The Speaker Cable Snake

Loudspeaker cables seem to have become the subject of an ongoing controversy. JOHN WATKINSON sharpens his sword as he is not impressed by the standard of the debate.

LOUDSPEAKER CABLES HAVE a pretty simple job to do, so it is somewhat surprising that the job can't be done properly more often than not. This makes me suspect that the job is being done properly but that the user has been convinced that it isn't by some form of superstition.

This column is not about moaning and taking cheap shots; it's about doing things properly. It would be worthwhile to start by considering what goes on between an amplifier and a loudspeaker and then to decide what to do to get the best results.

The conventional power amplifier generally has a lot of negative feedback to make it linear. The voltage on the output terminal is divided down and compared with the input and if there is any difference, the voltage is changed to eliminate the difference. The result of negative feedback is that the output impedance of power amplifiers is very low, typically a small fraction of an ohm. Essentially the amplifier is a voltage source, and will try to maintain the output voltage proportional to the input voltage irrespective of how much current is drawn from the output. Naturally there are practical limits, and a real amplifier would have to limit the current to some safe maximum value to avoid blowing itself up if an absurd amount of current was drawn. Operating an amplifier under these conditions is not going to produce good sound. An amplifier that is too small for the speakers is going to be disappointing as it may current limit during actual use. However, don't over react and buy an amplifier that has to be delivered on a fork-lift.

The conventional loudspeaker has typically two drive units and a crossover network to feed the appropriate frequency range to the driver best able to handle it. Although loudspeakers are always specified by nominal impedance, typically 8 Ohms, it is important to understand that the word 'nominal' is a euphemism. What nominal actually means in this case is something like: 'the following number is approximately the impedance of this speaker at a couple of spot frequencies whereas at other frequencies the impedance could be something else altogether and might differ by a large factor'. The only way of assessing the load presented by a speaker is to look at its impedance versus frequency curve. Expressing the impedance curve by a single number is a bit like trying to give an idea of Beethoven's Pastoral Symphony by sending a single sample. The difference between resistance and impedance is that an impedance may allow the current to flow with a different phase to the voltage waveform. Consequently the phase behaviour of a reactive load is very important to the amplifier designer.

The unfortunate speaker cable finds itself stuck between the amplifier, which is a low-output-impedance voltage source, and the loudspeaker, whose impedance and phase is all over the place. Given that the average speaker leads are only a few metres long, the speed of electricity is so high that for all practical audio frequencies the propagation delay through the cable presents a negligibly small phase shift. Thus the actual impedance with which the speaker cable works is substantially zero, because it is electrically short and connected across an amplifier having negligible output impedance. As a result, a loudspeaker cable is categorically not a transmission line.

This physical fact does not in any way prevent loudspeaker cables from being sold on the basis that their impedance matching or transmission line characteristics are somehow better than those of 'ordinary' cables. Such claims are utterly false and anyone making such claims is either ill educated or after your money. The only viable reaction to such claims is outright derision.

Another feature of exotic cables that amuses me is the use of thousands of fine strands of wire that, we are told, maximise the surface area of the conductor to take full advantage of skin effect. Skin effect is the tendency of high frequency electricity to mutually repel so that the current flows on the surface of a conductor rather than in the centre. You will notice that the waveguides used in microwaves are hollow because making them solid wouldn't offer any improvement. However, the frequencies at which skin effect becomes important are so far above the audio band that not even dogs belonging to hifi journalists can hear them.

In order to understand what characteristics a speaker cable should have, it is necessary to consider what goes on in a woofer. The speaker coil moves within the magnet assembly, and this creates a back EMF proportional to the velocity. The amplifier produces another voltage, namely a larger version of the input. The vector sum of the two, divided by the loop resistance determines the current in the coil. The reason we need the vector sum is that the two voltages are not in phase. Ideally we would like a super-conducting voice coil so that the back EMF would always be equal and opposite to the amplifier voltage. This would allow the cone to follow the amplifier waveform, which is a decided rarity in loudspeakers. Unfortunately, whenever the back EMF (the actual cone velocity) differs from the amplifier voltage (the desired cone velocity), the current that can flow to put matters right is limited by the loop resistance.

So what is loop resistance? This is really simple. It's the sum of the output impedance of the amplifier, the resistance of the speaker leads and the resistance of the voice coil. The higher the loop resistance, the less accurately the cone velocity follows the amplifier waveform. Consequently the only sonic attribute a speaker cable needs is that its resistance should be negligible compared to the coil resistance of the speaker. Clearly there is no point in using audiophile welding cable with zero resistance, as zero resistance cables cannot reduce the loop resistance below the coil resistance.

Now the best way I can think of to reduce the resistance of a speaker cable is to make it as short as possible. This is one of the tenets of power delivery. When a light aircraft is being designed, they don't put the engine in the back with a long shaft to the propellor, and there aren't any aerophiles advocating oxygen free propellor shafts. Instead the power plant is put where the power is needed and the debate disappears. Thus the obvious location for an audio amplifier is as close as possible to the speaker.

The conventional woofer is not a particularly linear device, and so the back EMF waveform will contain harmonics of the LF waveform. Hopefully the amplifier's low output impedance will stop these from changing the amplifier waveform, but the amplifier can't control the difference voltage. Thus if the resistance of the speaker cable is too high, the harmonic currents from the woofer can cause voltage drops effectively in series with the tweeter and the result is intermodulation. This can effectively be reduced by using bi-wiring. With a suitable loudspeaker having a crossover with one set of terminals for each drive unit, separate cables can be fed from the amplifier to each drive unit. Bi-wiring with lawn-mower cable from the electrical shop will always out-perform single wiring with audiophile cable and at lower cost. I have been recommending lawn mower cable for a long time and am often asked what mysterious properties it has which ordinary cables lack. Finally, I am prepared to divulge this closely guarded secret: lawn mower cable has two cores whereas ordinary mains cable has three.

Bi-wiring can improve quality, but only if the speaker is designed for it. Bi-amping is the next step up the scale. Here, a loudspeaker designed for bi-wiring is driven by two amplifiers each having the same gain and input signal. In this case there can be no intermodulation between the drive units whatsoever. Bi-amping works best with cheap amplifiers, which is just as well as you will need more of them. With a properly engineered amplifier, the output voltage would be so closely controlled that it wouldn't make any difference whether the speaker was bi-wired or bi-amped. This might make a good test for amplifiers.

The best results are obtained with an active crossover driving one amplifier per drive unit. As the crossover has to be designed to match the drive units, an holistic design approach is needed. It is then easier to put the whole electronic package in the speaker. Once this is done, it is also easy to use a negative output impedance power amp for the woofer or some form of phase correction so that the cone velocity has something to do with the input waveform. Interestingly, once this is done, the loudspeaker cable disappears, along with all of the nonsensical debate. Not before time. ■

DON'T	**Accept that speaker cables are transmission lines**
	Use excessively long or thin speaker cables
	Use amplifiers that don't have enough power for the speakers
DO	**Put amps and speakers as close together as possible**
	Use adequate wire gauge for the purpose
	Bi- or tri-wire when possible
	Use one amplifier per drive unit
	Use active speakers