Technology and Design of Clarus® Cable

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Theory and Application

Based on 8 years of research & development and five different patents**,** the basic technology used is the utilization of 3 distinctly different optimized conductor types for the Bass, Midrange, and High-Frequencies. Solid heavy-gauge conductors are used for bass, flat conductors for midrange and spiral-ribbon conductors (with a non-conductive core) for the high frequencies. The different conductor types are individually insulated thus isolating the different conductor types that are each more suited to particular frequency ranges. This results in each frequency range being free from coloration caused by interaction with adjacent frequency ranges. The basic idea is that there are advantages similar to those found in Bi-Amping. When mid-range & high-frequency speakers are freed from the requirement of reproducing bass frequencies, they gain clarity and the sound becomes more open and transparent. Similar improvements can be obtained in cables using this particular technology.

Background

Virtually all high-end audio cables on the market today use a combination of various gauges of solid, round cross-section copper conductors. If you listen to different wire gauges individually, you will find that they all sound different from each other. Large gauge solid conductors tend to have a lot of bass, with muted high frequencies. Medium gauge conductors tend to have less bass, more mid-range, and muted high frequencies. Fine-gauge conductors tend to reproduce high frequencies fairly well, but have little bass, and muted mid-range. The reasons for this are not clearly agreed upon by all. Many theories have long been presented mostly related to “Skin Effect”, although theoretically, this should have no bearing within the audio range. Listening, however, seems to indicate otherwise. It is widely accepted among cable designers that different wire gauges, have different frequency balances; this is the cornerstone of Clarus® Cable design.

When discussing larger conductors, flux density is often mentioned. Larger conductors are said to have a higher density of magnetic flux that concentrates in the center of the conductor. This may effectively choke off the higher frequencies, and force them to the surface of the conductor. Depending on the gauge of the conductor, this will occur in varying degrees and, depending upon how much of it has been affected by the flux density, yield different amounts of high frequency, bass, and mid-range information,. A lot of the differences in sound between different gauge conductors can probably be attributed to interactions between the different frequency ranges, probably due to magnetic effects. The resistance of a conductor also varies with gauge, and this may also play a role. “Skin Effect” is a well-known principle in cable theory. The higher frequencies tend to travel on the outside “skin” of the cable causing the effective resistance of the conductor to increase with the frequency. The depth of “Skin Effect”, skin depth, in a conductor varies with frequency, so differing conductor diameters should have an effect on all frequencies. Depending on whether the diameter of the cable is large, or small, the surface area that the high frequencies will travel on is clearly different and the ratios of the skin depth to conductor size related to frequency will also have an effect. These phenomena should have an impact on sound reproduction and perceived tonal balance. The effect of capacitance must also be considered.

The surface area of a conductor is directly related to the gauge of the conductor. The amount of surface area in contact with the dielectric material will affect capacitance which will influence the high frequency reproduction.

As a result, virtually all high-end audio cables on the market are based on the use of combinations of various different conductor gauges in an attempt to provide a balanced response across the audio spectrum. There is no agreement on the exact combination of gauges that works well, or the quantity of each that will provide a favorable result. This is mostly arrived at through experimentation and listening tests.

History

In 2004, I decided to explore the sound of flat, thin conductors. When listening to this conductor type individually, I was immediately struck with the purity and realism of the mid-range. I also noted a relative lack of bass, and high frequencies. It seems probable that the relatively thin cross section lacks the skin depth necessary to support low bass, and the large surface area in contact with the dielectric material yields high capacitance, which reduces the high frequencies. What remains is a very pure mid-range, uncontaminated or overshadowed by adjacent frequency ranges. This is what started the thought process that lead up to the development of this cable technology.

Starting with an exceptional mid-range, I then began to think about what could then be done to add both exceptional bass and high frequencies, and thus develop the best possible audio cable. Adding bass was the simple part. It is generally accepted that large-gauge solid conductors have the necessary skin-depth to support low bass signals. The skin depth of low bass is very deep, so a very heavy conductor is needed. When listening to the largest gauge conductors, it is generally agreed that they do provide outstanding bass, but this is at the expense of high frequencies and mid-range. Listening tests with single large-gauge conductors support this conclusion.

Adding large-gauge solid-core conductors to the flat conductors, yielded exceptional mid-range combined with exceptional bass. The final step is to add high frequencies, but this is always the most difficult part. Very fine thin-gauge conductors, because of “Skin Effect”, are the logical choice, but this is often very difficult to manufacture with individual insulation. Many designs use simple stranded wire; however, as stated below, this degrades the sound. Slightly larger conductors are then often used. These are easy to insulate but result in high frequencies that sound rolled-off. I began to think about what would constitute the ideal high frequency conductor. Because of “Skin Effect”, high frequencies travel on the surface of the conductor. The elimination any interaction between high frequencies and other frequency ranges is desirable. This interaction can negatively impact the sound quality of the high frequencies. So, the ideal conductor would consist of a surface only, and eliminate the center entirely. A very thin-wall tube would be the best choice; however this is impractical, since it would not bend, and flexibility is necessary in an audio cable. I began to think about a type of wire known as “tinsel wire”.

This is an old technology, seldom used or manufactured today, and was previously used in telephone cords and other cables where flexibility was desirable. The materials used were not suitable for audio applications, but the construction was intriguing. Essentially, one or more thin strips of copper foil (like tinsel) were spiral wrapped around a non-conductive core. Typically, it was manufactured with a nylon or Kevlar core, which is not suitable for audio applications, in that these are not good dielectric materials. Also, non-OFC copper is normally used in the construction of tinsel wire. This wire is also not insulated from other strands resulting in the same types of distortions heard in normal stranded wire. The task became to develop something similar but with audio applications in mind. The final result was to spiral-wrap thin foil strips of high-grade OFC copper around a core comprised of polyethylene (PE) strands, and to then extrude a thin layer of PE insulation over this to prevent strand interaction. I call these "Spiral Ribbon Conductors" to differentiate them from standard tinsel wire, which is not suitable for audio applications. The end result is a thin foil surface to carry the high frequencies, free from any interaction that might be caused by adjacent frequency ranges. The sound quality is superb, with high frequencies being clear and extended, without any trace of harshness or excessive brightness.

Any combinations of two or more conductor shapes are protected by these patents:

US Patents

6,969,805 (11-29-05)

7,034,229 (4-25-06)

7,091,420 (8-15-06)

7,170,008 (1-30-07)

7,476,808 (8-11-06)

Having determined the conductor shapes, the final task is to determine quantities and the specific sizes of each and, to properly balance the Lows, Mid-Range, and Highs. This was done through years of experimentation. Patents were applied for and granted. The patents cover the use of the three conductor shapes, and also the use of magnet wire for the upper frequency conductors. Magnet wire, which is a polymer-coated conductor, can also be used in some circumstances. Since AC Power Cables and Subwoofer cables are primarily designed for low frequencies, the conductor sizes and combinations are specified for this purpose. For this reason the "High Frequency" conductors are a larger gauge to provide superior current delivery, and these are typically magnet wire in my designs. For the power cables, noise rejection is also critical, and to accomplish this proprietary winding techniques are used.

When flexibility is required in the cable design, a combination of solid conductors and optimally selected stranded conductors are used o provide a balance between audio quality and ease-of-use. Fewer strands of a larger gauge yield less strand interaction than a larger number of smaller strands, and better sound quality.

Stranded Wire

It is commonly accepted in audiophile circles that stranded wire is generally undesirable for audio cable, and there are a number of probable explanations. The problem may be that the signal jumps from strand to strand in an undesirable, possibly unpredictable manner, varying with level, causing a type of distortion that is not typically measured. It may be that there is magnetic interaction between all the strands. It is also possible that oxidation among the strands impedes signal flow, and causes negative effects. This appears to be manifested primarily in the higher frequencies. The symptoms are primarily a grainy distortion to the sound that most audiophiles find irritating. The moment that wire is drawn down to its final gauge through a die, it begins to oxidize. There are normally no steps taken to prevent or eliminate this in manufacturing. When strands are bundled and twisted together, oxidation is interspersed among them. A "diode effect" has been postulated in the past, and this states that the nonconductive material interspersed among the conductive strands forms an effective diode that fires when the potential to ground becomes sufficient. This would manifest itself as a type of high frequency distortion, or diode noise. The reason that stranded cable is used in audio cables is mainly because of cost, ease of manufacturing, ease of termination. It also results in much smaller, flexible cables that are sometimes required for specific applications, such as Custom Installation.

Copper Types

One of the other most important considerations in developing a high-performance audio cable is the grade of copper.

If you look at the typical conductor materials available, typical high purity electrical-grade copper has approximately 1500 grains (or crystals) per foot. The boundaries of all these crystals must be crossed by the signal in the process of being transmitted across the cable. It is not hard to imagine that crossing all of these boundaries must cause some sort of loss and/or distortion of the signal. This may be similar to the effects of stranded wire, and it does seem to cause the same sort of audible distortion. In video and digital cables, this would also cause loss of information.

The next grade above normal high purity electrical-grade copper is called OFC (Oxygen-Free Copper), or sometimes Oxygen-Free High-Conductivity (OFHC) copper. This term is quite misleading, because OFC is not really oxygen free. It is cast and drawn in a process where oxygen content is limited, thus reducing the formation of copper oxides, which lead to a larger number of crystals. The oxygen content for OFC is typically in the range of 40 PPM (parts per million), while normal grade copper is approximately 235 PPM. The end result is that OFC has approximately 400 grains or crystals per foot, as opposed to 1500. There are significantly less boundaries for the signal to cross, and thus the signal is degraded far less. This is a substantial improvement over normal high-purity electrical wire. OFC and OFHC copper materials are not all the same, however, and these are much-abused terms. The oxygen content does vary, and it is a range, rather than a finite definition. Performance levels do vary with the quality level of the material, and not all “OFC” sounds or performs at the same level.

The next higher grade is an elongated grain copper sometimes called "linear-crystal" (LC-OFC), “mono-crystal”, “long-crystal”, or “long-grain” copper. These coppers have been carefully drawn in a process that results in only about 70 grains or crystals per foot. Since OFC typically has approximately 400 grains per foot, this is clearly an improvement, and the reduced amount of crystal boundaries causes far less signal loss or distortion.

The best level of copper for audio and video applications would obviously be totally free of crystal boundaries.

Professor Atsumi Ohno began the study of the solidification of metals in the mid 1960’s, and published his landmark book, “Solidification; The Separation Theory and its Practical Applications”, in 1984. In this book, Dr Ohno describes his many theories and concepts regarding the processing and solidification of molten metal, and the resulting crystal structures. He goes on to describe his unique process for casting metals with virtually no crystal structure, the O.C.C. process. This concept was first conceived of in 1978, and utilizes heated molds in a continuous casting process. Eventually, international patents were granted for O.C.C. (Ohno Continuous Casting).

The copper produced by this method is small rods of O.C.C. pure copper, from which wire can be drawn and which can have Copper grains of over 700 ft in length. A Japanese manufacturer is currently using this process and produces O.C.C. under the trade name PCOCC (Pure Copper by Ohno Continuous Casting).

Conclusion

As the foregoing clearly indicates, many different factors, concepts, and theories were taken into consideration during the development of the Clarus Cable®. These are not simple cables, and many years of experiments and research went into their development. The conductor geometry itself is quite unique and complex, and there is nothing similar on the market. It is also quite complex and expensive to manufacture. This is a purpose-built cable, and not something sourced as standard product from a cable factory. It was designed and engineered specifically for audio.

Starting at the materials level, many different materials were evaluated and tested, so only the best possible sound quality would be achieved. But, early on it was determined that the cable geometry itself, was just as important as the materials used. It is important to realize that many cables on the market rely on materials only, as their primary technology, and this is simply not enough to guarantee the best possible sound. In the case of the Clarus Cable®, the optimum conductor was developed for each frequency range, and with distinctively different shapes, this is what sets the Clarus Cable® apart.

The best possible sound was the primary motivation in designing these cables. The technology was not developed to fit a specific cost target. If you have taken the trouble to read this, then you are probably just as obsessive an audiophile as I am. I designed these cables as something that I would want to use myself, and that would satisfy my desire for the best possible sound quality, and If this can be shared with others, then all the better.

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