



## White Paper: XLO Limited Edition™ cables

### Introduction

Jonathon Scull's review of XLO's Limited Edition in the August, 1998 issue of *Stereophile* said that "...the Limited Edition was always and totally superb.", and went on to say that "...[the] **Limited Edition is almost certainly the best cable that will ever be made.**" One month later, in the September, 1998 issue of *Fi, The Magazine of Music and Sound*, Michael Gindi reviewed the Limited Edition and enthused that "... [As it burned-in,] It just kept getting better and better and better, until it disappeared entirely, and nothing was left but the music." Dr. Gindi came back with more high praise for the Limited Edition in "*Fi magazine*" in February of 1999, and in the Spring of 2000, Myles Astor, after reviewing nine of the world's best speaker cables in *Ultimate Audio* magazine, declared that "Compared to the XLO, other cables sounded muddy and distorted."

Those reviews were just the beginning. For more than half a decade, since its introduction in 1998 until just now in 2003, the world's leading audio reviewers have found XLO's Limited Edition to be clearly and obviously "The Best in the World." This paper will tell "how" and "why" that is.

### XLO Advanced Technology

More important, perhaps, than any other one reason for the Limited Edition's superiority is that the design for every XLO Limited Edition cable is based upon genuinely advanced technology, applied in a "total system" approach, to each specific cable application, always in accordance with XLO's basic controlling philosophy that the cable should pass signal exactly as it receives it, with no addition, subtraction, coloration or distortion whatsoever.

One example of XLO's advanced technology is found in its proprietary "Field Balanced" winding geometry. Put most simply, although many other cable manufacturers seem to recognize and design for the effects of ambient electromagnetic fields, and some even (but many don't) allow for electromagnetic fields self-generated by internal current flow, **XLO is still the only cable manufacturer in the world to recognize and design for the fact that ALL CABLES IN OPERATION GENERATE BOTH ELECTROMAGNETIC AND ELECTROSTATIC FIELDS WITHIN AND SURROUNDING THEM.**

These internally generated fields (the intensity of the electromagnetic field controlled by current flow, and that of the electrostatic field controlled by voltage) both - individually and by their interaction - affect the signal passing through the cable, and therefore affect the sound of the entire system.

Because the signals passed in each different cable application all have different



relative amounts of current flow (amperage) and of voltage,<sup>1</sup> but there is only one optimum relationship for the two fields that result from them, every XLO cable, in every series from XLO/Ultra all the way up to the Limited Edition, is specifically designed to produce that one optimum relationship in its own application. THE REASON WHY XLO CABLES ARE WOUND DIFFERENTLY AND LOOK DIFFERENT FROM EACH OTHER AND FROM EVERY OTHER BRAND OF CABLES IS SO THAT ALL WILL HAVE THE EXACT SAME OPTIMUM FIELD RELATIONSHIP, WHATEVER THEIR APPLICATION MIGHT BE. This is XLO's exclusive "Field Balanced" technology, and it's one of the reasons why XLO cables really *are* The Best in the World.

The reason for the Limited Edition's incredible detail, focus and ambience retrieval lies in another example of XLO's advanced technology: Functionally, cables (of any brand, even XLO) have many of the characteristics of capacitors: They store energy in their dielectric (on a cable, that means the insulation) and they release it OUT OF PHASE, DIRECTLY INTO THE SIGNAL PATH every time the carried signal changes polarity. This out-of-phase energy results in cancellation of the signal information at very low levels (like the fifth bounce of the music off the walls of the concert hall!), and works to reduce detail, blur imaging, and even result in "phantom" signal artifacts ("noise" signals that aren't a part of the recording being played) to further spoil your listening enjoyment. XLO IS THE FIRST CABLE MANUFACTURER TO RECOGNIZE THIS VERY REAL PROBLEM, AND IS STILL THE ONLY ONE TO HAVE SUCCESSFULLY ADDRESSED IT<sup>2</sup>.

### Everything is Important

XLO's "total system" approach to cable design is exactly what the term implies: Every aspect of every part of every XLO design is taken into consideration and optimized, not only in itself, but as it interrelates with all other aspects of the design before the design is finalized and sent to production.

Although there are cable manufacturers who seem to believe that there can be one "magic" solution that will always result in "perfect" cables,<sup>3</sup> the fact is that cables

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<sup>1</sup> The signal passed by phono cables is tiny fractions (thousandths or fractional thousandths) of an Ampere of current at equally tiny fractions of a Volt. The signal carried by an unbalanced interconnect in a high impedance circuit is just millionths of an Amp at as much as 10 Volts; that of a balanced interconnect or digital cable in a matched-impedance circuit is milliamps (thousandths of an Amp) at, again, as much as 10 Volts; and that of a speaker cable may be as much as 50 or 60 Amps of current at as little (typically) as just a few thousandths of a Volt.

<sup>2</sup> Interestingly, when capacitive discharge effects in cables were first made public by Roger Skoff, XLO's founder and Chief Designer, in a *Stereophile* interview with Jonathon Scull, the internet chat lines were for some time after clogged with audiophiles and other cable manufacturers denying that such a thing could ever be possible. Even more interestingly, within two months after the appearance of the interview, a number of the manufacturers were, themselves, talking about capacitive discharge effects, although usually with some different (and often "proprietary") name.

<sup>3</sup> You know who these are: Siltech seems to believe that the only thing important about a cable is what metal it's made of; MIT and Transparent put all of their faith in "magic boxes"; Nordost and others seem to think that geometry is the be-all and end-all of cable design; and so on...



are not nearly as simple as they seem. Even though the casual observer may see them as just bits of wire and plastic, cables are actually extremely complex in their operation, and EVERYTHING about them affects their performance: The material used for the conductors (usually either copper or silver in most audio cables<sup>4</sup>) has a clear and obvious effect on the sound of your system. So does the thickness (the AWG gauge) of the conductors, their purity, how they were made,<sup>5</sup> and whether they are solid-core or stranded. Dielectric and capacitive discharge effects mean that the choice of insulating material for the primary wires<sup>6</sup>, its dielectric constant<sup>7</sup>, its “dielectric absorption” or “dissipation factor”<sup>8</sup>, its “dump rate”<sup>9</sup>, and how thickly it’s applied are all crucial. And these same considerations are all equally important to the kind and thickness of each of the overall conductor jackets, the filler materials, if any, and the final overjacket on the finished cable. The cable winding geometry is important. Whether or not the cable is shielded is important, too, because shielding - even shielding done the way XLO does it - can affect sound quality and overall system performance. And so can the *spacing* of the shield, if any, over the cable and the spacing of the conductors within it: Nothing more than the distance between them determines the capacitance and inductance of any pair of conductors, and those factors, plus the resistance of the conductors, themselves, are the sole determinants of the cable’s characteristic impedance. The ultimate importance of absolutely *everything* to good cable design is perhaps best shown by the fact that even as

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<sup>4</sup> silver-plated copper has also been used, as has MU-metal (a specialty product originally developed for electromagnetic shielding), aluminum, copper-plated steel and even - possibly - on the theory that if it costs more it must be better - so has gold!

<sup>5</sup> Wires can be rolled, drawn, cast, continuously cast, or slit from sheets or foil.

<sup>6</sup> The primary wires are the individual conductors from which the major conductors are made. Primary wires may be either solid or stranded, but are always used in groups to form a single current-bearing conductor.

<sup>7</sup> Any non-conducting material may be used as a dielectric, and, if placed between two active conductors, will store energy for as long as the flow of current in the conductors remains of the same polarity. The amount of energy that will be stored by any cubic volume of a material as compared to the same volume of hard vacuum is the dielectric constant of that material. As an example, PVC with a particular kind and amount of softeners used in its manufacture may store six times as much energy as would the same volume of hard vacuum. That being the case, it would be said to have a dielectric constant of six. By comparison, Teflon, one of XLO’s preferred dielectrics, has a dielectric constant of just two.

<sup>8</sup> Of the amount of energy stored in any dielectric material, some portion will be lost as heat and the rest will be dumped back into the signal path when the polarity of the signal changes. The dumped energy is the source of capacitive discharge effects and the other amount, that which is lost to absorption or dissipation is the “dissipation factor.” If the dissipation factor were 100%, there would be no capacitive discharge effects, but, lacking functioning capacitors, there would also be no electronics and no need for cables, either.

<sup>9</sup> A dielectric material’s dump rate is the rate at which it is able to discharge its stored energy in preparation for recharge with energy of the opposite polarity. The higher (faster) the dump rate, the less capacitive discharge energy will affect the transmitted signal energy and the better the cables will sound.



seemingly small a factor as whether or not its center core is perfectly round can significantly affect how closely a coaxial cable will come to meeting its designed impedance specifications.

In designing its cables, XLO takes every one of these things into consideration, and more. And that, finally, is the biggest difference between the Limited Edition and almost every other cable - even from XLO's own other product lines. Every other product that we know of embodies compromises that must be made to comply with budgetary considerations, the vagaries of the market, or the realities of manufacturing. Even if the manufacturers know what *should* be done to make for truly outstanding performance, they're limited by what *can* be done within the budget they have available, the price they think their customers might be willing to pay, or the machines and processes they have available to them for manufacturing.

The Limited Edition is different. Absolutely uncompromised in any way, and representing the fullest development of the thoughts and skills of designer Roger Skoff, the Limited Edition is, even as compared to XLO's justly world-famous Signature Series and UnLimited Edition, a huge step forward. Barring radical improvements in materials technology or major scientific breakthroughs, it is almost certainly, just as Jonathon Scull wrote: "...the best cable that will ever be made."

### **The Limited Edition Product Line**

The Limited Edition consists of only six products: **LE-1, The Unbalanced Interconnect**, **LE-2, The Balanced Interconnect**, **LE-4, The Digital Interconnect**, (available either balanced or unbalanced), **LE-5, The Speaker Cable**, (along with its companion product the **LE-5js Jumper Set**) and **LE-10, The Power Cord**. No other model names have been assigned or are necessary -- The Limited Edition cables are the best XLO knows how to build, and just their performance is all it takes to set them apart from any competitor.

### **Materials and Construction**

#### **! Limited Edition Interconnects**

All XLO Limited Edition interconnecting and digital cables are made from custom-drawn and specially treated "Laboratory Grade Plus" copper, which is so pure that it actually exceeds the test capabilities of any U.S. commercial laboratory. Conductors of this rare and expensive material are individually insulated with thin films of a special DuPont™ Teflon™-related fluoropolymer material and then arrayed in XLO's own proprietary "Field-Balanced" geometry between an air- and nitrogen-bearing concentric two element fluoropolymer central core and a single element air-bearing fluoropolymer outer core analogue. The insulation and core structure thus formed has a lower effective dielectric constant than any other kind or combination of commercially available materials and has a mean audio frequencies dielectric absorption factor significantly lower than even DuPont's own Teflon AF™ -- an ultra-premium licensed



product for special military and aerospace applications that sells for more than US\$ 7.00 per *gram*! Where necessary for balanced or AES/EBU operation, a special grounding network is incorporated within the central core.

The outer "skin" on all Limited Edition Interconnects and digital cables is woven from multiple custom-extruded air-bearing tubes of Teflon-related material in a special "cross-one" pattern, which can only be done on specially adapted machinery. The result is outstanding electrical, dielectric, and field characteristics, with a degree of flexibility never before achieved in any large diameter high performance cable.

All connectors used on Limited Edition interconnects and digital cables are of XLO's own design and built to XLO's own high standards. Every connector is non-magnetic, to avoid hysteresis effects, and each is designed for minimum self-inductance. Every part in the signal path of every Limited Edition connector is precision manufactured from either Laboratory Grade ultra-pure copper or from an ASTM-designated copper alloy selected to be best for its particular application. RCA connector contact pins, for example, and those of XLO's proprietary male XLR connectors are machined from solid billets of Tellurium copper, while the pin receptacles of female XLR connectors are formed from special Brush-Wellman Alloy 174 Beryllium copper. Where gold plating is used, it is applied directly, with NO nickel substrate, just thickly enough to prevent connector tarnishing, WITHOUT affecting sound quality<sup>10</sup>. To ensure minimum self-inductance, steps are taken on every Limited Edition connector to remove all conductive materials not absolutely necessary to signal transmission from the signal path. The dielectrics of all XLO Limited Edition XLR connectors are made of a special General Electric engineering grade thermoplastic polyester resin. All other Limited Edition connectors which employ dielectric materials use DuPont Teflon.

All interconnects are unshielded, and do not require shielding in most applications. Special external shielding may, if necessary because of unusually high-noise environments, be ordered at additional cost. Where shielding is specified, it is of XLO's own free-floating "Faraday Cage" design, with gold-plated grounding clips at both ends.

## ! **Speaker cables**

XLO Limited Edition speaker cables are made from the same specially treated ultra-pure (exceeding U.S. commercial lab test capabilities) "Laboratory Grade Plus" copper as is used for Limited Edition interconnects and digital cables. Multiple small-diameter conductors (23AWG) of this material are individually insulated with thin films (0.076 mm or less) of a special DuPont™ Teflon™-variant fluoropolymer material and served, in accordance with XLO's proprietary "Field-Balanced" geometry, over air-bearing composite multi-element concentric Teflon-variant core structures to

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<sup>10</sup> Perhaps surprisingly, gold is neither particularly good-sounding nor a particularly good conductor. It's only about 40% as conductive as copper and is extremely self-inductive at very high frequencies. For these and other reasons, most well-designed connectors use gold ONLY for cosmetic purposes or to prevent contact corrosion.



make the cable's four individual conductor "legs". Each of these four legs is then wrapped and extruded with a twin-element Teflon-variant fluoropolymer jacket and the four legs are cabled, either around an air-bearing central core member or a special internal shielding network (depending on whether the cable is for unbalanced or balanced amplifier operation), into a minimum-inductance "quad", and finally given a braided Teflon mesh outer jacket.

Limited Edition speaker cables are two conductors of 6 gauge (AWG) in their normal "shotgun" configuration (2 legs per conductor) or four conductors of 9 AWG when terminated in the optional "bi-wire" mode. Regardless of configuration, all Limited Edition speaker cables feature individually machined gold-anodized "end caps" with two-part epoxy brand and directional markings and laser-etched serial numbers. Protruding through these caps at either end are the actual hook-up ends of the cable. These are sheathed in multi-element air-dielectric tubes woven from custom-extruded Teflon-variant materials, colored in purple or a pale lavender shade to match the leg color of the conductors for which they provide termination. The actual termination is, in every case, an individually billet-machined Laboratory Grade copper spade lug (of either 6 or 8 millimeter terminal size) covered in a separately machined anodized aluminum shell. Only spade terminations are offered, as these are the only termination type XLO believes to be of sufficient quality to match the cables.

### **Specific Product Descriptions**

**LE-1 The Unbalanced Interconnect** -- Much larger in diameter than would normally be expected from XLO, this Limited Edition cable features unique jacketing braided from ultra thin-wall air-filled Teflon tubing. This results in truly remarkable dielectric characteristics and an appearance and texture reminiscent of snake skin. Highly polished low self-inductance connectors of XLO's own design complete the impression of luxurious high quality, while fully symmetrical windings and special geometry make this unshielded unbalanced cable unusually resistant to EMI and RFI.

**LE-2 The Balanced Interconnect** -- Similar in construction and jacketing to The Unbalanced Interconnect, this unshielded cable relies upon the Common Mode Rejection inherent to balanced ("differential mode") operation to provide outstanding sonics without the need for shielding. Special Limited Edition XLR connectors are custom machined *and* precision die-cast, with pins (male) and pin receptacles (female) of billet-cut Tellurium copper or patented Brush-Wellman Alloy 174 beryllium copper as standard.

**LE-4 The Digital Interconnect** -- Designed for quick rise-time, broad bandwidth, and the lowest available cable-induced jitter of any product currently available, this Limited Edition cable has been adopted as an absolute reference standard by manufacturers of some of the most technically advanced digital equipment in the world and is the cable of choice for many of the world's most critical and demanding audio reviewers. LE-4 cables are available either unbalanced, with RCA or BNC connectors, or in balanced configuration with XLR connectors, for AES/EBU.



**LE-5 The Speaker Cable** -- Six AWG; Quad multi-core construction; ready for either "shotgun" or "internal bi-wire" application<sup>11</sup>; billet-cut direct gold-plated Laboratory Grade copper fittings, phenomenal dynamics, and sound quality that puts all others to shame make this the speaker cable of choice for systems that really do strive to duplicate the reality of the musical experience. Unquestionably and by far "the Best in the World", the LE-5 is also available in a model (**LE-5B**) specifically designed for balanced output amplifiers. This model features a special internal shielding network that, when used with balanced output amplifiers, acts like more than twenty interlocking coils, to trap current-induced noise between the "Hot" and "Cold" legs of the circuit and dump it to chassis ground. The result can be an improvement in signal-to-noise ratio<sup>12</sup> of as much as 12dB, and the improvement in sonics and detail resolution can be simply amazing! *(Note: LE-5B's special construction functions by taking advantage of the fact that a balanced circuit has no true ground, but that, instead, each of the two amplifier output terminals acts as "ground" for the other. This is not the case with conventional (unbalanced output) amplifiers, which DO have a true ground, and will therefore derive no benefit from LE-5B's special construction.)*

**LE-10 The Power Cord** This is the ultimate premium version of the spectacular new power cord that's getting rave reviews from audiophiles and reviewers everywhere. Sharing an entirely new approach to power transmission technology with XLO's Signature 2 Type S2/10 AC cord and the phenomenal UnLimited Edition UE-10, it's an all hand-made 9+ equivalent gauge (AWG), multi-conductor, Teflon-dielectric, Teflon-jacketed masterpiece that will clearly and obviously outperform any other AC power cord now or ever likely to be made. Amazing high frequency detail, sweetness and extension, coupled with greater image width, depth and focus, plus utterly astounding bass "weight", power and "slam" make this new power cable a required addition to any High-End system seriously intended to challenge the state of the art. And because they also make a clearly visible improvement to the performance of any Video Projector or other video electronics device, XLO highly recommends LE-10 power cords for any video application calling for state-of-the-art performance. LE-10 AC power cords are jacketed in specially-woven XLO Purple Teflon braid with black and purple trim, gold markings and a precision machined anodized and individually laser-engraved serial number block. Each is fitted with custom-made ultra-premium gold-plated U.S.-style plugs (NEMA males are Audio Grade), and delivered in its own laser-engraved wood presentation case. European-style or 20 Amp connectors are also available at slight additional cost. Because of this cable's genuinely radical design and construction, UL listing, which is currently being sought, may not be available. ***XLO certifies, however, that all connectors used on LE-10 power cords are UL approved, and that the cables, themselves, will exceed all performance and fire safety standards known to XLO by***

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<sup>11</sup> Or use **LE-5js** jumper cables as an alternative to bi-wiring when using bi-wireable speakers. LE-5js jumpers are made from exactly the same conductors and dielectric materials as the LE-5 speaker cables and match their performance perfectly.

<sup>12</sup> relative to actual signal level



*no less than 100 percent and, depending on the specific standard and the specific performance or safety characteristic, may exceed it by as much as THIRTY TIMES!*