QED

Supremus Zr Loudspeaker Cable

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Introduction

At QED all our cable designs are informed by our exhaustive ongoing research into cable performance which was begun in 1995 and detailed variously in the QED Genesis Reports. These reports set out the design principles to which we have since adhered and which have resulted most recently in the development of QED Supremus Zr loudspeaker cable – the ultimate expression of sound through science without compromise.

QED Supremus Zr benefits from the appliance of **Aircore™** technology incorporating advanced polyester coated solid core conductors and therefore boasts very low impedance across the audio band. At just 5 mΩ/m QED Supremus Zr has an extremely low DC loop resistance because it uses 6.2 mm^2 of cryogenically treated silver-plated 99.999% oxygen-free copper conductors. The exclusive use of factory-terminated, rhodium-plated, low eddy current **Zirconia Airloc™** locking banana plugs, ensures that this low resistance characteristic is maintained all the way through to the speaker terminals. This brings the amplifier electrically much closer to the loudspeakers, enabling it to exercise better control over them, so that fidelity to the original music signal can be more accurately maintained.

Cable capacitance and inductance are strictly controlled through the use of low loss dielectrics in synergy with the unique constraints of the Aircore geometry, this helps address the twin issues of *skin effect* and *proximity effect* which until now have made such large cross-sectional area cables less effective than they might otherwise be. Let's find out more.

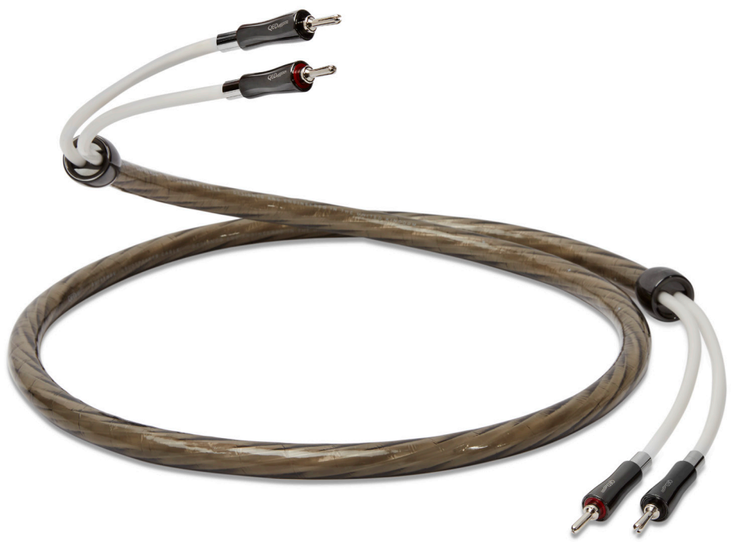


Figure 1. Supremus Zr cable

Aircore™ Cordage

6.2 mm^2 Cross-sectional Area

Loudspeaker cables must deliver electrical power to the speakers and that means that they must have a large current carrying capacity. As current flows through the cable it encounters electrical resistance and therefore voltage is dropped across the cable; this means that the musical signal reaching the speakers has been altered by the resistance of the cable and so fidelity of the music has been lost. That would be acceptable if the losses were completely linear (i.e. every frequency was affected equally) as the resulting uniform drop in signal level could be compensated for just by turning up the volume. Unfortunately, these losses are not linear because the loudspeaker is a complex load involving two or more separate drivers. At different frequencies the speaker cable represents a different proportion of the total load seen by the amplifier and so its losses become more, or less significant depending on the part of the audio spectrum that is measured.

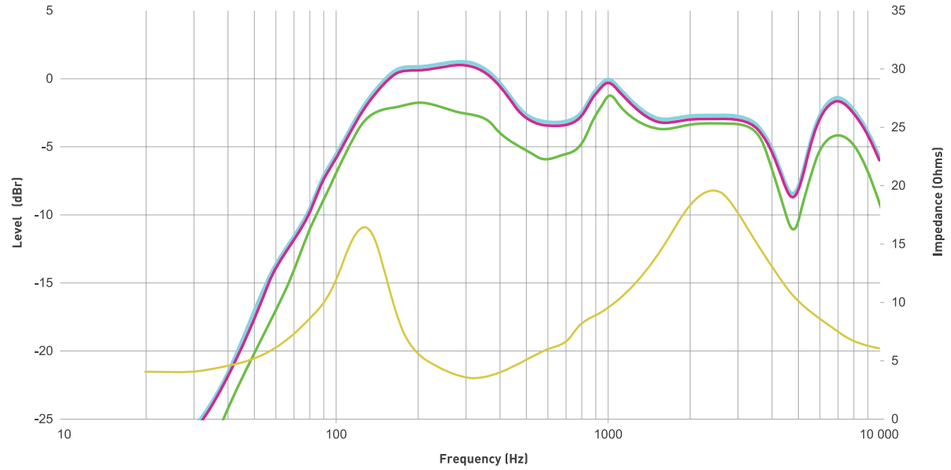


Figure 2. The effect of cable resistance on loudspeaker frequency response
original signal (—), QED Supremus Zr (—), high resistance cable (—), speaker impendance (—)

In figure 2, the impedance of a typical two-way loudspeaker system (yellow line) shows two pronounced peaks at 135 Hz and 2.5 kHz, corresponding to the resonant frequency of each driver. At resonance the loudspeaker demands the least current from the amplifier for a given power output and so only a relatively small voltage is dropped across the cable. Away from resonance, where the impedance is lowest, the speaker will demand much more current for the same power output and therefore a relatively higher voltage will be dropped across the cable. This non-linearity leads to a measurable difference in loudspeaker frequency response when comparing a high resistance speaker cable (green line) with very low resistance QED Supremus Zr (pink line). Figure 2 shows, the sound level using the high resistant speaker cable is altered markedly at some frequencies and hardly changes at others. Therefore, with the high resistance cable the fidelity of the system has been significantly changed whereas with QED Supremus Zr, fidelity to the original signal (blue line) has been maintained.

In order to achieve the extremely low resistance that we require, Supremus Zr needs a very large cross-sectional area, in fact it is the largest cable that QED have yet produced measuring in at 6.2 mm^2 (10 AWG). A further increase in conductivity is gained by having each individual core of the internal conductors plated with two microns of pure silver.

Aircore™ Technology

Electrically however, for large cross-section cables such as Supremus Zr, there can be a serious limiting factor on their fidelity. Due to a phenomenon known as the *skin effect*, high-pitched sounds are forced to travel towards the outside of the conductor and so are able to use less and less of the available cross-sectional area as the pitch increases. This unavoidable problem is a result of the self-inductance generated by all current carrying conductors. By carrying an alternating current, the cable creates a varying magnetic field around itself and these in turn generate *eddy currents* within the conductor (and any surrounding conductive material, more of which later) that oppose the very current which creates them. In this way the current is forced to move towards the periphery of the conductor as frequency rises.

The reason this is a problem for large speaker cables is that the readily calculable minimum skin depth for copper at 20 kHz insists that all conductors larger than 1 mm in diameter will be affected by the skin effect within the audio band and not, as some sceptics would have it, at radio frequencies only. The result is that for higher audio frequencies the resistance of the cable appears to be larger than it does for lower pitched sounds. This has a detrimental effect on the fidelity of the sound you hear.

QED Aircore technology drastically reduces this problem by creating a tubular conductor around a polythylene core, through which each frequency can pass with equal ease when compared to traditional solid or stranded conductors. The absence of conductive material at the centre of the conductor prevents the magnetic and electric fields interacting with the musical signal, causing self-inductance and its attendant eddy currents to be effectively reduced to under half that found in a normal cable.

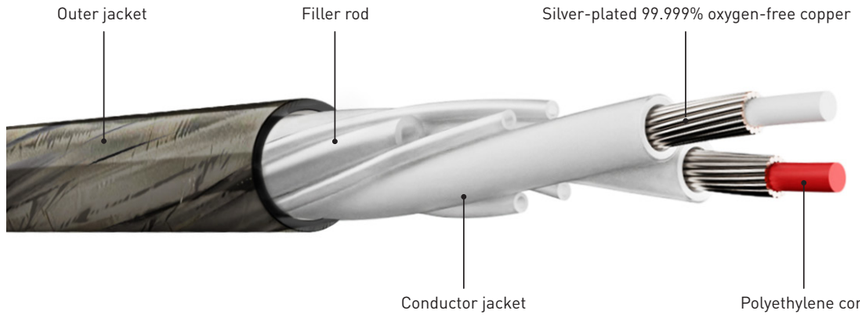


Figure 3. Supremus Aircore™ cordage

Aircore technology, which is unique to QED, also features a special polyester-insulated cable geometry designed to attenuate an equally damaging sonic problem which occurs in speaker cables, known as the *proximity effect*. Where two conductors are laid side by side and carry current in opposite directions (such as in a loudspeaker cable), the alternating magnetic fields built up around each conductor tend to reinforce current flow in the parts of the conductors which are nearest to each other and to cancel current carried in the sides of the conductors furthest away.

Therefore, in a normal "figure of eight" speaker cable - even one below the size where the skin effect becomes a problem - the proximity effect will cause the resistance to rise within the audio band; affecting linearity and therefore fidelity of the music being conveyed. QED Supremus Zr almost entirely avoids this problem by utilising Aircore technology. Each of the sixteen silver-plated 99.999% oxygen-free solid copper cores which comprise the conductors within QED Supremus Zr are individually insulated by a nearly invisible layer of polyester coating. This material was chosen because it has extremely good insulating properties for a given very thin layer and so can effectively separate each core within the conductor bundles while maximising the available cross-sectional area of conductive material. Because they are twisted around a hollow central polyethylene core, no single conductor remains at the outside or inside of the overall conductor along its entire length – thus evening out the current density and keeping the resistance uniform throughout the audio band.

How Aircore™ Measures?

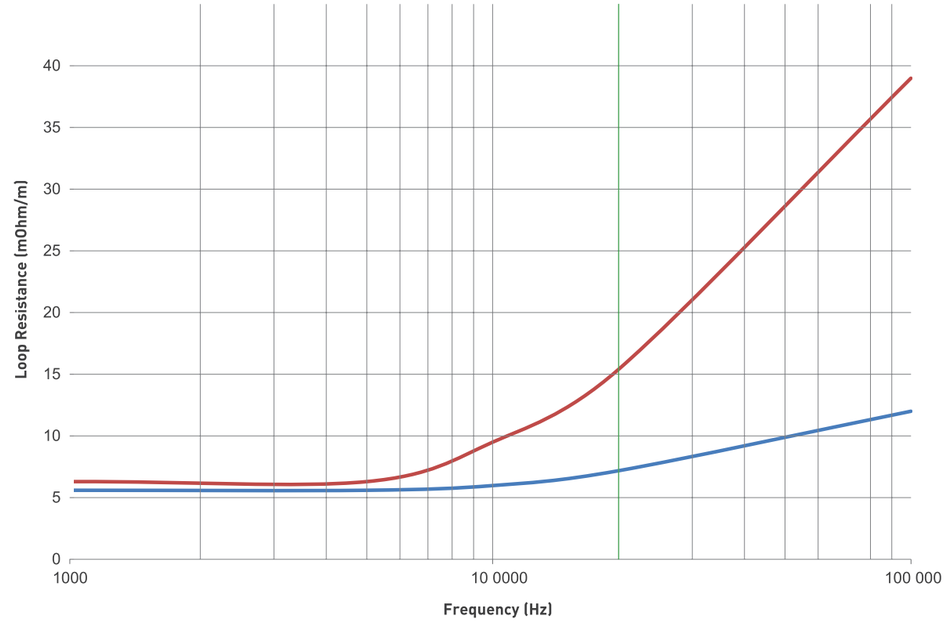


Figure 4. Graph of resistance against frequency of QED cables
QED Supremus Zr (—), cooker flex (—)

Figure 4 shows how QED Supremus Zr speaker cable (blue) compares with a cooker flex (red) of the same cross-sectional area when measurements are taken of the resistance (real part of the impedance) at different frequencies within the audio band and beyond. Cooker flex was chosen as it is made of similar size solid core copper strands as Supremus Zr and is often cited by sceptics as being no different in performance from so called audiophile cables. From about 5 kHz upwards the cooker flex starts to exhibit a rising resistance due to the combined skin and proximity effects, whereas the QED Supremus Zr cable does not exhibit any resistance increase until well beyond 10 kHz at which point the resistance of the cooker flex already exhibits a runaway impedance rise. At the limit of the audio band (green line) the less sophisticated cable has increased its impedance by 100% whereas the Supremus Zr cable is only 23% larger in that respect.

The table below shows the difference in electrical parameters between QED Supremus Zr cable and ordinary cooker flex of the same cross-sectional area.

Cable	CSA mm^2	Parallel Capacitance pF/m	Loop Inductance µH/m	Loop DC Resistance mΩ/m	Dissipation Factor @10 kHz
QED Supremus Zr	6.20	48	0.49	5.00	0.009
Cooker Flex	6.00	80	0.70	6.10	0.070

Table 1. Electrical parameters of QED Supremus Zr vs cooker flex

The use of high-quality dielectric materials and increased conductor spacing enables QED Supremus Zr to boast only 60% the capacitance of cooker flex. At the same time, through the use of Aircore technology, inductance of the cable has been reduced by 30%. Without Aircore technology these two parameters are inversely proportional (i.e. a fall in capacitance must always be accompanied by a corresponding rise in inductance) but QED alone are able to side-step this electrical law through the intelligent use of engineering research. In addition, due to the use of low permittivity dielectrics the dissipation factor has been reduced to 1/10th that of the PVC clad cable.

Deep Cryogenic Treatment

Figure 5. Cryogenic treatment

To further enhance the improvements brought about by the large cross-sectional area and uniform impedance of the Aircore geometry, QED Supremus Zr is also subjected to a cryogenic cooling process. It is thought that the improvement in physical properties of copper when cryogenically treated results from the elimination of dislocations in the crystal microstructure. Trumpets and other brass instruments have been found to produce a better tone after deep cryogenic treatment, and it is also used to enhance guitar and piano strings. Cryogenic treatment of welding electrodes, for example has been shown to improve their current carrying capability and extend their working life. Whether this can make the cable sound better is of course debatable, but our own subjective testing has shown that the cryogenically treated cable is preferred over the same cable without the treatment and therefore this bonus feature is provided as standard.

Zirconia Airloc™ Plug

Unlike our other hi-fi cables, QED Supremus Zr cables are not available loose on the reel for self-termination. They can only be obtained from dealers as a finished cable set which has been factory terminated in a choice of standard or custom lengths with Zirconia Airloc speaker plugs or spades.

The enamelled conductors require a special chemical process to ready them for termination and both the plugs and the spades are attached using our exclusive **Airloc™** cold welding system which requires a specialist cold welding tool. This process completely eliminates air from the cable/plug interface, preventing oxidisation of the silver conductor surface, ensuring the connection remains low resistance for life.

Cold Welding System

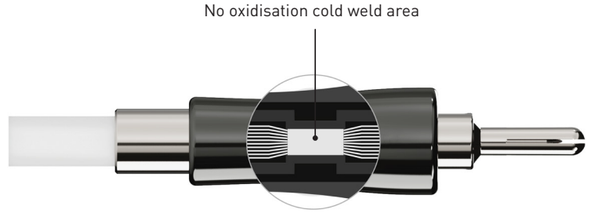


Figure 6. Airloc™ cold welding system

Airloc is a form of cold weld system used to permanently attach QED plugs and spades to our entire range of speaker cables. The superior DC resistance characteristics offered by our exclusive use of 99.999% oxygen-free silver-plated copper conductors can only be guaranteed through the correct use of our Zirconia Airloc plugs. Seen under a microscope the surface of a typical copper strand is very rough and so electrical contact is only made in a relatively small number of places using normal screw type terminals. In addition, the oxidation of exposed conductors will further increase the resistance of the cable-to-terminal interface. By using a high-pressure termination tool, the Airloc process compresses the conductors and plug together so hard it creates a chemical cold welded area where the conductors and plug effectively become one. By the time the full pressure has been applied, the resistance of the joint has reached its minimum value. Now, because all the air has been removed from the joint there will be no oxidisation of the contact surfaces so the low resistance will remain for the lifetime of the cable.

Rhodium-plated Locking Design

QED Zirconia Airloc plugs also feature a new zero-insertion-force banana plug, designed specifically for QED Supremus Zr cable. We developed a unique contact expansion system which securely clamps the rhodium-plated beryllium copper pins into the speaker binding posts, while at the same time increasing the contact area of the plugs, simply by twisting the plug barrel until it is tight.

Rhodium (Rh) is a naturally occurring and very rare silvery white transition metal which is extremely hard and corrosion resistant. Its rarity and aesthetic qualities make it one of the most valuable precious metals on earth. It was only during the late 1970's, due to its use in three-way catalytic converters, that rhodium became more readily available. It undoubtedly has a use as a purely decorative material - for plating white gold jewellery and silver to provide them with a tarnish free coating - but it is also prized for its use in electrical contacts because it is so hard-wearing and resistant to oxidisation. An electrical contact coated with rhodium will have a very high conductivity not only because it is a reasonably good conductor but also because the plating process renders a previously coarse surface such as that of copper or brass as smooth as glass, thus increasing the contact area and reducing resistance at the contact point. It is very important in speaker cable terminations that the contacts do not tarnish and degrade over time and rhodium is perfect for this as being part of the platinum group of metals it is even less reactive than gold. For correct functionality of Zirconia Airloc plugs its use is essential, as the locking feature means that the use of a less hard wearing and softer plating material, such as gold or nickel, would render the contact area vulnerable to abrasive removal of the plating. This defect is simply not possible with rhodium.

Figure 7. Exploded plug and barrel view

Zirconia Barrels and Boots

The plugs have also been specially designed to bring the low eddy current nature of the cordage afforded by Aircore technology right the way through to the speaker terminals. This is achieved by keeping the metal content of the plug to an absolute minimum and therefore the plug and the cable boot have instead been crafted from a high-quality ceramic material called zirconia. This extremely hard and electrically inert material not only rids the cable/speaker interface of the effects of eddy currents but is also aesthetically pleasing with a lustrous surface finish which complements the rest of the cable perfectly.

Black zirconia (Zr) is a modern technical ceramic made from Y_2O_3 doped zirconia dioxide sand and is used for the manufacturing of decorative advanced ceramics, combining outstanding colour and gloss, high mechanical strength, superior scratch resistance as well as great durability. Dubbed "ceramic steel", it is the perfect replacement for anodised aluminium or brass speaker plug barrels because it is electrically inert and therefore resistant to the establishment of eddy currents and yet has the beautiful finish and tactile quality which has made it attractive to makers of watches and luxury fountain pens. Zirconia also has many uses in specialised industrial applications where it is prized for its high temperature and wear resistance in sectors such as high-pressure seals and bearings, automotive brake materials and aerospace coatings.

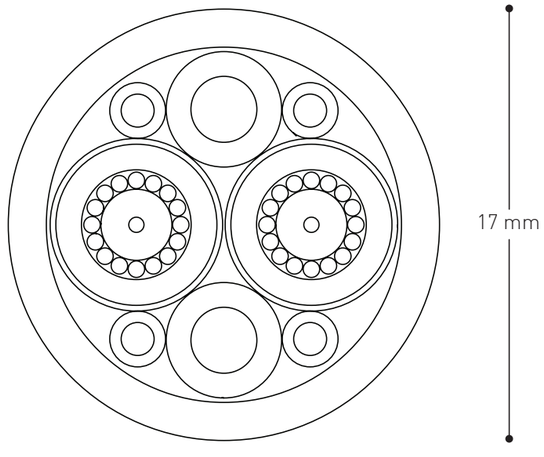
Selecting zirconia for plug barrels and boots ensures that Supremus Zr loudspeaker cables not only look beautiful, but are durable and have very low distortion.

Figure 8. Zirconia boot

Conclusion

Owners of high-end hi-fi systems know that each small sonic upgrade requires a greater and greater investment in audio hardware. It is imperative that these hard-won incremental improvements are not swamped by inadequacies in the link between amplifier and speakers. By utilising our largest ever cross-sectional area alongside an Aircore geometry, Supremus Zr cables make sure that the fidelity of the signal chain is maintained from beginning to end by making the whole of the conductor available at all audio frequencies. A faultless experience is further guaranteed by the reliable and steadfast connectivity provided by low distortion Zirconia Airloc plugs and spades, so that the speaker cable is effectively removed from the sonic equation and the music can simply pour out of the speakers instead.

Specification



Cross-sectional area	6.20 mm^2
Wire gauge	10 AWG
Outside diameter	17 mm
Loop resistance	0.005 Ω/m
Parallel capacitance	48 pF/m
Loop inductance	0.49 uH/m
Dissipation factor	0.009
Technology	QED Aircore™; cryogenically treated; QED Airloc™
Conductors	32 solid core, silver-plated 99.999% oxygen-free polyester coated copper
Dielectric	Foamed polyethylene, LDPE, and air
Plugs	Zirconia Airloc: Rhodium-plated, locking Airloc plugs with zirconia barrels

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