you? This is what audiophiles strive for, and unless you have a very high-fidelity system, your answer to this question will most likely be no. You may have a hard time describing what exactly does not sound right about your system, but you know that it doesn't sound like a live performance.

Of course, the reason why the music does not sound live cannot be blamed solely on the cables. The degradation of the sound occurs in every component of your system. However, the point here is that even a casual listener can detect the subtle distortions that can prevent music playback from sounding live. Improving the quality of your audio cables will improve the sound quality of your system.

It is fairly safe to say that no matter what cable you use, the modifications to the sound will be small. Audio cables will never cause a listener to hear a piano when a flute is being played. *However, it is the small detail that makes all the difference between good and bad quality sound.* That is why very strong opinions are formed about various cables.

As audio systems continue to improve in accuracy, listening to a "live" performance in your living room gets closer to reality. Cables are an enabling factor for advancements in audio reproduction and can play a remarkably important role in your system.