Cable Construction Guide

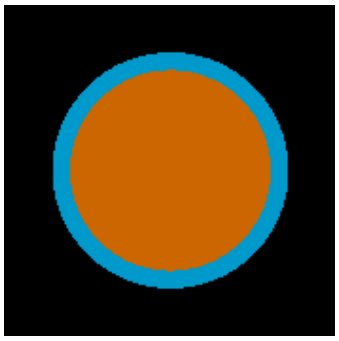
This article was kindly donated by George Cardas

Recent years have seen ferment in every area of high-end audio. Nowhere has this produced more of a revolution (controversy to match) than with audio cable. Many sizes, shapes and constructions have been tried, but as the dust has settled, a few design parameters have proven to be essential. As a result, several general approaches have prevailed. The best contemporary designs all share a good ratio of conductor resistance to cable capacitance, conductor inductance to cable capacitance and low electro-mechanical resonance. Helically wound multi-filar cables and braids now predominate. Symmetry, balance, mechanical stability and quality of materials are features that differentiate today's leading cable designs. Following is a description of the general principles, pros and cons of these designs (not discussed here are flats, tinsels, ribbons, co-axes, and certain other random or asymmetrical constructions). Electrical conductors have been made in many sizes, shapes and geometries, but over the years a definite pattern has emerged. Contemporary designs have a good ratio of conductor resistance to cable capacitance, conductor inductance to cable capacitance and low electro-mechanical resonance. Designs that do not incorporate these aspects, don't last.

Compare the different cable designs listed below and read my summary or conclusions on who in high-end audio has the best designs.

- Solid Round
- Bare Stranded Wire
- Multi-Gauge Stranded Wire
- Litz Wire
- Tubes and Tubular Stranding
- Parallel Multi Solid Core
- Constant 'Q' Stranding (Golden Section)
- Conclusion

Solid Round



Advantages:

1. Simple construction.
2. Low DC resistance per unit area.
3. Good resistance to capacitance ratios achievable in most embodiments.

Disadvantages:

1. High relative inductance.
2. Stiff and likely to harden with use.
3. Solid conductors tend to ring, do to low “Q”.
4. High DC to AC resistance ratio.

Given the best of associated materials, single/double solid core designs represent good “values”.

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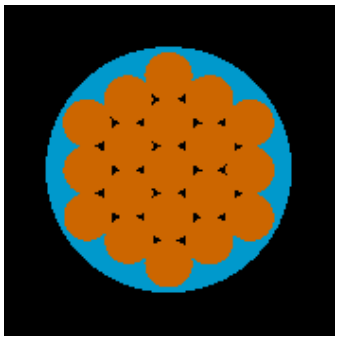
Bare Stranded Wire



Basic stranded wire, “lamp cord”, this is the most common wire.

Advantages:

1. Flexibility.

Disadvantages:

1. High relative inductivity.
2. Very prone to corrosion.
3. Low ring point.
4. Resonant and gritty sounding.

Not generally used or sold in high-end, it usually comes free with mass market speakers etc.

Check out the comparison between Cardas entry level cable, Crosslink, and 12 awg. Parallel Twin with clear jacket.

Multi-Gauge Stranded Wire

Advantages:

1. Slightly lower inductivity.
2. Much lower electro-mechanical resonance due to the elimination of strand multiplicity if done right (as in Kimber cables).
3. Low DC resistance for given cross-section.
4. Flexibility.
5. Works well in braided cable construction.

Disadvantages:

1. Relative inductivity still high.
2. Possible corrosion in non-Litz configurations.

Ray Kimber's multi-filar braids are state-of-the-art in this type of construction and have found a home in high-end audio. Ray's combination has advantages and has stood the test of time. These embodiments are practical, flexible, cost effective and attractive.

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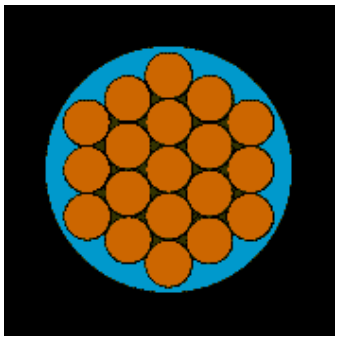
Litz Wire



Advantages:

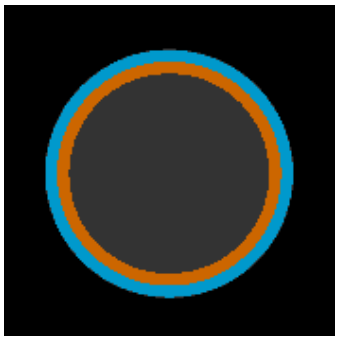
1. Low inductivity.
2. Coated strands don't corrode.
3. Embodiments tend to have good conductor resistance and inductance to cable capacitance ratios.

Disadvantages:

1. Resonant or wooly sound in traditional configurations due to strand multiplicity and harmonic interaction.

Litz wire has been the standard for conductors since the time of Tesla. The principals of Litz are embodied in all the successful designs. Litz in recent years has been reduced to standard stranding patterns using magnet wire in place of bare copper. This works well in RF applications, but is too resonant for present-day audio standards.

Tubes and Tubular Stranding

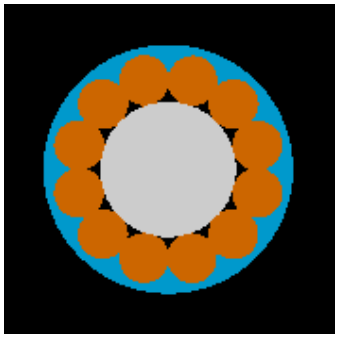


Advantages:

1. Low inductivity.
2. Semi-flexible in stranded versions.

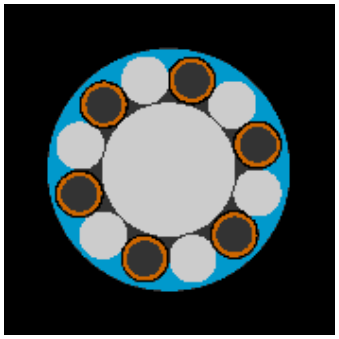
Disadvantages:

1. High resistance for a given size.
2. Tubes work by virtue of their thinness, so as an audio conductor they are limited by the fact that their resistance (and related cable capacitance) goes up as the conductor inductance goes down, giving poor resistance to capacitance ratios.



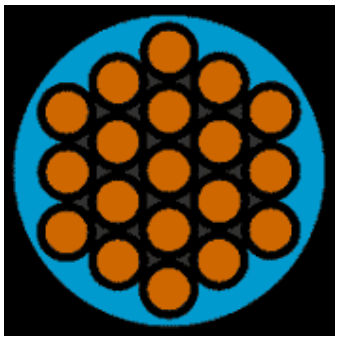
Stranded tube

Thick-walled tubes offer little advantage over solid core and thin walled tubes collapse. Stranded tubes have seen some success: Bill Low's Hyperlitz is a unique example. Of the solid tubes, only Cogan-Hall's very simple and clever connectorless design seems to have survived. I would have to say that it is the reference standard for tubes.



Hyperlitz

Parallel Multi Solid Core



Advantages:

1. Lower inductivity.

Disadvantages:

1. Design is limited by high dielectric involvement, bulk, difficulty holding symmetry as the number of strands increases.
2. Higher resistance for given size construction.

The simplest of constructions have found some success in the interconnects, and some of the very small speaker cables (Audioquest, Space and Time). Rodger Skoff's counter-helically wound XLO interconnect is a classic example of this type of construction.

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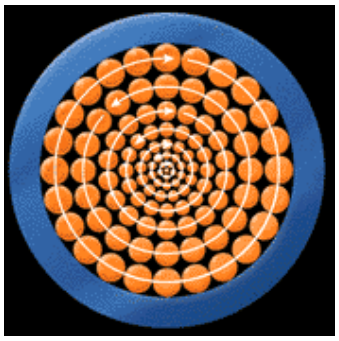
Constant 'Q' Stranding (Golden Section)



Advantages:

1. Lowest inductively for given size.
2. Low resistance for given size.
3. Very high Q (L/R) in both conductor and embodiments of the conductor.
4. Compact very low energy storage and characteristics and flexible.
5. Virtually eliminates electromechanical resonance.
6. Very low polar moment - conductor field interaction is dramatically reduced.
7. Stored energy is almost eliminated allowing direct transfer cables to be produced.
8. Coated strands eliminate corrosion.

Disadvantages:

1. Labor and time intensive construction.
2. Rather costly.

This construction is patented by Cardas Audio, and requires no hype on my part. It is obviously (in my mind) the best of conductor design.

Conclusion

It is easy to see that Ray Kimber, Bill Low, Rodger Skoff and myself have arrived at similar formulas from diverse paths, our common use of multiple parallel conductors and multi-filar constructions is the most obvious common element. The electrical similarity is less obvious. If you measure the capacitance of each of our cables, they are all about the same, 45 pico farads per foot more or less. In fact, the standard super-market give-away cable is within that same range). The difference is the inductance and resistance of our conductors. Capacitance by itself means little unless viewed in the light of conductor inductance and resistance. High-end cables as a whole lower conductor resistance and inductance without increasing capacitance. Even less obvious to the eye, but most obvious to the ear, is the degree to which conductor resonance is reduced by various geometries.

In retrospect I think we should credit those who long ago understood and incorporated these ideas. Not counting Nikola Tesla, who seemed to have everything figured out even before stereo was born, I have to pay tribute to Alex Gibson of Family Music Systems as the great un-heralded pioneer of cable design.

There is more to cable design than the simple perspective outlined here. Many improvements are still to be realized. However, I believe we have arrived at some basic principles. The two real options for cabling the conductor are obvious (multi-filar helical and multi-filar braid). I believe high purity copper to be the best conductor. I will say that there are a few un-revealed secrets in the department of characteristic impedance, and I will admit to the possibility of a dynamic symmetry in the works, but these and other designs will have to wait for their day.