PM-2 AUDIO CABLES

PAUL MESSENGER JULY 99

Twenty years ago, the very idea that connecting cables could influence the sound of a hi-fi system was right at the edge of the lunatic fringe. Today it's an accepted fact that the cables play a significant role in even a modest system. However, many of the mechanisms involved remain poorly understood, so the empirical 'suck-it-and-see' approach remains at the core of most selection processes.

Nevertheless it's possible to identify a number of different factors and properties, any or all of which can influence the net sonic effect of introducing a specific cable into a specific system. For the sake of simple explanation, these are listed separately (see BOXOUT), though in practice there is considerable overlap and mutual dependency between these various elements.

There are three basic kinds of audio cable: analogue interconnects; digital interconnects; and speaker cable. (Not strictly audio cables, mains cables can also affect sound quality.) Although each has subtly different requirements - a digital interconnect benefits from a 100MHz bandwidth, while speaker cable must have serious current carrying capacity - many of the requirements for good sound in any context are broadly consonant with good engineering practice.

Unfortunately, what has undoubtedly proved itself to be good practice in cable construction, is often not applied in the construction of the actual hi-fi components themselves. A problem with the most exotic cables available is that their potential performance is quite likely to be limited by rather less painstaking engineering standards applied inside the hi-fi components which they connect together.

Indeed, the performance of the plugs and sockets which terminate both the cables and the hi-fi components are quite likely to compromise a system's performance more than the quality of the conductors and insulators in the cables themselves.

METALLURGY ETC

High purity in the (primarily) metals used for conductors is undoubtedly worthwhile. Impurities in the conductor's crystal lattice certainly have the capability to disturb something as complex as an analogue musical waveform. Copper is particularly susceptible to oxidation within its crystal structure, so audio cables usually specify 'oxygen free' grades, known as OFC. The actual purity is sometimes expressed in 'Nines', ie '5 Nines' (or 5N) purity is 99.9999% pure.

However, purity is by no means the only issue. High consistency in the cross-sectional thickness and packing of a conductor and its insulator is equally important. Cables also have a 'directional' character, sounding better one way round than reversed, which is believed to originate from the actual wire-drawing manufacturing process, and the melt-zone properties of the insulation material.

Different conductor materials impose their own specific 'character' on system or component sound, a phenomenon which might be due to sub-atomic structural differences. However, copper is overwhelmingly the most popular core material for cable conductors (albeit frequently silver-plated, in part to inhibit corrosion), because of its low cost, good conductivity and high malleability/ductility. Furthermore, copper's suitability to electroplating makes it the material of choice for the printed circuit boards inside the hi-fi components themselves.

Despite its high cost, pure silver is strongly favoured by some audiophiles. But it's very difficult to put together a complete system, end to end, using silver wiring throughout, and a part-silver system cannot avoid some 'copper character' being part of the mix. Aluminium is another metallic option, favoured for speaker voice coils because of its low mass, and possessing a crystal structure that's quite resistant to impurities, but not as easily worked as copper. Non-metallic carbon-based cables also exist, and have again achieved a constituency of support amongst audiophiles.

While impurities within a conductor will adversely affect sound quality, the effect is often rather less than the 'impurities' which are introduced at the terminations, both of the cables and the equipment being connected. Changing from one metal to another can create 'diode, 'semi-conductor' and 'battery' effects at the boundary (albeit on a microscopic scale), and the termination of a connecting cable can involve several metal-to-metal transitions. The tin/lead alloys and flux used in regular solder can be particularly pernicious, which has led to an alternative practice of 'cold-welding' wires and plugs together simply by applying high pressure to the join, eliminating the need for solder entirely.

INSULATION

We tend to think of electrical signals travelling along and within a conductor, a simplistic model that only applies to low frequency signals. At higher frequencies the signals actually travel along the skin of and outside the conductor, so that the material used to insulate one conductor from another can easily play a part.

Its influence will depend on its dielectric loss factor. PVC (polyvinyl chloride) is the cheap, flexible and very effective insulating material which is ubiquitous in domestic electrical installations and appliances, but it's far from ideal for hi-fi sound transmission, as the dielectric losses start to increase above 500Hz, creating a subtle characteristic coloration.

Polypropylene has a more stable molecule which is less inclined to absorb electromagnetic energy, and therefore defers the dielectric absorption to higher frequencies, introducing less much coloration. Teflon is even more stable, and therefore offers still further improvements at higher frequencies.

Long lengths of high current capacity speaker cable can be difficult to accommodate domestically, so some brands have developed wide-but-flat cables convenient to lay under carpets. The disadvantage is that the ratio of insulating dielectric to conductor is higher than with conventional bunched strands, so the dielectric effect is increased.

Some wonderfully exotic cable confections have been tried, in terms of materials and construction, using individually insulated strands of Litz wire, silk thread for insulation, and even proposing the use of bare conductors suspended on a pylon arrangement (so that the air forms the dielectric.

GEOMETRY

One of the main variations found in different brands of interconnect or speaker cable lies in the geometric relationship of their conductors.

This has immediate consequences for the 'bulk parameters' which are particularly relevant to speaker cables (see later). Specifically, the spacing of the + and - strands determines the compromise between inductance and capacitance. Close together, the cable will favour capacitance at the expense of inductance, and vice versa if the conductors are well separated. Some speaker cables leave the + and - stands essentially separate, which leaves the L (inductance) and C (capacitance) components undefined, as well as permitting mutual electromechanical interaction.

Geometry plays a role in interconnects too, partly as a result of the construction methods used to minimise susceptibility to mechanical vibration effects, and partly in order to avoid picking up RF interference.

A one metre length of connecting cable might be a useful device for wiring up a hi-fi system, but it also potentially represents a reasonably efficient radio aerial. Rectified by an unfortunate termination at one or other end, the unwanted radio signal can then 'dirty up' the wanted signals with a particularly insidious, if subtle form of distortion.

The classic technique adopted for RF shielding is to use co-axial cables with the outside braid connected to earth. Though effective for shielding, co-ax construction sacrifices the symmetry of both the conductors and the dielectric environment. Twisted pair construction techniques also offer some RF immunity, by cancelling mutual inductance, and form the basis for many exotic geometric layouts. At the high end of the cable sector, some brands incorporate special networks into cables to act as 'RF sinks', and these can be very effective at avoiding RF degradation.

BULK PARAMETERS

Much of electronic engineering is concerned with manipulating the relationships of resistors, capacitors and inductors. Cables too possess resistance, capacitance and inductance, in proportion to their length.

Apart from some extreme instances with valve equipment, these properties are largely irrelevant to interconnects operating at relatively high impedances, but low resistance is important for speaker cables, especially over long runs, to avoid modifying the balance of the system and reducing the damping factor which the amplifier output stage exerts over the loudspeaker. High capacitance/low inductance speaker cables can also be incompatible with some wide-bandwidth and deliberately uncompensated transistor amplifiers.

MECHANICAL

Plastics might not always be the ideal insulation material from a dielectric perspective, but they do have very useful properties which aid the manufacture of mechanically inert and vibration resistant cables.

Vibrate a piece of wire within a magnetic or electrostatic field and you generate current in the wire - it's the basic principle of dynamos and electric motors (and the reason loudspeakers work). And around the back of a hi-fi system, there are always going to be plenty of magnetic fields just hanging around. And since the whole area is likely to be bathed in the vibrations of a musical sound field, there's plenty of opportunity for the cables to vibrate and generate low level distortion.

Mechanical integrity and good vibration immunity in both cables and connectors (plugs and sockets) is therefore of major - some would say paramount - importance in maximising cable performance.

EARTHING

Strictly speaking earthing and grounding provision is a 'whole system' issue, not one specific to cables. Indeed, one of the reasons for the success of the 'one make' system route in recent years is undoubtedly that it deftly avoids the grounding unpredictabilities inherent in mixing and matching components from different sources.

Said unpredictabilities make it difficult to give useful general advice, over and beyond pointing out that the integrity of grounding throughout a system is a vital ingredient in keeping the noise floor low. Grounding should always follow a linear path from the various components to (usually) the amplifier earth, as any loops will create current circulation and introduce hum and noise.

One possible way of avoiding earthing problems is to use 'balanced mode' connections between the system components, a technique which 'floats' the signal earth quite separately from the chassis earthing of the components. Balanced operation was originally developed by broadcasters to avoid hum pickup in long runs of microphone cable. While it might have some potential domestic hi-fi applications where long cable runs are used, in practice the extra complexity needed to implement the isolation and cable-driving electronics can be a limiting factor.

CABLE FACTORS

Metallurgy - composition and purity of conductors

Insulators - dielectric coloration effects

Geometry - proximity and interaction of conductors; RF resistance/immunity

Bulk parameters - resistance, inductance and capacitance; mainly relevant to speaker cables

Mechanical - immunity from soundfield and other vibration effects

Earthing - tends to be system rather than component or cable specific; also relevant to balanced operation.