

# CABLE DESIGN



## *Theory Versus Evidence*

The following discussion is based on decades of evaluation experience. It is not the result of “ivory tower” isolation. Designing, whether it be amplifiers, speakers or cables, requires attention to all empirical data, whether derived from test equipment or from human eyes and ears. Solutions come from an open-minded acknowledgement of all that is understood, and all that is not yet understood. Unfortunately, there is division in the audio/video community. At one extreme are those who only believe in their favorite measurements. At the opposite extreme are those who listen to or view a limited selection of equipment and then develop pet theories that conform to their limited experience. A lack of a proper scientific approach often causes each side to ridicule the beliefs of the other. The most effective audio and video designs come from those who take into account all the evidence, regardless of how measured or how well understood.

## Wire-Just Getting From Here To There

On the face of it, nothing could be easier than just getting an audio, video or digital signal from one place to another-no amplification, no conversion of mechanical energy to electrical energy or vice versa. The truth is, every cable must transfer a complex multi-octave signal without changing any of the information carried in that signal.

## Damage Control

We all like to describe how a good component improves the performance of our system, a perfectly legitimate comment. Unfortunately, buried in this statement is often the misunderstanding that the better component actually improved the signal in some way. There are certain areas of digital processing where this is possible, but in the analog world signals don't get better, they only get worse. The substitution of a superior component improves a system only because it causes less damage.

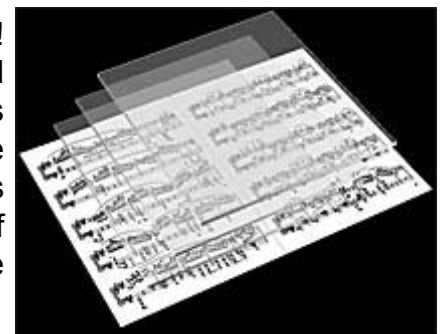
Cables, like all components, should be chosen because they do the least damage. This "damage" comes in two basic forms: a relatively benign loss of information, or a change to the character. A visual analogy might illustrate this distinction: consider "perfect" as a totally clear pane of glass. Since no component is perfect, the best we can strive for would be analogous to a pane of glass with a light gray tint. Lower quality components would have a darker gray tint. These various densities of gray tint would represent various amounts of lost information.

If the glass were tinted green or yellow or red, these colors would represent changes in character. We are far more likely to notice, and be bothered by, a light colored tint than a denser gray tint. It is this mechanism of character versus quantity that causes much of the confusion in the pursuit of higher performance.

## Chain Analogies, Synergy, Enhancement and Other Lies

We have all heard the truism that "a chain is only as strong as its weakest link." Certainly this is true of a chain, but it becomes a misleading lie when applied to the world of audio and video. The quality of sound coming from your speakers and the quality of picture from your video monitor have both been compromised by some degree of distortion in every component, starting with the microphone or camera. No one actually believes that if you changed every piece of equipment except the proclaimed "weak link"-that there would not be any change in the sound or the picture. No matter how bad a CD player might be, no one would argue that you couldn't hear the difference if you changed speakers. It is worth noting that some components are more cost-effective to change than others, or that a particular complaint will not be eliminated until a specific component has been changed. These truths might seem like an approximation of the chain analogy but the chain story has so much strength because it is an absolute, and it absolutely doesn't apply.

The logic of a good system is very simple: Every component matters! The electronics, the speakers, the cables, even every solder joint, all cause damage. Each component is like one of the dirty panes of glass in this illustration. Each one blocks a bit of the view. The quality of the final performance, or the clarity of the view, is the original signal minus the damage done by all the pieces in-between. Improving any one of the components will improve the performance. Cleaning any one of the glass panes will allow a clearer view.



Recognizing that the challenge is to reduce negatives, to prevent distortion, makes it much easier to understand "unexplainable" improvements. If the panes of glass are not only dirty, but also have a red tint, then as each pane is cleaned and the tint is eliminated, the "view" of the music will improve as expected. However, the red, and the awareness of the red, will not be eliminated until the last pane has been de-tinted.

De-tinting this last pane will seem to make a bigger difference than de-tinting any of the previous panes. We are naturally more impressed by the elimination of the red tint than by the previous reduction in the tint's density. If you didn't want to hear traffic on the street, reducing the traffic from three cars per minute to none at all would be more impressive than reducing the flow from nine per minute to six. People are more sensitive to the presence of a phenomenon (the red or the cars) than to the quantity.

This type of surprise result, where we expected  $1+1=2$  and we think we got  $1+1=3$ , is often called "synergy." In truth, the "synergistic" aspect of this improvement would have been the same no matter which pane of glass happened to be the last one cleaned not much magic or synergy in that.

Sometimes we are faced with empirical data that we simply don't understand. However, such a lack of understanding doesn't mean the phenomenon is magical or incomprehensible. A visual analogy might be; just because something is too far away to see doesn't mean that the distance in-between is infinite. Our limitations might seem infinite, but that doesn't mean that a phenomenon we don't understand takes place on the same scale. A more rigorous application of logic and scientific method might prevent all the brouhaha we get about magical combinations.

Assembling or upgrading a system to cost-effectively maximize performance requires a broad perspective and a trustworthy evaluation methodology. Combined productively, these ingredients make the process predictable and enjoyable. (Please see "Evaluation Methodology" at the end of this booklet.)

### **The Challenge Of Speaker (High Current) Cable Design**

While there are many physical, electrical and magnetic phenomena responsible for distortion in cables, there are really only a few basic mechanisms which account for the majority of the performance variations between cables. After considering the following information and evaluating even a small variety of different cable types, you can acquire the ability to look at a cable's design and know pretty well whether it deserves your further attention. Please don't close your mind to new possibilities, just develop an educated skepticism.

Skin-Effect is one of the most fundamental problems in cables. It is useful to think of a metal conductor as a rail-guide. Electric potential is transferred as current inside a metal conductor and as a magnetic field outside the conductor. One cannot exist without the other. The only place that both magnetic field and current density are 100% is at the surface of a conductor. The magnetic field outside a conductor diminishes at distances away from the conductor, density is 100% only at the surface of the conductor. Something similar is true inside the conductor. Skin-effect means that current density diminishes at distances away from the surface on the inside.

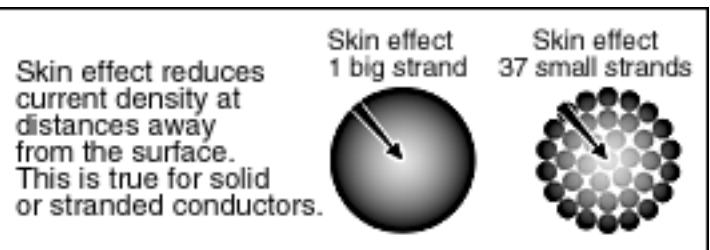
There is some disagreement as to whether skin-effect is relevant at audio frequencies. The argument concerns whether skin-effect causes damage other than simply power loss. Since the 3dB down point (50% power loss) for a certain size strand might be at 50,000Hz, not everyone understands the mechanism by which skin-effect is a problem at audio frequencies (20-20,000Hz). However, the problems are very real and very audible. This is because well before skin-effect causes a substantial power loss, it causes changes in resistance and inductance. Skin-effect causes different frequencies to encounter different electrical values at different distances from the surface of a conductor.

If a single strand is too large, skin-effect will cause each frequency component of an audio signal to behave differently. Each frequency component will exhibit a unique current density profile. The result

is that some of the delicate high frequency information, the upper harmonics, will be smeared. We hear sound that is dull, short on detail and has a flat sound stage. The energy is there, the amplitude (frequency) response has not been changed, however the information content of the signal has been changed in a way that makes it sound as though the midrange notes have lost their upper harmonics.

There is a textbook equation which describes the reduction in current and power density at any depth from the surface of an electrical conductor. For copper the equation is:  $6.61$  divided by the square root of the frequency (Hz) equals the depth in mm at which the current density will be  $1/e$ . Since  $1/e$  is 37%, this equation tells us the depth at which the current density has been reduced by 63%. For 20,000Hz, current density is only 37% at a depth of 0.0467 mm, which is the center of a 0.934 mm (18 awg) conductor. Conventional use of the above formula falsely assumes that it is acceptable to have a 63% reduction in current flow and an 86% reduction in power density at the center of a conductor. However, this formula does not by itself describe at what depth audible distortion begins. Listening (empirical evidence) shows that audible distortion begins at somewhat lesser depths.

There is a solution to skin-effect-using a single strand of metal which is just small enough to push skin-effect induced audible distortion out of the audio range. Simple evaluation of multiple sizes reveals that audible skin-effect induced anomalies begin with a strand (or conductor) larger than 0.8 mm. A much smaller strand yields no benefits but encourages the problems discussed below.



A common misunderstanding of skin-effect results in the claim that “the bass goes down the fat strands and the highs go down the little strands.” The surface of a fat strand is just as good a path as the surface of a thin strand, only the fat strands also have a core which conducts differently. In cables with fat strands which are straight and little strands which take a longer route, the path of least resistance at higher frequencies is actually the surface of the fat strands. Since the lower frequencies are less subject to skin effect, they travel everywhere in all the strands.

### Misunderstanding Resistance And Other Pitfalls

If a speaker cable used a single 0.8mm strand of copper, it would have too much resistance to do its job properly. Speaker sensitivity varies, but if the path between the speaker and amplifier has too much resistance, the sound quality will suffer. Such degradation is not actually distortion in the cable, but is the result of using too small a cable. For this reason, even a short speaker cable should be at least 18 awg (.82 sq. mm) or larger.

Power loss due to resistance is not usually a significant problem. If a very small cable were to cause a 10% power loss, the result would be like turning down the volume a fraction of one dB. If a signal has been robbed of the information that allows you to perceive dynamic contrast, harmonic beauty and subtlety, we tend to refer to the loss as an “amplitude” loss. However, the signal sounds so dull and lifeless at the far end of a poor cable not because of lost power, but because of added distortion.

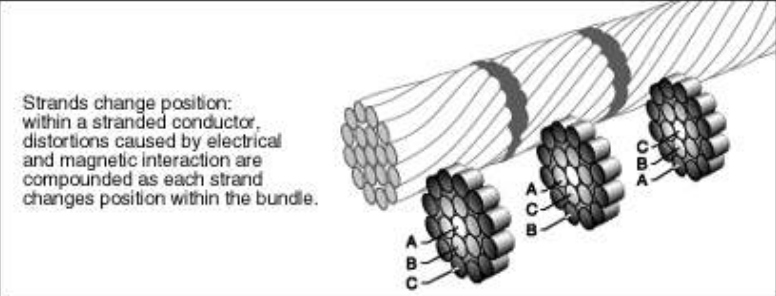
Unfortunately, the language of audio very often includes misleading terms. Many types of distortion are referred to as making the sound “bright” or “dull”, both of which imply a change in amplitude. “Bright” is often used as a way of saying that harshness in the upper midrange has somewhat the same effect as

turning up the treble. “Dull” is often thought of as turning the treble down, even though it is usually the result of distortions which obscure information. In most products, and certainly in cables, the amplitude response (frequency response) is not the culprit.

Probably the biggest obstacle to predictably assembling a high performance audio or video system is too much thinking and not enough evaluating. It is tempting to follow some logical story as to why some key ingredient will make all the difference, when in fact, pursuing any one priority almost always means inadequate attention to dozens of other often more important concerns. Please be careful not to get seduced by some common myths. Simplistic and ineffective solutions are often “sold” as cures for complicated problems. Dogma isn’t productive, results are what count. The best phono cartridges aren’t the ones with the lowest tracking forces, S-video outputs are not necessarily better than composite, two way speakers are not necessarily better or worse than three way speakers, more powerful amplifiers are not etc. The most relevant fallacy in this discussion is the one about “the more strands, the bigger the cable, the better”.

**Not Causing More Problems Than We Solve The Trouble With Strands:** Since a good speaker cable needs to have more metal than a single 0.8mm (20 awg) strand, our challenge is to provide a larger electrical pathway without introducing new problems. If we take a group of strands and put them into a bundle, the entire bundle will suffer skin-effect. The strands on the outside present an ideal electrical pathway, but the ones on the inside have different electrical values. This causes the same information to be distorted differently in different parts of the cable. The bigger the bundle of strands, the bigger the problem. If resistance is to be lowered by using a bundle of strands, the bundle size must be kept small. Possibly several separate bundles will be needed.

There are many ways in which skin-effect causes more distortion in a bundle than in a single over-sized strand. Strands are constantly changing positions over the length of a cable. Some leave the surface and go inside, others are “rising” to the surface. Since the current density distribution in a conductor cannot change, some of the current (particularly at higher frequencies) must continually jump to a new strand in order to stay at or near the surface. Unfortunately, the contact between strands is less than perfect. The point of contact between strands is actually a simple circuit that has capacitance, inductance, diode rectification—a whole host of problems. This happens thousands of times in a cable, and causes most of the hashy and gritty sound in many audio cables. This distortion mechanism is dynamic, extremely complex, and because of oxidation will become worse over time.



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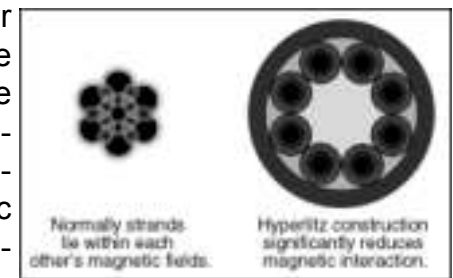
**Magnetic Interaction** is the other primary problem in cable design, both with a stranded conductor, and between conductors. A strand carrying current is surrounded by a magnetic field. In a bundle, each strand has its own magnetic field. These magnetic fields interact dynamically as the signal in the cable changes. On a microscopic level, a stranded cable is actually physically modulated by the current going through the cable. The more powerful magnetic fields associated with the bass notes cause the greatest magnetic interaction, which modulates the electrical characteristics of the cable, which in



turn modulates the higher frequencies. Because the music signal modulates the contact pressure between adjacent strands, it also modulates the distortion caused by current jumping between strands.

Reducing magnetic interaction is the primary reason speaker biwiring helps so much. Biwireable speakers have separate inputs for the bass and upper frequency ranges. These speakers simply allow separate access to the two halves of the “crossover”. A crossover is simply a low-pass filter which allows low frequency energy to pass to the woofer, and a high-pass filter which allows higher frequency current to pass to the tweeter, or midrange and tweeter. These filters block the undesired signal by causing the amplifier to “see” an essentially infinite impedance (resistance) at the frequencies which are to be blocked. Because there is no closed circuit at the blocked frequencies, current at these frequencies does not travel in the cable—just like a light bulb which does not light when the electric switch is turned off, no matter how many megawatts are available.

Taking high frequency energy out of the cable feeding the bass does not significantly affect bass performance. However, taking the bass energy out of the cable feeding the tweeter or midrange/tweeter causes a big improvement. The magnetic fields associated with the bass notes are mostly prevented from interacting with and distorting the fields associated with the higher frequencies. While the fundamental bass frequency is not affected, the bass sounds better because the bass instrument’s harmonics are in the midrange. The harmonics define the bass note and describe the instrument which created the note. Even if we could ensure absolute mechanical rigidity in a stranded cable, the interaction between magnetic fields would still be a prime source of distortion. Current within a conductor is directly proportional to the magnetic field outside the conductor. In most cables, the magnetic field of any given strand encounters a complex and changing series of interactions as it travels through a constantly changing magnetic environment. As the magnetic field is modulated, the audio signal becomes confused and distorted.



Distortion due to both magnetic interaction and from bare strands touching can be dramatically reduced by using Semi-Solid Concentric-Packing. In such a construction the strands are applied in a layer or layers spiraling around a central strand. Each layer is packed perfectly tight, exactly fitting around the strand or layer underneath. The strands in a given layer are uniform and never rise or fall to a different layer. This construction mimics many of the most important attributes of a solid conductor, while maintaining most of the flexibility of a stranded cable. The complete solution is solid conductors.

Magnetic interaction between conductors is also an area of major concern. This is discussed in the section following Material Quality.

**Material Quality** also dramatically affects the performance of cables and their terminations. By material quality we mean both the intrinsic quality of the metal, such as gold, nickel, brass, aluminum, copper or silver, and we mean the way the metal has been refined and processed. Pure silver is the very best performing material for audio, video or digital. However, if silver is not carefully processed, even low grade copper will sound better. Silver has also earned a confused reputation because sometimes the term “silver” is used to describe silver-plated copper. When carrying an analog audio signal, silver-plated copper causes a very irritating sound, sort of a “tweeter in your face” effect. In a different application, such as video, RF or digital, good silver-plated copper becomes an extraordinary value, out-performing even the highest grades of pure copper.

Why no gold wire? Because gold has neither low distortion nor low resistance. Gold is used on connectors because it is a “noble” metal, it doesn’t corrode easily. Because gold is “noble” it is ideal for pro-

tecting more vulnerable materials like copper and brass. The nature of gold's distortion is mellow and pleasant, which makes it preferable to the irritating sonic signature of nickel. A bare copper or brass part will outperform a gold plated part, but only until the metal corrodes. In comparison, high quality thick silver plating actually improves performance. Silver is not noble like gold, but it does resist corrosion and it enhances performance.

As for conducting materials, normal, high purity (tough pitch) copper has about 1500 grains in each foot (5000/m). The signal must cross the junctions between these grains 1500 times in order to travel through one foot of cable. These grain boundaries cause the same type of irritating distortion as current crossing from strand to strand.

The first grade above normal high purity copper is called Oxygen-Free High-Conductivity (OFHC) copper. In fact, this copper is not Oxygen-Free, it should more properly be called Oxygen-Reduced. OFHC is cast and drawn in a way that minimizes the oxygen content in the copper: approximately 40 PPM (parts per million) for OFHC compared to 235 PPM for normal copper. This drastically reduces the formation of copper oxides within the copper, substantially reducing the distortion caused by the grain boundaries. Additional improvement can be attributed to OFHC copper having longer grains (about 400 per foot), further reducing distortion. The sound of an OFHC copper cable is smoother, cleaner, and more dynamic than the same design made with standard high purity copper.

Not all OFHC is the same. If the poorest copper were given a value of one, and the best was a ten, then OFHC ranges from two to four-it is actually a range rather than a single performance level. Since the most important audible attributes are due to the length of the grains, we use the name LGC (Long Grain Copper) to describe the very best OFHC.

The next higher grade is an elongated grain copper sometimes called "linear-crystal" (LC-OFC) or "mono-crystal". These coppers have been carefully drawn in a process that results in only about 70 grains per foot. Cables using LC-OFC have an obvious audible advantage over cables using the same designs with OFHC or LGC. From 1985 to 1987 several AudioQuest models benefitted from this quality material.

|   | FPC | OFHC |
|---|-----|------|
| Cast  |     |      |
| Drawn   |     |      |
| Material Quality: It's visible. It's explainable. It's audible. |     |      |

In 1987 AudioQuest introduced FPC (Functionally Perfect Copper) in the higher models. FPC was manufactured by a process called Ohno Continuous Casting (OCC). Through this process, the metal is very slowly cast as an almost perfect single crystal small diameter rod. This near-perfect rod is then carefully drawn to maximize grain length. However, OCC is a process, not a material. The metal (usually aluminum or copper), the purity, and the size of the cast rod all make a tremendous difference. FPC copper was drawn from a smaller rod, causing less damage to the near perfect cast state, a single grain was over 700 feet long. The audible benefits were very obvious.

A couple of years later the "nines" race began. This refers to how many times the number "9" can be repeated when specifying a metal's purity. In 1989 AudioQuest introduced FPC-6 in the highest models. FPC-6 had only 1% as many impurities as FPC. The prime contaminants in very high purity (99.997% pure, four nines) copper, like LGC and FPC, are silver, iron and sulfur, along with smaller amounts of antimony, aluminum and arsenic. FPC-6 was 99.99997% (six nines) pure with only 19 PPM of oxygen, 0.25 PPM of silver and fewer than 0.05 PPM of the other impurities. The improvement was dramatic. From 1989 to 1999, many of AudioQuest's most famous models used FPC-6.

As with OFHC and OCC, the nomenclature “six nines” or “eight nines” has almost no meaning. All else being equal, higher purity is a straight forward benefit. However, grain structure, softness and surface finish can each make more difference than a “nine” or two. Then there is the matter of measurable purity. Due to contamination caused by the measuring process, there is a serious question as to whether any metal can be verified as having greater than six nines purity. Also, since “nines” became a selling point, some quite absurd and dubious claims have been made. Let the ears beware.

Once copper has been processed and refined to the Nth degree, the only improvement left is to go to a long-grain high-purity silver. AudioQuest FPS (Functionally Perfect Silver) is just such a superior material. It was expensive, but the results were transparency, delicacy, dynamics and believability that weren't possible any other way... until PSC copper. FPS silver is still used to excellent effect in many CinemaQuest (from AudioQuest) wideband cable.

In the previous several paragraphs a number of important metallurgical concerns have been listed, such as purity, grain structure, softness and surface finish. Earlier in the discussion of skin-effect it was mentioned that the only place with 100% magnetic field and current density is at the surface of a conductor. This means that the surface purity and smoothness does more to define the sonic character, or hopefully lack of character, than any other part of a conductor. This is why AudioQuest's recently introduced new range of metals are called “Perfect Surface.”

Perfect Surface Copper (PSC) is drawn and annealed through a novel proprietary integrated process which creates an exceptionally soft copper conductor with an astonishingly smooth and uncontaminated surface. Ever since the beginning, AudioQuest cables have improved over time. Starting in 1987 with FPC copper, a foundation was created by four levels of superb conducting materials. On this foundation, refinements such as SST continually provided further discrete improvements. With the introduction of PSC copper, a whole new foundation has been laid. For a price not much higher than FPC, PSC offers more natural and accurate performance than even FPS silver. AudioQuest's CV-4 speaker cable is identical to Type 4 in every way, except for the use of PSC copper instead of LGC. Coral interconnect is identical to the previous Ruby and Quartz designs, except for using PSC instead of FPC (Ruby) and FPC-6 (Quartz).

### **Importance Of Overall Speaker Cable Geometry**

We have been discussing problems within a single conductor, solid or stranded, regardless of polarity (+ or -). The relationship between conductors is also very important. If this relationship is not consistent, then the electrical parameters (such as capacitance and inductance) of the cable will be constantly changing and the signal will be distorted. Conductors can be parallel, spiraled (twisted), or braided. These various geometries have certain inherent qualities. Parallel construction is inexpensive. Spirals have good RFI (radio frequency interference) rejection and usually lower inductance. Braids have good RFI rejection and low inductance, but suffer the consequences of a constantly changing electrical environment for each conductor.

A cable may have two or more conductors. The arrangement of these conductors dictates the magnetic interaction, the capacitance and the inductance of the cable. Both capacitance and inductance cause predictable and measurable filtering and progressively more phase shift at higher frequencies, though neither is a magic key leading to optimum performance. The effect of capacitance is somewhat like a cliff, you can go near the edge as long as you don't go over the edge. In a given application there is a value at which capacitance becomes a problem. At a lower value, away from the edge of the cliff, there



is not much penalty. On the other hand, inductance is always a problem—a constantly accumulating problem. Capacitance and inductance are not the only important variables in cable design. However, it is productive to create cables whose capacitance doesn't "go over the cliff" while also designing for minimum inductance.

One theory of cable design holds that the characteristic impedance of a cable should match the impedance of the loudspeaker (When an antenna cable is referred to as 75 or 300, that is the characteristic impedance). Impedance matching is a valid concept which only applies when the impedance of the source, the cable and the load are all the same, and when the cable is longer than the wavelengths of the frequencies to be transmitted. Amplifiers do not have 4 or 8 ohm output impedances, in fact amplifier designers try to have as low an output impedance as possible. Speakers are all different and never have the same impedance at all audio frequencies. Since characteristic impedance equals the square root of the ratio of inductance to capacitance, very high (over the cliff) capacitance is a necessary corollary of a low characteristic impedance. Such high capacitance can severely affect amplifier performance and should be avoided.

Some of the first generation of specialty speaker cables had a characteristic impedance of about 8. These very high capacitance cables sounded better or worse because of their ability or inability to deal with the problems discussed earlier. However, many of these cables were accused of being extremely bright and irritating. It was not the cables which were so bright, it was the sound of the amplifier, which had been encouraged into instability by the cables.

Such false conclusions could be avoided if products were judged on their merit and then methodically analyzed. Consumers, store buyers, and reviewers each need to discover what sounds good. Unfortunately the desire to understand "why" can cause more confusion than insight if not pursued empirically as well as theoretically.

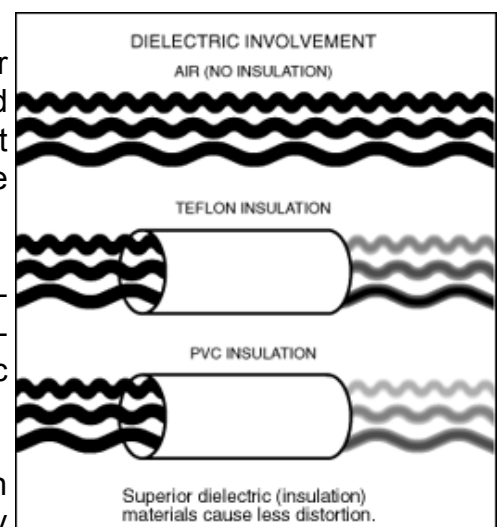
### The Challenge Of Interconnect (Low-Current) Cable Design

If you haven't read the previous discussion of problems in speaker cables, then please read that first. The following is meant to build on that foundation. The same problems exist in both high-current (speaker) and low-current (interconnect) applications. However, the hierarchy among these problems differs.

In low-current cables; skin-effect, electrical interaction, magnetic interaction and conductor quality are still primary problems. The negative sonic effect of internal mechanical modulation due to magnetic fields is greatly reduced.

The electrical behavior of the dielectric (insulating material) is much more important in low level cables. Dielectric involvement (the way in which a particular material absorbs and releases energy), has a profound effect on an audio or video signal. Dielectric constant, the most often quoted specification for insulating material, is actually not very helpful in understanding the audible attributes of different materials. The coefficient of absorption value is more relevant, and the dissipation factor and the velocity of propagation are even more useful.

The problem is that any insulating material next to a conductor acts like a capacitor which stores and



later releases energy. This is true of circuit board materials, cables, resistors and of course capacitors. The ideal wire is one with no insulation except for air. When a solid material must be applied, it should be electrically invisible, meaning that the less energy it absorbs, the better. The energy which is absorbed should stay absorbed (turned into heat, a high dissipation factor), and the energy which does come back into the metal conductor should have minimal phase shift and not be frequency selective (a high velocity of propagation, independent of frequency). All dielectrics absorb more energy at higher frequencies, but some are more linear in their overall behavior relative to frequency.

The most commonly used insulations are PVC, polyethylene, polypropylene and FEP. These can be mixed with air (foamed) or applied in ways which maximize the amount of air around the metal strands. Which material is used and how it is applied will dramatically affect the performance of a low-level cable.

Capacitance is more important in low-level than high-level cables for two reasons. If a long, “over the cliff” high capacitance cable is used, many preamplifiers, CD players, tuners, surround processors, etc., will not be able to “drive” the cable. The resulting distortion does not happen within the cable, but is caused by using the cable. There is never a disadvantage to using low capacitance low-level cables.

The other important reason for low capacitance is that high capacitance causes greater field strength between the positive and negative conductors (and the shield). This means more energy is put into the dielectric material. There is always a priority to minimize dielectric involvement, through proper selection of materials and low capacitance design.

**Important Cable Facts Running-In:** As with all audio components, audio cables require an adjustment period. This is often mistakenly referred to as “break-in”. However, break-in is properly used to describe a mechanical change—engines break-in, loudspeaker and phono cartridge suspensions break-in. A cable’s performance takes time to optimize because of the way a dielectric behaves (the way the insulating material absorbs and releases energy), changes in the presence of a charge. Cables will continue to improve in sound or picture quality over a period of several weeks. This is the same reason amplifiers, preamplifiers and CD players also require an adjustment period. The key difference between “adjusting” and “breaking-in” is that things don’t “un-break-in”, however, electrical components do “un-adjust”. Several weeks of disuse will return a cable to nearly its original state.

The run-in time is essentially the same for all cables. However, the apparent need for run-in varies wildly. As with amplifiers and other components, the better the cable, the less distortion it has, and therefore the less there is to cover up the obnoxious distortion caused by being new. Since human perception is more aware of the existence of a distortion than the quantity, the better the cable, the worse in some ways it will sound when new, because the anemic forced two-dimensional effect resulting from being new will not be ameliorated by other gentler distortions. Please be patient when first listening to any superior product.

**Directionality:** All cables are directional, from hardware store electrical cable to the finest pure silver cables. All AudioQuest cables are marked for direction. With other cables it might be necessary to simply listen to the cables in one direction and then the other. The difference will be clear—in the correct direction the music is more relaxed, pleasant and believable. While cable directionality is not fully understood, it is clear that the molecular structure of drawn metal is not symmetrical, providing a physical explanation for the existence of directionality.

**Biwiring:** Many of today's speakers can be biwired. This type of speaker has one input for the woofer and a separate input for the upper frequency ranges. This often leads to the question "is biwiring so important that I should spend twice as much on cable?" Maybe it is worth spending twice as much on cable in general, but that's a separate question. Biwiring is a way to save money, to get higher performance for the same price. The biwiring question is not about how much money to spend, but about how to get the most performance for one's money. Biwiring is done in order to substantially reduce the distortion caused by speaker cable. In a biwire set-up the cable feeding the higher ranges no longer has to handle the large magnetic fields caused by the high current needed to produce bass. The bass fundamentals are not affected by biwiring, but the treble signal now travels a less distorted path. A little like the difference between swimming through waves versus through smooth water. The bass will sound better because bass definition is in the midrange and higher. It is worthwhile to take advantage of the benefits of biwiring when the speaker manufacturer has gone to the extra expense of including this capability. At the very least, please connect a single set of speaker cables to the treble input, and then use even a modest cable like AQ F-14 to jump down to the woofer. Please replace the jumpers supplied by the speaker manufacturer. These are self sabotage, by the speaker manufacturer and by any listener who uses them. Just like better electronics do not come with poor interconnect cables, it is best to pretend your fine speakers did not come with stamped metal jumpers. When biwiring, the two cables used must either be identical, or have essentially identical designs. If the cables have different inductance or capacitance, they will cause different amounts of phase shift. The integrity and coherence of the speaker will be compromised.

**Connections:** The highest quality connections are first made mechanically. Solder is never a good conductor, not even "silver solder." A good solder connection is one that uses as little solder as possible, and prioritizes the connection interface between wire, solder and plug. Welding makes the best connections: either resistance welding (which can be done with small cables), or cold welding (usually called crimping). When a connection is crimped hard enough to cause the metals to deform, to change shape, the area of contact becomes a "gas-tight" connection or a "cold weld." Any solder applied to such a quality connection is purely cosmetic. When connecting a speaker cable, much greater attention should be made to contact pressure than to contact area. A 14 awg (2 sq.mm) connection is more than enough current path. It is much better to have a small area tightly secured than any larger area under less pressure. Speaker cables are sometimes quite large as way to dilute distortion mechanisms, not to carry more current. Please do not confuse this size advantage with the priorities at the connection point.

### **The AudioQuest Objective**

AudioQuest cables have a mandate: to transmit a signal without changing it. Since 1978 we have been actively researching the mechanisms responsible for altering an audio or video signal as it travels through a cable. The better we understand these mechanisms, the more effectively we can minimize their harmful effects. We take the only reasonable approach: instead of trying to fix something after it is "broken", we try to prevent it from breaking.

Every AudioQuest cable, from the least to the most expensive, is designed to minimize change. The problems we seek to conquer are the same for all cables. We make so many models of AudioQuest cables in order to ensure financial compatibility. We are certain to have several models which are extremely cost-effective in your system, whether it's a mini-rack system or state-of-the-art. The best cable is always the best cable, a difference you can hear on a boombox, but that does not mean that it's cost effective to make such a match.

AudioQuest, the company, manufactures cables using the brand names AudioQuest and CinemaQuest.

**The AudioQuest Solutions HyperLitz®** construction is the ultimate solution. “Hyper” means to go “over, above or beyond”. “Litz” type cable construction was invented long ago for the purpose of preventing skin-effect induced power loss in high-frequency applications. Conventional litz construction uses multiple individually insulated strands arranged so that no matter how big the cable, skin-effect is only that effect which would be associated with a single strand.

By “Hyperlitz” we mean a construction which meets the litz definition of reducing skin-effect to the strand level and a cable which goes significantly beyond conventional litz in its ability to prevent other distortions associated with the use of multiple strands. Conventional litz does not address the major problem of magnetic interaction. We have defined Hyperlitz as a construction which virtually eliminates magnetic interaction and ensures that the electrical characteristics of each strand are constant and unchanging over the length of the cable. Hyperlitz design fulfills the ideal of preventing the distortion normally associated with multiple strands or multiple conductors, yet allows us to make cables with a large cross sectional area and low resistance.

Litz design is a conductor specification, and therefore has no bearing on the relationship between conductors. Litz construction is completely independent of values such as capacitance, mutual inductance and resistance.

AudioQuest uses two basic versions of Hyperlitz construction. Most AudioQuest cables use a helical array of individually insulated solid conductors. The insulation is thick enough to provide significant magnetic spacing between the strands. AudioQuest’s previous top interconnect cables used a more complicated patented Air-Hyperlitz construction in which the strands are not insulated, but are instead isolated. The metal’s surface was never damaged by a hot insulating process. Around its entire circumference, a metal conductor only touched solid insulation at four points, everywhere else was air. AudioQuest’s new top cables now use polyethylene or FEP tubes having an inner diameter larger than the outer diameter of the solid conductor inside. This means only one point of contact, more air, less distortion. Because low-level cables are most sensitive to dielectric involvement, such cables benefit the most from these superior construction techniques.

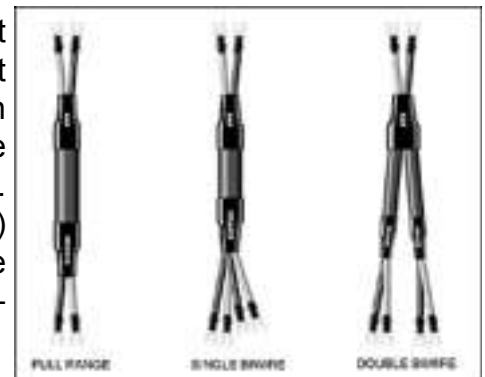
**Third Generation Spread Spectrum Technology (SST):** To minimize a distortion mechanism, one first has to be aware of it. Near the beginning of this discussion we discussed how skin-effect causes strands larger than 20 awg (0.811 mm) to distort an audio signal. There is also some distortion associated with smaller strands. For sizes larger than 20 awg, the audible skin-effect induced distortion is simply wrong. However, for sizes smaller than 20 awg, even though the distortion signature is simply different for each size, one is not more wrong than the other, they are just different. There is no size or shape which doesn’t have some limiting characteristics. The conductor shape which causes the least distortion is radially symmetrical. Round is simple, round is best.

SST, now in its third generation, is an extremely effective way to reduce distortion signatures and better preserve a natural homogenous harmonic balance across the entire frequency range. By using a multiple of different size conductors whose character flaws are similar but slightly different, the “visibility” of any one character flaw is greatly reduced. In order to optimize this defocusing of distortion awareness, the conductor sizes must be close together. If they are too far apart, then the cable simply

has multiple compound character flaws. SST does not do the impossible: it does not eliminate this type of distortion. We can't actually strip away the undesirable artifacts, but we can make them virtually invisible (to the ear).

**Biwire versatility-using two speaker cables:** As discussed previously, it is important to biwire speakers whenever you have the option. The two cables must be identical, or must use essentially identical designs in order not to compromise the coherence of the speaker. If money were no object, double runs of our best cable would be an easy choice for everyone. However, since money usually is relevant, it is important to consider the best sounding and most cost-effective alternatives. As you will see below, many AudioQuest speaker cables are grouped into families which use very similar or identical designs. Within a family, cables can be mixed to create some very effective combinations. Since bass frequencies can never be harsh, it can be advantageous to use a cable with a lower quality conducting material for the bass in combination with a superior cable for the upper ranges. Within the AudioQuest line there are many opportunities to take advantage of this cost efficiency: Type 4 could be used on the bass with CV4 for treble; Bedrock on the bass might be used with Granite on the treble; Caldera on the bass with Kilimanjaro on the treble. You can biwire by using two separate pairs of cables, or you can use what we call a Double Biwire set. In such a set the two cables are joined together at the amplifier end so that only one spade lug goes to each amplifier terminal.

**Biwire versatility-using one speaker cable:** Many AudioQuest cables have the built-in ability to biwire with a single cable. Almost every AudioQuest cable can be used as a single biwire set in which the cable is prepared normally at the amplifier end. However, at the speaker end there are four connections instead of the normal two. Two of the ends are prepared 2" (5cm) longer (for the tweeter input) so that the cable will hang properly from all four connections. Please read individual cable descriptions and consult your dealer for recommendations.



Biwiring within a single cable is a compromise, though often a very practical and cost-effective compromise. Much of the advantage of biwiring is due to magnetically isolating the high and low frequency conductors, and they cannot be isolated quite as well within a single cable.

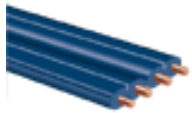
However, single-bi wiring with Slate, Bedrock, Granite and Gibraltar speaker cables is always the most cost-effective way to biwire within their price range. This is true whether the speaker has its frequency range divided above or below the midrange. The conductor sizes and placement have been optimized to not only make the lowest distortion full range cable, but also to make the best universal single-biwire cable. The "flat rock" models, Slate, Granite and Gibraltar use double quad-helices, creating an unprecedented isolation of magnetic fields when these cables are used to single-biwire.

When the speaker is a three way or a panel/dynamic hybrid, the bass cable needs to have a good design and be big, but it doesn't have to be the best full-range cable since it carries such a limited frequency range. On the other hand, the cable carrying the midrange and high frequency information has to be a good full-range cable. It needs good design and size because the lower midrange has much the same requirements as the bass, and it must be extremely low distortion so that the more delicate high frequencies suffer minimal distortion.

If the speaker is a two way, then the woofer reproduces both bass and midrange, and only the tweeter is driven separately. In this situation it is the bass cable which must be a good full-range cable since it carries bass and very delicate midrange information. However, the cable driving the tweeter can now be quite small. Having low distortion is as important as ever, but carrying current is almost irrelevant as a tweeter receives very little power. With many previous models, and with the more expensive Caldera, Volcano, Kilimanjaro and Everest, when preparing the cable for single-biwire use, we divide the conductors differently. If the crossover frequency is high and the midrange is carried in the bass cable (biwire high), most of the conductors are used for the bass/midrange. If the crossover frequency is low and the midrange is in the treble cable (biwire low), then the conductors are divided more evenly. Using a single-biwire set can also increase system flexibility. If you choose to upgrade your system later, you can use the entire existing cable on the bass and simply add a second run of the same cable, or a run of a superior cable, for the top. For example, start with Bedrock as a single-biwire now, and have the option of adding Granite or Gibraltar as the treble cable later.

Following are descriptions of the various AudioQuest cables. You can see how the previously discussed problems are dealt with and in large measure overcome.

### Flat Hyperlitz Speaker Cables



AudioQuest F-14 is flat! The third generation SST version of F-14 is 0.45" (11.4mm) wide and only 0.10" (2.5mm) thick. In addition to excellent sound, easy preparation and low cost, F-14 runs neatly under carpets or along baseboards and up walls. F-14 uses four solid LGC (Long Grain Copper) conductors; 2 x 21 awg and 2 x 18 awg. One of each size for positive and one of each for negative, making 16 awg (1.23 sq. mm). All strands are spaced apart, making this a flat Hyperlitz cable. F-14 is available in blue or white.



**AudioQuest G-4** is Flat and Flexible. Only 1/12" thick (2 mm) and 3/8" (9.5mm) wide, F-40 is easy to use, easy to hide and sounds great. Long Grain Copper (LGC) in carefully designed bundles avoids skin-effect and provides superior resolution. 17 awg (1 sq. mm). Available in white.

### Helical Array (Round) Hyperlitz Speaker Cables with Spread Spectrum Technology

All these speaker cables employ Hyperlitz design and Spread Spectrum Technology for optimal performance. Please also see the SA-Series cable section on page 13 for information on additional Hyperlitz SST models.



**AudioQuest Type 2** SST Hyperlitz uses four individually insulated LGC copper conductors, two are 21 awg and two are 19 awg, making this a 17 awg (1.06 sq.mm) cable. These conductors are spiraled for optimal signal carrying characteristics and good RF rejection. The four-conductor geometry provides a superior balance of forces between the opposing conductors. The performance is audibly superior to using the same conductors as a double set of twisted pairs. "Mild Red" satin outer jacket. (UL/CL-3 rated.)



**AudioQuest Type 4 SST Hyperlitz** uses two solid 20 awg (0.52 sq.mm) and two 17 awg (1.02 sq mm) LGC conductors. One of each size used together makes 15 awg (1.56 sq.mm). Available in Blue or White (both UL/CL-3), or with a Blue/Black textile outer braid (not UL rated). This finely tuned “4” design maximizes the amount of metal which can be used in a four conductor cable. If the 20 awg conductor were larger, skin-effect would smear the high frequencies, if the 20 awg were smaller, the character flaws of the 21 and 17 awg conductors would be heard as two flaws instead of working together as the 20 and 17 awg conductors do to minimize any such awareness (SST). If the 17 awg conductor were smaller, the cable would lose some “authority.” If the 17 awg were larger, the 20 and 16 awg conductors would lose their SST advantage



**AudioQuest CV-4** is “living” proof that metal quality can make a huge difference. CV-4 uses the same exceptionally efficient design as AudioQuest Type 4 speaker cable. While Type 4 takes advantage of LGC (Long Grain Copper) in order to provide high performance at an excellent price. CV-4 uses the astonishing new PSC (Perfect Surface Copper) in order to “get out of the way” far more completely. CV-4 is smooth, pure, clean and dynamic to an extent not previously possible anywhere near this price, even from AudioQuest. While CV-4 is a wonderful full-range cable, it will perform even better when two CV-4 cables are used with biwireable speakers; serious take-no-prisoners performance. With two-way (high crossover) loudspeakers, CV-4 also makes an excellent single-biwire cable. To single-biwire a three-way (low crossover) speaker we suggest considering Slate or especially Bedrock. Available in Sea Green, Navajo White (both UL/CL3) and Green/Black textile braid.

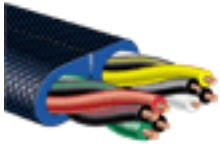
### Double Quad-Helix Construction - The Flat Rocks

These three cables use the same remarkably effective Double Quad-Helix design. Eight conductors in the same four sizes as in Slate (16,18,19,21) optimize the potential of SST (Spread Spectrum Technology) to minimize audible character flaws. In the explanation of Type 4 above, it is explained why none of the conductors in Type 4 (or CV-4 or KE-4) can be any larger or smaller without sacrificing quality. However, with eight conductors in two four-conductor helices, the game changes. In the “bass half” of the Flat Rocks, all four conductors are one size larger. The cable has better authority, and the loss of high frequency detail does not matter. In the “treble half” of the Flat Rocks, the four conductors are all one size smaller, allowing an even more open and detailed top end. If used full range this would compromise bass weight and cause a light sound (compare Type 2 to Type 4). However, when all eight conductors are combined, the SST Double Quad-Helix design allows unprecedented clarity and dynamics. A wonderful byproduct of the superbly effective full range design of the Flat Rocks, is that these models are also ideal for use as single-biwire cables. The “bass half” and “treble half” have already been optimized for their particular priorities, and they have a degree of magnetic isolation not found in any other single-biwire cable.



**AudioQuest Bedrock** uses the incredibly efficient Flat Rock design. Bedrock is our most affordable cable that combines Third Generation SST, Double Quad-Helix Geometry and Hybrid Technology. The 19 awg and 16 awg conductors in the “bass half” are LGC (Long Grain Copper). The 21 awg and 18 awg conductors use our amazing PSC (Perfect Surface Copper). When used full range, the hybrid use of PSC/LGC coppers provides much of the benefits of PSC, while keeping the price closer to LGC. When

used for single biwire, the more sensitive “treble half” is pure PSC, making Bedrock an ideal single-biwire cable; especially for three-way (low crossover) speakers. This Mild red cable is 12 awg (3.19 sq.mm) Mild Red cable.



**AudioQuest Gibraltar** is The Top Rock! The big difference in this dark blue cable is the quality of the metal. In this fine-tuned Hybrid design the character of the overall cable is determined by our proprietary PSC+ copper used for the 21 and 18 awg and 19 conductors. Only the large 16 awg conductors are the remarkable, but in this case inferior, PSC copper. As even the “bass half” of this Flat Rock is a hybrid, even the bass half has mostly the character of PSC+. Leaving only the largest treble impaired 16 awg conductors in PSC saves money and gives up almost nothing in absolute performance. Thanks to the use of these exclusive coppers, the music is sweeter, cleaner and more dynamic. As with all the other Rocks, Gibraltar is also excellent for single-biwire use, or to make a double-biwire set with Bedrock or Granite on the bass.

### Counter Spiraling Circular Helix Hyperlitz - The Earth Features

If the only change to the new AudioQuest cables was the inclusion of the wonderful Perfect Surface metals, we would be shouting from the rooftops about our great new cables. If the only difference in the new cables was Third Generation SST, we wouldn't shout as loudly, but even a quick listen would show that the SST improvement alone would easily justify new models and a proud designer. If Double Quad-Helix construction were our only new trick, that alone would provide reason to sing the praises of the Flat Rocks.

However, there is even more to shout about. The top four new models have enough conductors to be able arrange them in a new and extremely effective manner. In each Earth Feature cable there is a circular array of positive conductors spiraling in one direction. Around this helix is another circular array of negative conductors spiraling in the opposite direction. The inner group spirals more quickly (has a shorter lay length), while the outer group spirals more slowly (longer lay), so that for every foot or meter of cable, the length of the positive and negative conductors is equal.

This arrangement meets the Hyperlitz criteria of a never changing regular and fixed relationship between positive and negative; the two cylinders of conductors are in a fixed non-changing relationship, even though the conductors are crossing each other instead of being in parallel. This crossing of conductors has always been sited as (potential) the advantage of a braided cable. However, the magnetic disruption (as the high frequency engineers call it) in a braid causes far more audible damage than any benefit from non-parallel conductors.

Since all four of these great cables use new Perfect Surface metals, all include third generation SST, and all are bigger and meatier than anything from AudioQuest since the 1980's; it is impossible to listen to the magnificent performance and hear just the contribution made by the Counter Spiraling Circular Helix construction. We can tell you that this construction technique is crucial to these cables' ability to clearly place individual sounds all over a huge three-dimensional stage.

All the Earth Feature cables were first optimized for their full range performance. Then when decisions were made about the spacing of the conductors in the outer circular array, they were divided into bass, midrange and treble groups. This facilitates superior single-biwire performance. To achieve maximum



results, the cables should be specified as “single-biwire high” for use with two-way dynamic speakers, or as “single-biwire low” for use with three-way or two-way hybrid speakers (such as electrostatic/dynamic hybrids).

### Audio Interconnecting Cables

All the AudioQuest interconnecting cables are low capacitance. They can all be used in long lengths with most any preamplifier. Using a CD player (or tuner or tape deck) with a passive preamplifier can yield unpredictable results no matter what cable is used. However, AudioQuest cables have an extra advantage in these applications and will allow the best possible performance.

Often the cosmetic qualities of plugs are used to judge the value of an interconnecting cable. This is a terrible mistake. How the plugs look and feel has nothing to do with sound quality. AudioQuest plugs look great, but it is their superb sound which is most important. The various AudioQuest cables use several different plugs, most with FEP insulation, all with precisely applied gold or silver plating, and all making excellent electrical contact. Some models are carefully soldered using the best available solder, most models are resistance welded. Welding sends 8,000 amperes through the junction of wire and plug for 33 millionths of a second. The resistance of the metals turns some of this energy to heat, which causes the molecules of the cable and plug to commingle in an essentially perfect connection, a difference you can clearly hear.

All the AudioQuest interconnect cables can be special ordered as “Y” connectors. We recommend that you avoid “Y” adapters and instead use a custom “Y” with both “legs” long enough to reach the equipment directly. We can even mix the cables, you could use Diamondback to a woofer amp while using Viper to the main speaker amp with both cables joined to a single plug at the preamp output. We also offer the excellent AQ M22F one piece “Y” adapter.

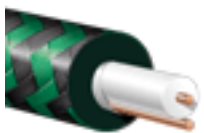
### Accessory Cables

AudioQuest PreAmp Jumper Cables are short, positive conductor only cables which replace the horrible little “U” plugs on many receivers and integrated amps. The AQ Python Jumper Cables use solid PSC+ together with high quality RCA plugs. The result is like replacing a worse than bad cable with the equivalent of Python-for very little cost.

### Interconnecting Cables



**AudioQuest Sidewinder** uses two solid LGC copper conductors in a novel symmetrical Hyperlitz arrangement. One conductor is insulated and used for positive. The other is uninsulated and makes contact with the 100% coverage shield, allowing it to connect (drain) the shield while at the same time being used as a high quality conducting path for the negative signal. This mild red jacketed cable carries a UL CL-3 rating, enabling it to be used inside walls without conduit.



**AudioQuest Copperhead** uses two solid PSC copper conductors in the symmetrical Hyperlitz arrangement. One conductor is insulated and used for positive. The other is uninsulated and makes contact with the 100% coverage shield, allowing it to connect (drain) the shield while at the same time being used as a high quality conducting path.

for the negative signal. This black PVC jacketed version of this cable carries a UL CL-3 rating, enabling it to be used inside walls without conduit.



**AudioQuest Diamondback** uses two solid PSC conductors, and what a difference PSC makes. This extremely long grain copper allows for clarity and dynamics simply not possible with lesser materials. Double Balanced Hyperlitz design welded connectors and superior materials make this blue and black textile braided cable a great value.



**AudioQuest Coral** is a Triple Balanced cable featuring Hyperlitz construction. Coral uses three solid PSC copper conductors, each insulated with foamed Polyethylene. When used single-ended (with RCA plugs), one conductor carries the positive audio signal, two carry the negative. The 100% coverage shield is only attached at one end so that it is not used as an inferior audio conductor.

When used with balanced equipment (XLR type connectors), one conductor is used for each of the three signals (positive non-inverted, positive-inverted and the reference ground). The shield is connected to the case of the XLR at both ends to ensure ideal chassis to chassis grounding.

The audible differences resulting from multiple single construction, PSC copper, and not using the shield to carry audio information are dramatic. Coral is available with either the superb AQ #788 RCA plug or with AudioQuest custom #20 and #21 XLR plugs both color coordinated to match Coral's distinctive black and red braided jacket.

When a double balanced (or twin axial) cable is used "single ended" (with one RCA plug on each end) the shield is not used as an audio conductor, it is only grounded at one end. This provides complete shield coverage while preventing the shield from being used as an inferior audio conductor.

When a double balanced cable is used with balanced electronics, it usually has XLR connectors on both ends. One conductor is used for each of the two positive signals, and the shield is used for ground. To us, this is a step backwards: the reference ground is just as sensitive to distortion mechanisms as the positive signals and so deserves exactly the same respect. For this reason (and for better performance when used with RCA plugs) all cables from Coral and above are triple balanced.

An XLR plug can make four possible connections. AQ triple balanced cables use the three pins or sockets to connect the reference ground and the inverting and non-inverting positive signals. The case of the XLR is used to connect the shield to chassis ground.

The AudioQuest #700 series RCA plugs and most CinemaQuest RCA plugs employ a patented design which eliminates extra internal contacts, ensures a large self-wiping (self-cleaning) contact area, and provides extraordinary strain-relief. Very thick high purity silver plating actually provides a superior parallel conducting path. For the same reason Hybrid design works so well in many of the AQ/CQ speaker cables, it also makes for superior plug performance. All the same plugs are resistance welded to their respective cables in a process which actually commingles the molecules of the cable and plug into a single alloy. 8,000 amperes of current are put through the cable plug interface over a period of 33 millionths of a second. The extremely localized super-heating causes the metals to melt and become one.

## Digital Cables-Wire and Optical

There are four standard ways that a digital signal is carried from one piece of equipment to another. The four different types of cable are each connected to a different type of transmitting and receiving circuit.



**S/PDIF** or “digital coax” cables look like normal cables. However, for superior performance, they must be specially designed for wideband applications. These 75 cables are used with either RCA or BNC connectors depending upon the equipment.



**AES/EBU** is a balanced wire system. This professional standard has been around for many years, but has only recently been adopted by the home market. AES/EBU uses a balanced 110 cable fitted with XLR plugs.



**Toslink or EIA-J**, is the most common fiber optic system. Toslink cable usually contains a synthetic (plastic) light conducting fiber, though the best Toslink cables use quartz fiber (glass).



“**ST**” is the highest quality fiber optic system used in audio. As the specifications for this system were set by AT&T, it is most often called AT&T or “glass”. However, neither term actually defines the system. ST is just one of many fiber optic standards set by AT&T, and many companies besides AT&T make parts that conform to the “ST” standards. ST systems operate at seven to fourteen times the frequency bandwidth of the Toslink system.

If you have the choice of using Toslink or ST, you will obtain higher performance with ST. In a choice between coax and AES/EBU, odds are in favor of AES/EBU, but not always, it depends on your transport and your digital processor. Between ST and a wire system, it also depends on the specific equipment-and it always depends on the cable. Comparing a high quality coax against a normal Toslink, or a quality Toslink against a poor AES/EBU isn’t going to tell you which system is better. If you compare systems using AudioQuest digital cables with similar prices, you will get a fair reading as to which system yields the highest performance with your equipment.



**AudioQuest Falcon** (AES/EBU) also uses Hard Cell Foam insulated solid SP-LGC conductors. Falcon is a dedicated 110 triple balanced design. Triple balanced means that each of the three “signals” has its own identical low distortion conductor. A super low distortion non-braided silver plated shield is connected to chassis ground through the case of the XLR plugs. Exceptional AQ#40/41 direct-silver plated FPC XLR plugs help maximize performance.

## CinemaQuest from AudioQuest

Please don’t be confused ... this is where we switch (for a while) to using the CinemaQuest name. CinemaQuest (CQ) the brand, from AudioQuest (AQ) the designer and manufacturer. CinemaQuest

products all have a significant role in Home Cinema ... which is much of the purpose of Home Theater. All our many types of cable which carry a picture, are under the CinemaQuest banner. Video is the core of the CQ line. Some CQ products, such as OptiLink 1, 2 and 4, have important applications outside video (CD transport or MiniDisc to DAC). All the AQ brand products are also ideal in a Home Theater. However, the video based world is a little less central to the existence of AQ brand products.



**CinemaQuest OptiLink 1** provides significantly higher performance than is often thought possible with the Toslink interface system. Even though OptiLink 1 has a very modest price, that first step from normal cable into the CQ OptiLink series, is the biggest step .... the most sonic improvement.

CQ OptiLink cables can make so much difference because, when used in a Home Theater system, a Toslink cable is carrying five (5.1 or more) channels of audio information. It is the only single cable that so globally affects the performance. In a two channel application, a Toslink cable is also carrying all the audio information. Performance is equally important no matter the number of channels, but the cable is doing two and half (or more) times the “work” in a Home Theater system.

OptiLink 1 uses a low-loss low-jitter synthetic fiber, a precision machined termination (to minimize dispersion and reflections), a brass ferrule plug, correct cladding (the fiber’s intimate covering), and effective mechanical damping (cushioning for the fiber). The result is low distortion and better sound from this reliable cable.

### Video Cables

There are four different systems for transferring a video signal. All four systems need low-distortion high-bandwidth 75 cables. The differences are in how many channels of signal need to be carried, and the type of plugs on the end.

**Composite video** requires a single high quality cable to carry the complete video signal. Standard connectors are either RCA or BNC plugs.

**S-Video** is a two cable system which carries the two basic parts of a composite signal separately. The black and white picture signal is known as “Y” and the signal containing all the information for decoding the color information is called “C”. This explains why the proper name for this system is “Y/C”. When color TV was brought to market, it had to be compatible with existing b&w TV sets. The solution was to continue to broadcast a b&w “Y” signal, but to supplement it with a second “C” signal at a higher frequency. This is why broadcast TV and VHS tape recorders are Y/C media. Since an S-VHS tape machine has an “S” (Y/C) output, it gives you direct access to the separate Y and C signals, whether from a tape or from an over-the-air broadcast. “S” outputs on tape machines, cameras, DSS and DVD machines will provide better performance than a composite output. However, the video signal on a LaserDisc is composite. The “S” output on an LD player will only outperform the composite output if the LD player’s filters (which separate composite into Y and C) are better than the filters in the TV set.

**Component video** is the somewhat confusing name for a three wire system which carries the “Y”, “I” and “Q” signals. Slightly confusing because the components of a color signal are RGB (see next paragraph). “Y” is that same b&w signal as in Y/C cable (see previous paragraph). “I” and “Q” are the components (get it?) of a “C” signal. In order to derive three colors from a b&w signal, there need to

be two color difference signals, I = blue minus Y (add Y and get blue), Q = red minus Y (add Y and get red), and once you have blue and red and Y you can derive green. These three signals need exactly the same care and respect as a composite video signal. Since standard YIQ connections are either RCA or BNC, you can simply use three identical composite video cables, or for convenience use a YIQ cable which has the three joined together. Don't get fooled by some hype about specially designed for component video—either it's a proper video cable or it isn't. When a piece of equipment sources from a YIQ signal, such as DSS and DVD, using a YIQ cable setup will provide superior performance over composite or "S".

**RGB** are the real components of a video signal. This five conductor cable carries the three unadulterated color signals, red, green and blue. The other two cables carry the synchronization information which tells the monitor where a picture starts and ends, and a signal called "burst". The five together give you a complete picture. When you have this option, use it. You'll know who you are.

**FLX 16/2** and **FLX 16/4** are UL CL-3 rated Round Flexible speaker cables, specially designed to be very easy to use in a wide variety of applications. The insulation on the conductors is PVC to ensure maximum flexibility and good flame resistance. The outer jacket is a slippery smooth PVC: flexible, easy to pull, installer friendly. FLX cables are printed with sequential feet numbers.



**AudioQuest FLX 16/2** is a very effective 16 awg (1.23 sq. mm) cable using Long Grain Copper (LGC). Each conductor in FLX 16/2 uses 19 strands of 29 awg, ensuring that 63% of the strands will be on the surface all the time, where they do the most good. The two conductors are spiraled together to provide good RF rejection and optimum signal carrying capability.



**AudioQuest FLX 16/4** uses 4 of the same conductors found in FLX 16/2. The 4 conductors are separately color coded so that they may be used with two conductors tied together (13 awg, 2.27sq. mm) to carry a single channel signal, or separately so one cable can carry two signals.

The **SR** cable series is most unusual because each cable has a 100% coverage shield. Each conductor is tightly held in high temperature PVC and the overall cable is jacketed in a slippery high temperature PVC jacket. This outer jacket is abrasion and heat resistant, and can be used in a variety of harsh environments. The SR-16/2 and SR-16/4 cables sound better than the FLX 16/2 and FLX 16/4, have lower resistance, and are shielded. A tape under the jacket of SR cables is printed with sequential feet numbers.



**AudioQuest SR-15/2** uses 2 spiraled conductors, each with 26 strands of 30 awg LGC copper (16 awg, 1.32 sq. mm).



**AudioQuest SR-15/4** uses 4 of the same 26 strand LGC copper conductors coded with 4 colors. When used with 2 conductors for positive and 2 for negative, the superior 4 conductor geometry greatly improves sound quality. In this configuration SR-1604 is a 13 awg (2.64 sq. mm) cable.



**AudioQuest SR-13/4** uses 4 color coded LGC copper conductors (14 awg, 2 sq. mm). When used with 2 conductors for positive and 2 for negative, this is an 11 awg (4 sq. mm) cable.



**AudioQuest CV-4** is a small (0.26") SST Hyperlitz cable using four solid PSC copper conductors; 2 x 20 awg (0.52 sq. mm) and 2 x 17 awg (1.02 sq. mm). Overall CV-4 is a 15 awg (1.54 sq. mm) cable. The dynamics and clarity will rearrange all your cable prejudices. The four conductor geometry provides a superior balance of forces between the opposing conductors. PSC copper significantly reduces distortion within the conducting material. SST technology reduces cable awareness and allows authority and kick not otherwise possible in such a small cable. Use full range, or as the top half of a biwire combination, or as an ideal single biwire cable in autosound applications.

## How To Get The Most Performance Out Of Your Cables

Sometimes the cable marketing types do nothing except talk about connectors and terminations. It is a serious mistake to think that connectors (and the way they look) are more important than the cable. It would also be a mistake to ignore the connection interface.

In the section about interconnecting cables we have described AudioQuest's very high quality proprietary RCA and XLR plugs. These plugs make an important contribution to performance—we are proud of them.

Terminations for speaker cable are more complicated, only because there is so much misunderstanding of the very simple priorities. The best connection is what is called a "gas-tight" or "cold weld" connection, formed when the wire and the piece it is connected to have been pushed together with enough force to cause a change in the shape of the materials at the surface where they meet.

When a spade lug is crimped around a group of copper strands, the strands develop flat spots where they touch each other and where they touch the inside of the lug. These flat spots are gas-tight connections. Because they are gas tight they will not oxidize or degrade. If this connection is soldered after crimping, the solder cannot flow into the area where the metal is pressed together. The gas-tight connection will continue to be the primary electrical pathway. If the connection had been soldered before crimping, the solder would be an additional material impeding the electrical pathway and contributing to distortion.

Sometimes speakers and amplifiers have connection facilities that let you really screw down on the incoming wire. If you were to connect a single strand (or two or three strands) directly to such a terminal, you would have an ideal gas tight connection. F-14, Type 2 and Type 4 speaker cables can often be used this way. However, most of the time the cable has too much metal to really make a proper permanent connection without being "prepared" before being connected to the amp or speaker.

Historically, the most common form of "preparing" or "terminating" cable ends has been tinning (soldering). This is still an effective solution for connecting to push-to-connect terminals. The solder will prevent corrosion and the spring action in the push-to-connect will bite into the solder. This method is superior to using hard gold plated machined pins—the round pins offer almost no contact area. AudioQuest direct-gold plated (#10GP, #14GP) or direct-silver plated (#10SP, #14SP) stamped pins are a suitable alternative to soldering.

Usually a spade lug is the most effective termination for a speaker cable. A spade can be securely attached to a screw terminal or binding post, or one “leg” can be inserted into a push-to-connect terminal. As long as the spade is made from soft copper, it will deform (become marked) where it connects to the screw terminal or binding post. These marks show that there was a gas-tight connection.

Unfortunately, the desire for spade lugs to look and feel “fancy” has resulted in the common use of inferior materials. Most spade lugs are very shiny. This is almost always due to the nickel plating underneath the gold. This nickel layer clearly distorts the sound, but it does make the lug look pretty-very important if you mount them on the wall instead of listening to music through them. All AudioQuest spades, pins, and bananas are direct plated without any intermediary layer to compromise the performance.

The advantages of gold plating are often misunderstood. Gold is not a very good conductor, and as an extra layer of material, it distorts the music. The reason for using gold is that it is a “noble” metal-it does not corrode easily. The only reason for gold on connections is to prevent corrosion. Luckily the distortion caused by gold is a fairly friendly smearing of the sound, as compared to nickel which causes an obnoxious irritation. AudioQuest terminations are available in a choice of thin gold plating (thin for complete protection with minimal distortion), or with thick silver plating for maximum performance.

In addition to inappropriate plating, the other common problem with spade lugs is the nature of the base metal. While pure copper is best, many “fancy” spades are often copper alloys harder and stronger than pure copper, but they don’t sound as good.

As an alternative to spade lugs that look better than they sound, AudioQuest makes spade lugs that sound better than they look.

The standard AudioQuest spade is pure soft copper. It isn’t very thick and it isn’t strong enough for prying nails. It is direct-gold or direct-silver plated for ideal performance. There is nothing between the copper and the gold. It sounds great and it doesn’t cost much! What else could you want?

Well, you might want the AudioQuest Premium #P-8 series spades. They are made from LGC, they are thicker than they need to be (you could pry small nails), and they are direct-gold or direct-silver plated. These deluxe spades are also the correct size to fit into terminal strips, and won’t short-out your positive and negative binding posts. Silver-plated #P-8 spades are standard on Type 6 and above.

### **Good Signals-Bad Signals**

This entire pamphlet has discussed ways to pass an electrical signal as clearly as possible with no filtering. Unfortunately there is often a signal running through your cables that should not be there.

There is a whole category of energy referred to as RFI (Radio Frequency Interference). When RFI gets into your equipment it compromises the circuit’s performance, and therefore compromises the sound or picture quality.

Often people assume that if they don’t hear a radio station coming over the CD player, they must not have any RFI. This is not necessarily true! In order to hear a radio station (without a tuner) you need to be picking up that particular radio frequency, and you must have some part of your system that rectifies the signal (tunes in the signal and converts it to audio frequencies).

Most RF interference is not demodulated into an audio signal. The real problem is high frequency energy from radio and TV stations, microwaves, radar, CBs and hundreds of other sources, including your own stereo system! CD players must be registered with the FCC (Federal Communications Commission) because they are sources of RFI. The same is true for tuners, TVs and computers.

The problem of RFI is not new, and neither is the most common solution. For decades, circuit designers have used “ferrite beads” around wires to help block RFI. When the “beads” are large, and hinged so that they can open and close, they are called “ferrite clamps”.

Ferrite reduces RFI in a cable by disrupting the radio frequency components of the magnetic field outside of the cable. For a current to travel within a cable, there must be an associated magnetic field on the outside. By altering the magnetic field, ferrite is able to filter the current inside the cable even though nothing has been inserted into the cable. No extra connections or electronic parts with their own distortion problems.

situation RF Stoppers on the refrigerator’s power cable will reduce (not eliminate) the noise.

Because they filter very high frequencies so well, do not use RF Stoppers on digital and video cables.

### **Evaluation Methodology**

How can something as simple as evaluating an audio component require serious thought? Don’t you just listen and either there is a difference or there isn’t? If there is a difference, isn’t one better and one worse?

YES! If you’ve never thought about equipment.

NO! If you have.

There is a fundamental distinction between listening to music versus listening to equipment. This is definitely the conundrum of our industry: How can one judge the “vehicle’s” effectiveness without becoming preoccupied with the vehicle?

The very definition of good audio equipment is that it is not noticed, it is instead listened through. If you view a far off landscape through a window, you would appreciate having a clean and undistorted window to look through. If the task at hand is to judge the usefulness of the window, it is the visibility of the view which must receive the viewer’s attention. A valid “test” would determine how much interference was caused by the window. It would be very unproductive for the eyes to focus on the window itself. Focusing on any dirt on the glass would clearly destroy the ability to see and appreciate the view, rendering the “evaluation” meaningless.

An important pitfall to avoid, is paying attention to the equipment, as that destroys one’s ability to judge the effectiveness of the equipment. This artificial separation of the equipment from its function is possibly the most fundamental pitfall in the evaluation process.

Despite rampant references to “golden ears” and such, it is the truly inexperienced listener who most easily appreciates differences and is able to establish hierarchy. Ironically, it is listeners with a total



absence of technical detail who are most easily able to cut directly to the truth. However, even these fortunate people need an appropriate context for the bare truth to come shining through. There are pitfalls even for virgin ears.

The challenge for most of us immersed in this fabulous world is to reclaim the innocence we once had when we first felt the emotional and sensual thrill of a sound system that was better than we had thought possible. Generally this ear opening experience took place around late adolescence. We then proceed to spend the rest of our lives trying to recreate that experience. The crucial distinction here is between “event” and “experience”. The “politically correct” paradigm for audio is to be preoccupied with recreating an event which occurred at another place and time.

To heck with living in the past. Music is about how we feel in the present! The purpose of an audio system (in the real world) is to evoke an emotional response here and now, not to give a history lesson. Even though an audio system might be able to convey whether a recording was made in Carnegie Hall before or after the renovation, it might not be able to convey the pathos and power of the music.

Music and data are not the same thing. If the recording and playback process were perfect, then music and data would be equally well served. However, audio systems are a long, long way from perfect. This vast discrepancy leaves room for some seriously warped priorities-what we call the “tyranny of perceived resolution”.

In an attempt to more predictably quantify audio performance, there is an imperative to pay attention to quantifiable values. At its most base level this means measuring and comparing numbers. At the listening level, this quantification fixation often leads to the mono-theistic religion of “resolution at all costs.”

In the artificial context of listening to (focusing on) the equipment, any additional “information” creates an imperative to follow that path, to use that equipment. If the purpose of an audio system is to be a vehicle to enable music to stimulate the mind and body, more information should only be one of the gods in a pantheon, not the only god.

For example: If two components are compared, and one presents a fine sounding quartet, but the other one reveals that it is really a quintet, the “politically correct” will immediately and absolutely declare the component conveying the quintet to be superior. However, what if the sound of the “quartet” is enthralling and involving, but the quintet is fatiguing and irritating? Isn't it more important to enjoy the music?

This dichotomy highlights why a system designed for monitoring a recording session is often so different from an entertainment system. Resolution is the purpose of a monitoring system. Sounding good and being enjoyable have little value, hearing what is going on is the whole story.

Besides the danger of listening to equipment instead of music, the next most fundamental challenge to useful evaluation is overcoming the amazing human ability to adapt.

- We are astonishingly capable of “seeing” through distortion. We (generally) don't feel our clothes, yet we are sensitive to even a single rain drop falling on our clothing. We can wear all colors of sun-

glasses and yet still see that the sky is blue. If we use yellow goggles while skiing on a cloudy day, when we take them off the snow looks purple. The “solution” isn’t to get out the yellow paint to fix the snow, the solution is to allow ourselves time to re-calibrate our references. Once we have adjusted to a colored (distorted) reference, we can be fooled into thinking reality is wrong.

Have you ever been given a cassette tape and you didn’t know if it was Dolby encoded or not? You probably pushed the Dolby button on and off, while you were playing the tape, in an attempt to decide which way was correct. Odds are that both positions sounded wrong. One way sounded too bright and the other sounded too dull. In this artificial context one is faced with two conflicting references, both of which make the other sound wrong. A common response is to wish there were a middle position, even though one of the existing positions is absolutely correct and the other is absolutely wrong. This is an example of how an instant comparison can be a highly deceptive selling technique and not part of a trustworthy evaluation methodology.

Whoever controls the switch can sell whatever they want. This also applies to a lone individual doing an “evaluation” by themselves. Just because a second party isn’t involved doesn’t prevent someone from “selling” themselves whichever component first grabs their attention, whichever one got the good review, whichever one has an attractive story.

- Another simple opportunity for deception (including self-deception) is the A/B phenomenon: The second time a piece of music is played, the listener is bound to notice something that wasn’t noticed the first time—even with familiar music. This perception feeds directly into the value system which dictates that more information is our most commanding priority. If you want to sell something, always play it second.

There are ways around this pitfall: Go back to “A”. No matter which is better, going back to “A” will be a surprise. Since the step from “A” to “B” included the “novelty factor” in addition to the real difference, the step back to “A” will be surprisingly different from the original step to “B”, simply because the novelty factor has disappeared. “A” will seem to be better than when played the first time. Continuing on to play “B” a second time, without the benefit of the novelty factor, then reveals its truer relationship to “A”. After an initial A/B/A/B, it is possible to move to “C” and “D” with far less confusion.

- It can be easier to evaluate three products instead of the apparently simpler task of evaluating only two. Even without the deception of an instant A/B, any A/B is subject to a certain amount of the effect described with the cassette tape example—the truth is perceived as somewhere between the two.

If two of the three products are relatively similar, probably (but not always) different models from the same manufacturer, then it is quite easy to establish an absolute hierarchy between the two products. When a third and different product is compared to a similar pair, it becomes a comparison between a line and a point, instead of just between two points. It becomes much easier to establish a hierarchy: that the third product is preferable to either member of the pair, inferior to either, or somewhere in-between.

- There is almost no way back to the “garden” of complete innocence. It requires great awareness and careful methodology to attain anything like the direct vision available to those who cannot be distracted by misleading details. This view flies in the face of those who declare that people have to learn what is good sound, go to lots of live concerts and study the technology. Bull!

The only thing that needs to be learned is how not to be misled by the incredibly deceptive process of listening to equipment. People hear real sounds all day long. None of these real sounds has the added layers of distortion which exist in every audio system. Whether or not we have ever heard a particular singer or instrument, we can recognize whether more or less “extra stuff” is in the way.

- As for comparisons where there seem to be only “insignificant” differences between components, this is usually proof of a faulty context and/or methodology. This is most obvious in the discussion of ABX testing.

In an ABX set-up, the listener does not know whether or not there has been any equipment change at all. ABX testing is not a question of how a fixed but blind “A” compares to a fixed but blind “B”. Because there are too many unknowns, the ABX test becomes primarily an opportunity for embarrassment. Context is everything, and the ABX set-up is one very distorted context, much too far removed from the purpose of an audio system. ABX fans believe that a lack of repeatable hierarchy proves there are no valid differences. Others of us believe the same evidence proves that the ABX test is an invalid methodology.

Does all this mean that trustworthy conclusions are impossible? No. It means a balanced perspective is paramount. It's a little like shopping for advice (which really is more useful than shopping for equipment): If honesty is the sole criterion, you'll probably end up taking advice from someone honest, but incompetent. If competency is the sole criterion you get the picture.

## **Burn This**

We sincerely hope that after you have absorbed some of this information, and after you have set up your music system, you will put on a recording and hear the music, not the equipment. Unfortunately, the very process of being an informed and careful consumer involves at least temporarily increasing your awareness of the equipment. When the evaluation process is over, we hope you can turn it off. Toward that end, burn any print outs of this text, or better yet, give it to a friend.

## **The Final Sell**

There is one more thing AudioQuest does want to remind you about-the AudioQuest Music recording label offers some of the finest artists performing some of the world's greatest music-and they just happen to be superb recordings using the finest studios, tube microphones, cables(!) and lots of loving care.