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LOUDSPEAKER CABLES FOR HIGH FREQUENCY TRANSDUCERS – A FURTHER ASSESSMENT

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1. BACKGROUND

At the Reproduced Sound 18 conference, in 2002, a paper was presented (by the same authors)[1] on the subject of how loudspeaker cables of different construction may affect, in different ways, the electrical signals which they are passing. The aim was to try to find justification for the widespread view that the sound character of loudspeaker / amplifier combinations can be influenced by the cables which interconnect them. As a result of the above presentation, several suggestions were made relating to how the measurement techniques could be refined, or made to be more revealing. The first part of this paper is therefore, in effect, a report on the continuation of the work which led to the 2002 paper. The second part of the paper re-visits some unpublished work which had previously only been presented as a conference workshop.

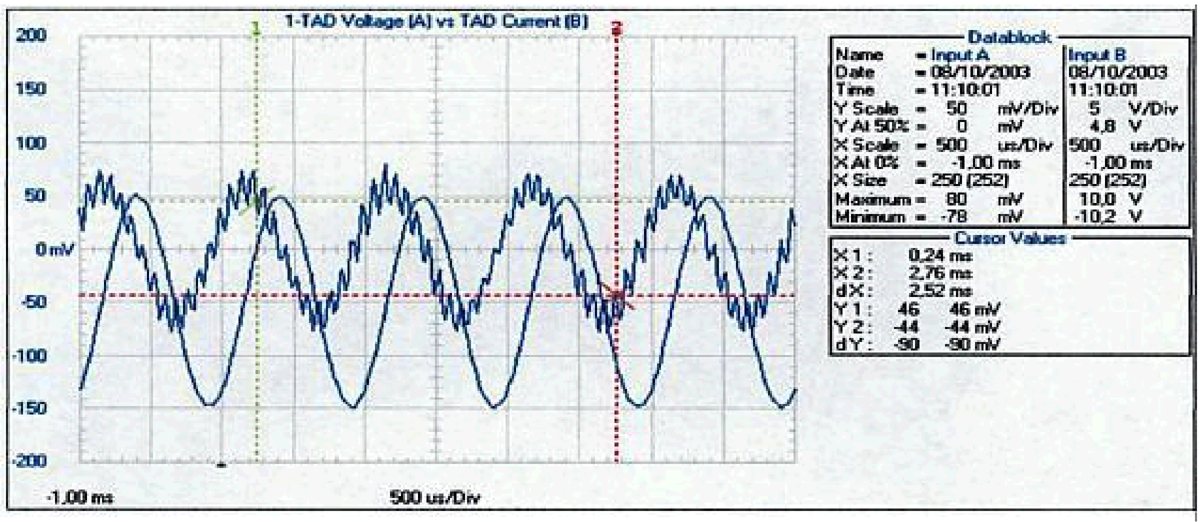
2. THE SEARCH FOR A CURRENT FLOW

In the paper presentation in 2002, it was shown how different cable constructions could give rise to different interference signals at the terminals of both the amplifiers and the loudspeakers when operating in an environment of moderate electromagnetic radiation; typical of what would be encountered in many recording studios using modern digital signal processors and computers. It was suggested by Bob Walker, from the BBC, that further investigation should be made in order to try to confirm the presence of the interference in the current flowing through the loudspeaker voice coil.

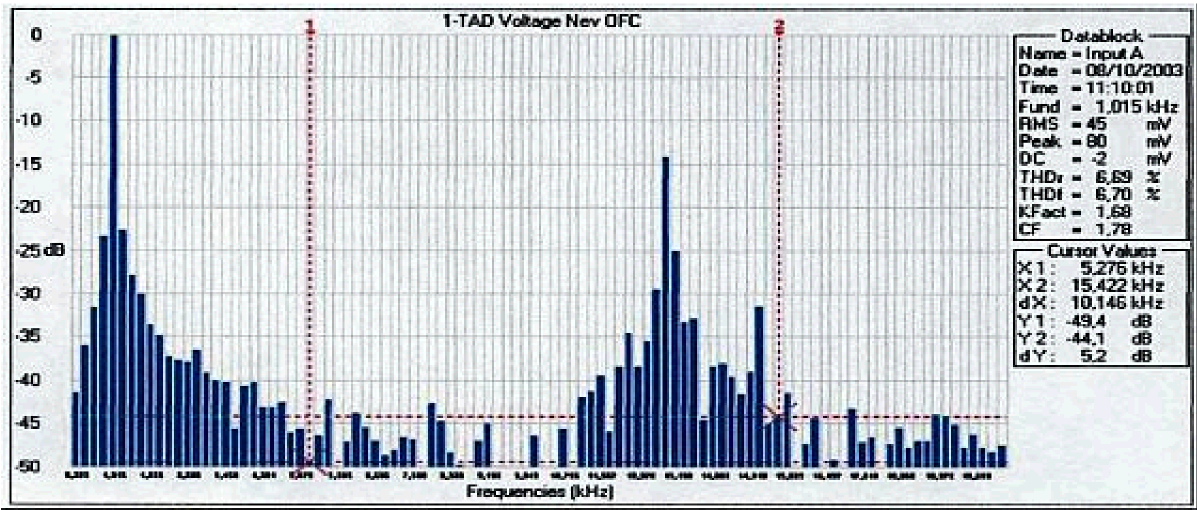
One year after the previous measurements were made, the tests were repeated. Once again, a Fluke measuring system was used, but this time it was a model with transformers and optically isolated inputs, to try to ensure that the measuring devices were having only a minimal effect on the circuit under test. Despite the intervening year, virtually the same interference fields were present in the workshop were the tests were carried out. All the tests from 2002 could be performed with excellent repeatability. This was good news from the point of view of the confirmation of the findings of the previous year, and also because it provided good conditions in which to search for interference in the signal current.

A 230V/6V mains transformer, of toroidal construction, was connected with the secondary (6 volt) winding in series with the red terminal of the TAD 2001 compression driver used in the test. The primary (230V) winding of the transformer was connected to one input of the Fluke analyser (Type 123 industrial scopemeter) to monitor the current though the voice coil. A second transformer was connected with the primary (230V) winding across the voice coil and the secondary (6V) winding to the other input of the analyser to monitor the voltage across the voice coil. The transformers had previously been tested with pink noise, and, as had been predicted from some earlier tests carried out by the BBC, the frequency response was found to be respectably flat from 40Hz to over 6 kHz, with only a gentle high frequency roll-off being exhibited up to the limits of the audio frequency range. It was found early on that the interference noise reported in reference #1 was still present on the voltage signal, but it was absent from the current signal. Furthermore, these findings were repeatable using a number of different analysers, either with or without isolation transformers. The results are shown in Figure 1. The spectrum analysis of the signals shows that they had little in common, suggesting that the interference was "riding on" the circuit components, rather than passing through them. If, in fact, these interference signals can influence the sound quality of music, the implication here is that the effect would be of a secondary nature, exacerbating the effects of intermodulation distortion, for example, rather then by the primary effect of direct superimposition of the interference signals on the loudspeaker drive current. It is worth noting that the 13kHz component of the interference was from an unknown source, but it served as a useful marker. It tended to disappear after about 9pm, everyday, despite nothing being turned on or off in the premises where the measurements were carried out.

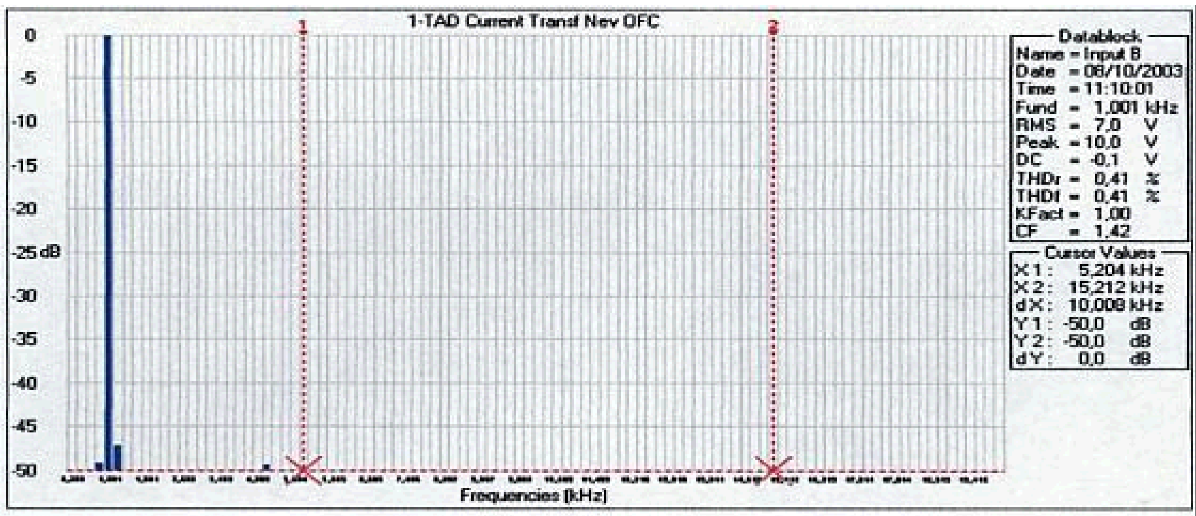
Figure 1 Current and voltage comparisons – Neva / OFC / TAD



a) input A – voltage across driver: input B – via current-sensing transformer



b) Spectrum of input A



c) Spectrum of input B

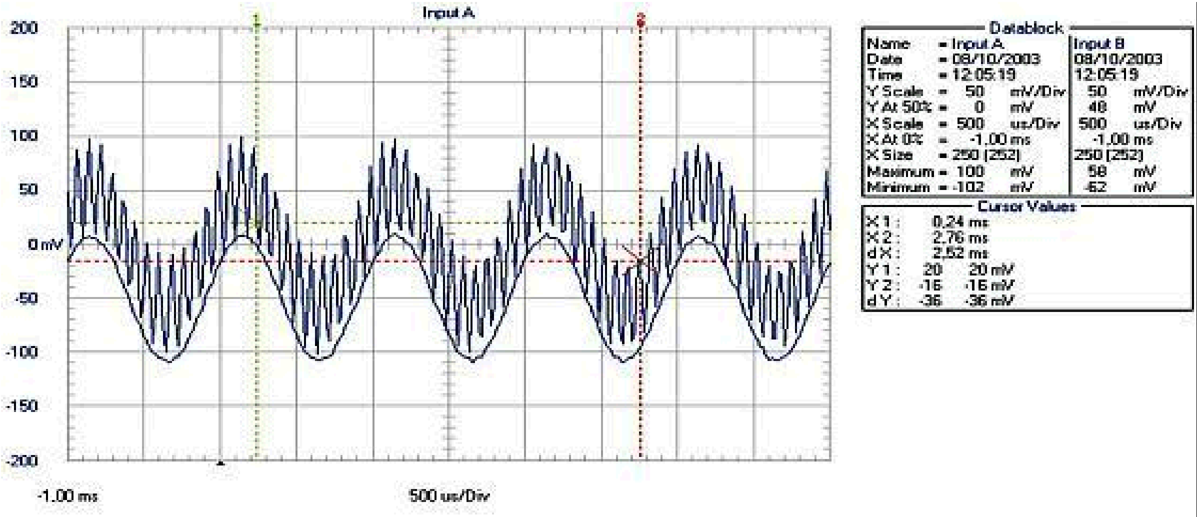
3. INTERDEPENDENCE OF SYSTEM COMPONENTS

A series of five measurements was next undertaken in which the basic circuit consisted of a power amplifier, a high-frequency loudspeaker, and 28 metres of interconnecting cable. First, a high sensitivity TAD 2001 compression driver was used as a load. Its sensitivity was around 110db/1W @ 1 metre. This was connected to a class A, 50W, Neva Audio amplifier, via a 4mm^2, parallel conductor, OFC loudspeaker cable.

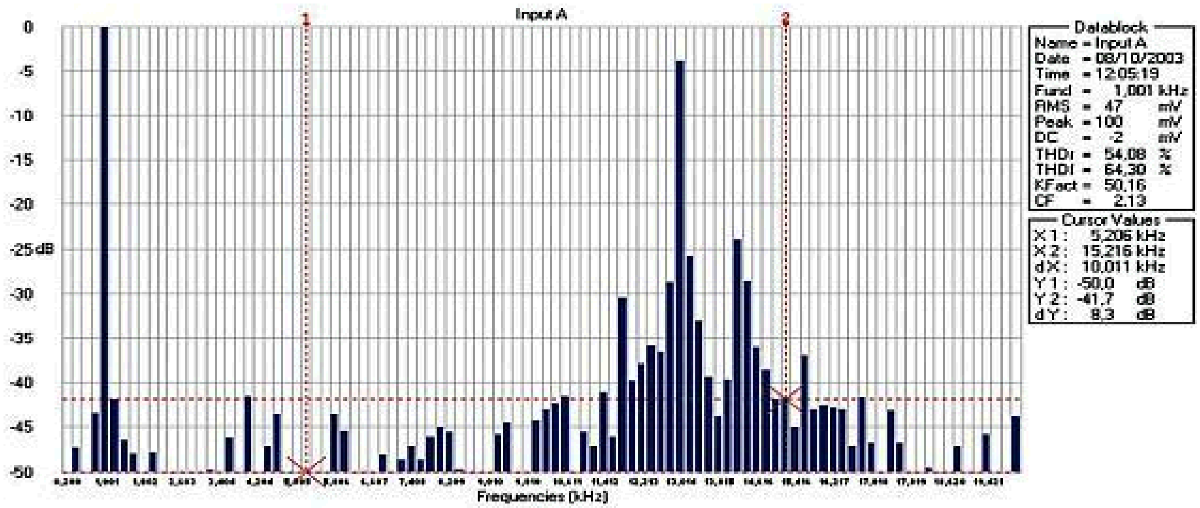
The compression driver’s electrical drive signal was measured whilst the system was producing a sine wave output of 80dB at 1 metre. The interference levels on the amplifier and loudspeaker terminals can be seen in Figure 2. After the substitution of a much lower sensitivity dome tweeter (about 90dB/1W @1m) for the compression driver, the amplifier gain control was increased in order to again produce 80dB at 1 metre. Figure 3 shows the electrical drive voltage across the tweeter. It can be seen from comparison with Figure 2 that the lower sensitivity of the dome tweeter needs a considerably higher drive voltage than the compression driver for the same given output. The higher drive effectively swamps the interference on the signal. The implication of this is that lower sensitivity loudspeakers could be less sensitive to any changes of loudspeaker cable if those changes only had a bearing on the susceptibility of the system towards the pick-up of interference.

In the third test of the series, the standard, 4mm^2, OFC loudspeaker cable was replaced by a cable with 2.5mm^2 coaxial conductors,. This test was again performed with the compression driver as the load. It can be seen from Figure 4 that with the amplifier and loudspeaker in the same places as during the first measurements, and with the analyser connected in exactly the same manner, the coaxial loudspeaker cable gives rise to much lower levels of interference than had been evident with the standard OFC cable, as shown in Figure 2.

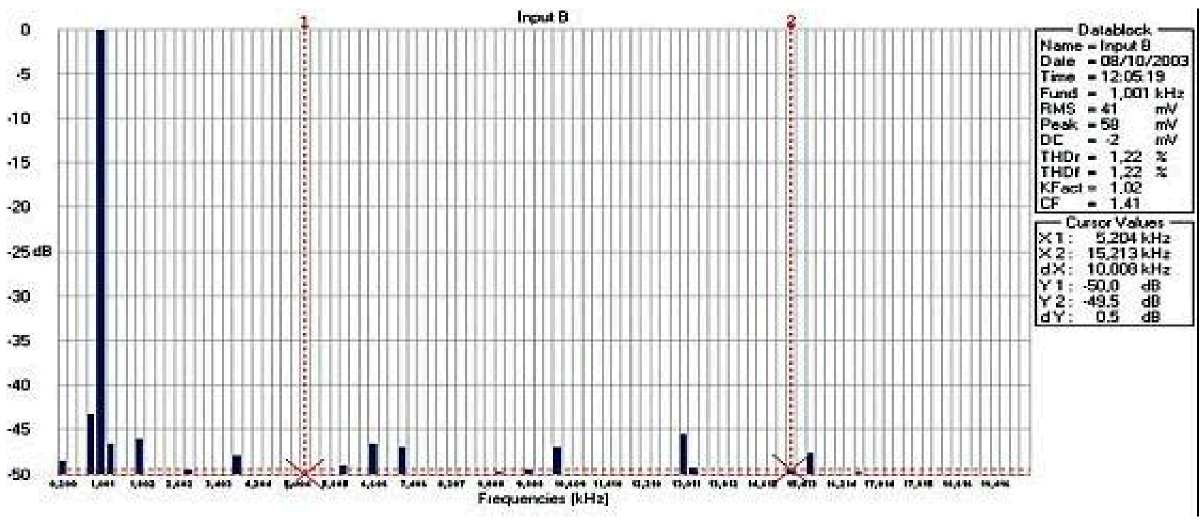
Figure 2 Neva amplifier / standard OFC cable / TAD 2001



a) input A – voltage at the loudspeaker: input B – voltage at the amplifier

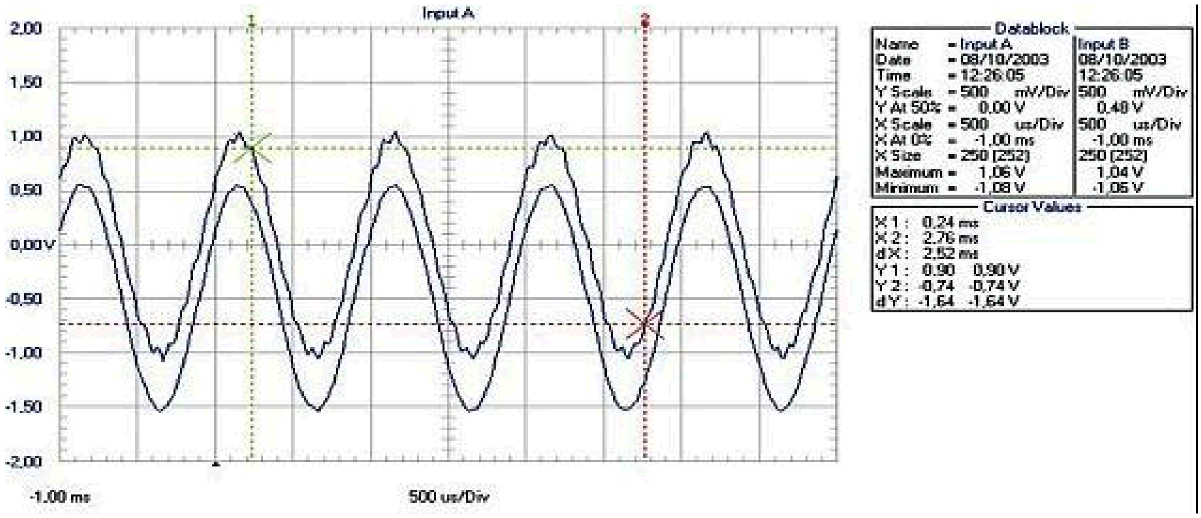


b) Noise spectrum at the loudspeaker terminals

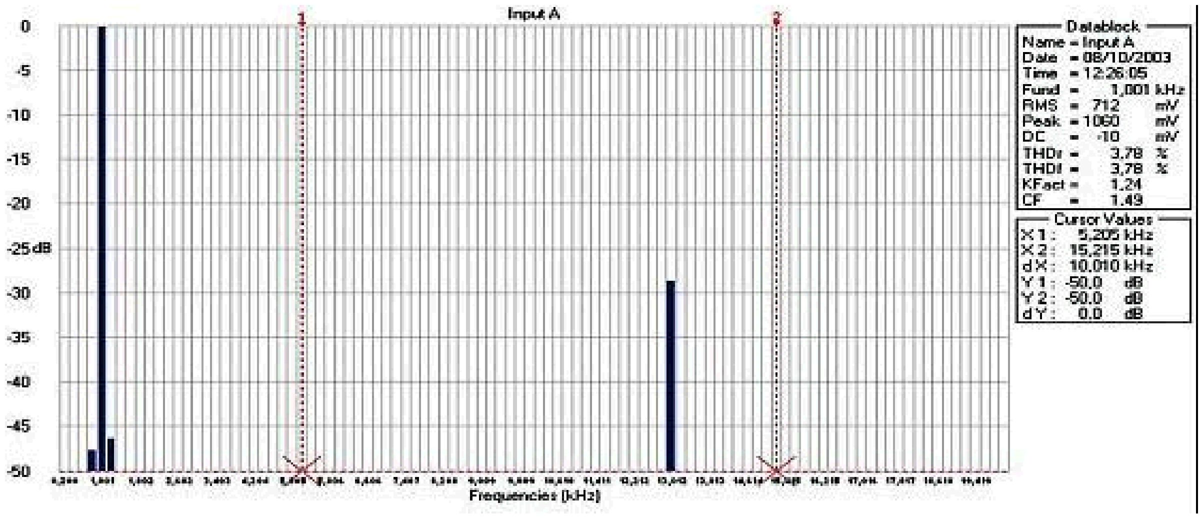


c) Noise spectrum at the amplifier output terminals

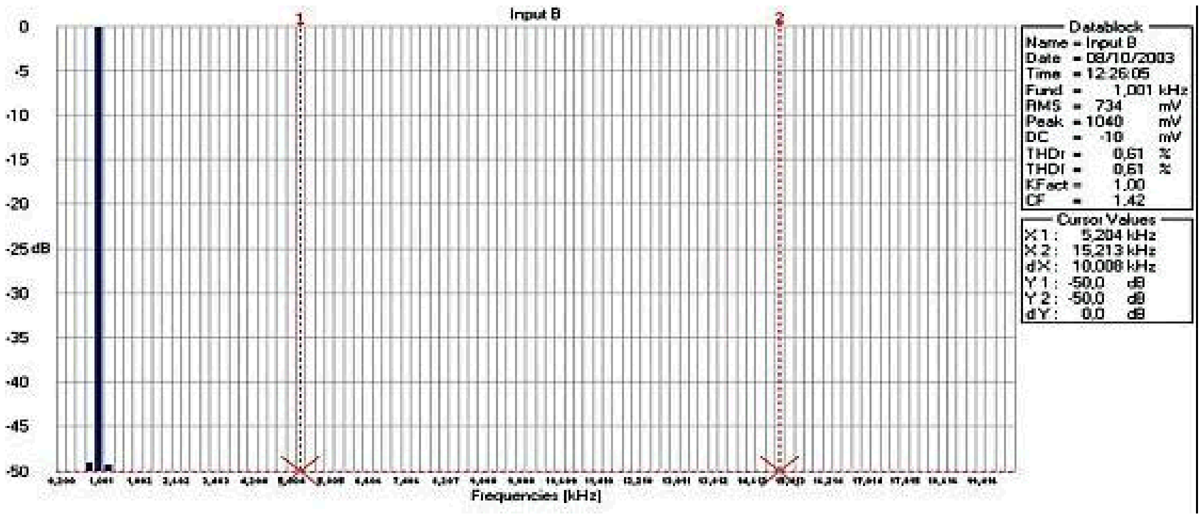
Figure 3 Neva amplifier / standard OFC cable / Morel dome tweeter



a) Input A – voltage at the loudspeaker: Input B – voltage at the amplifier

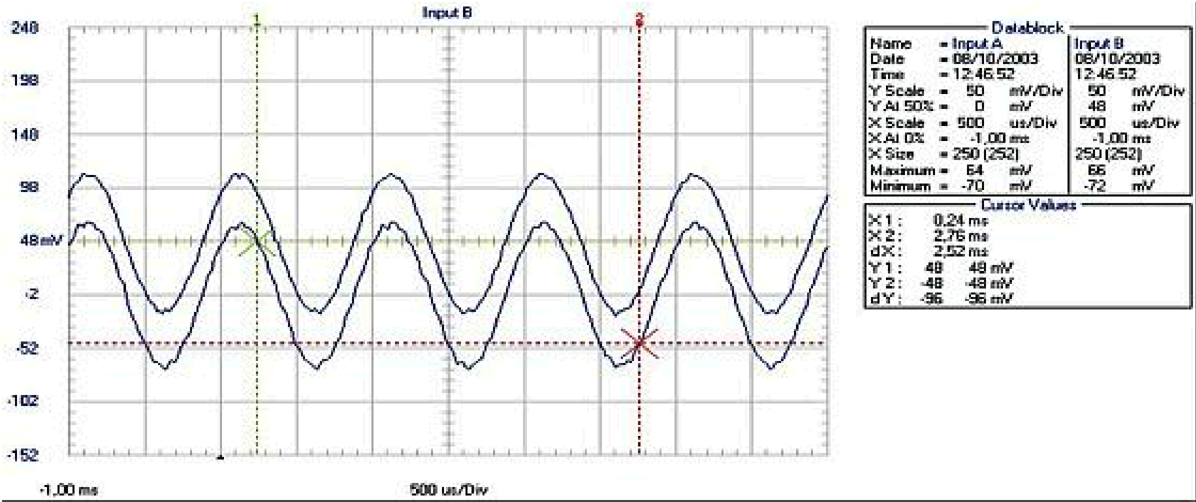


b) Noise spectrum at the loudspeaker terminals

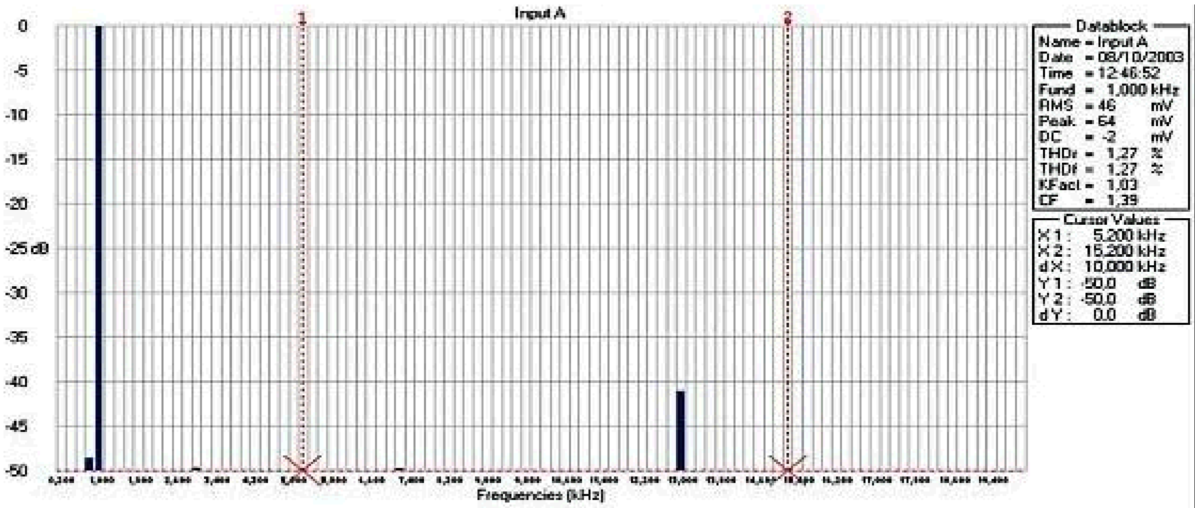


c) Noise spectrum at the amplifier output terminals

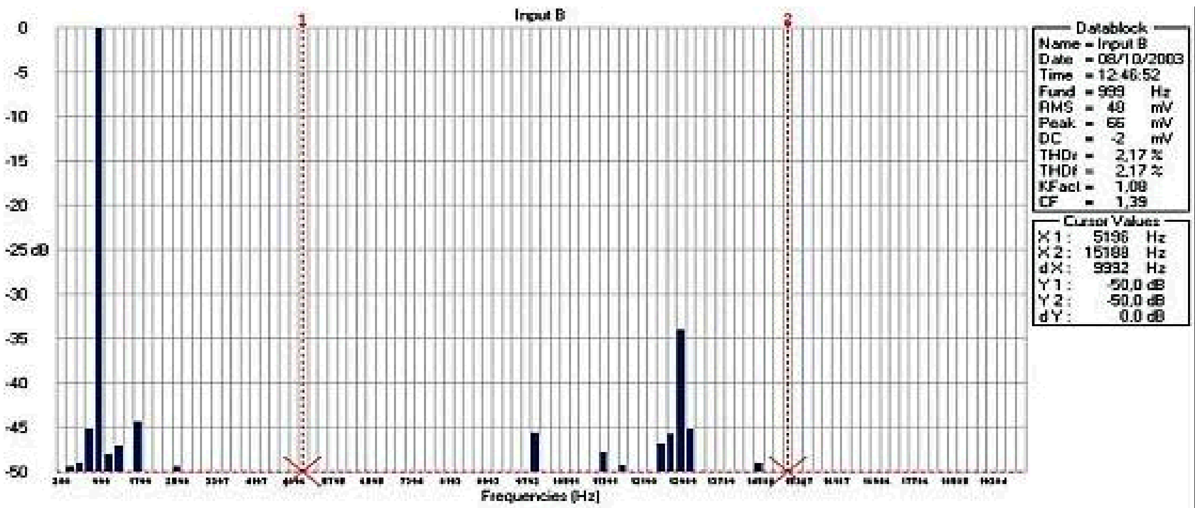
Figure 4 Neva amplifier / Cordial coaxial / TAD 2001



a) Input A – voltage at the loudspeaker: Input B – voltage at the amplifier



b) Noise spectrum at the loudspeaker terminals

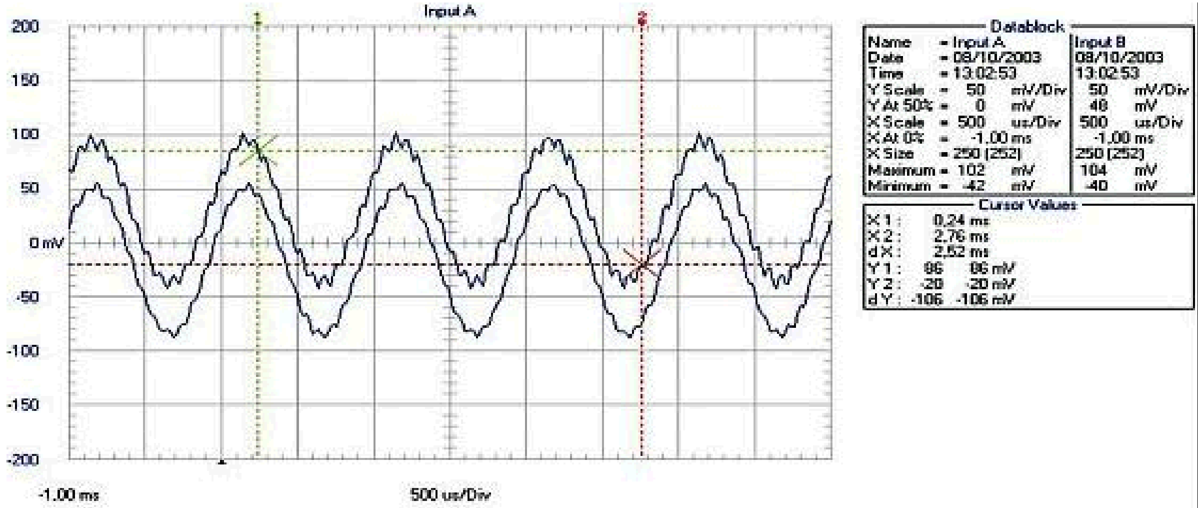


c) Noise spectrum at the amplifier output terminals

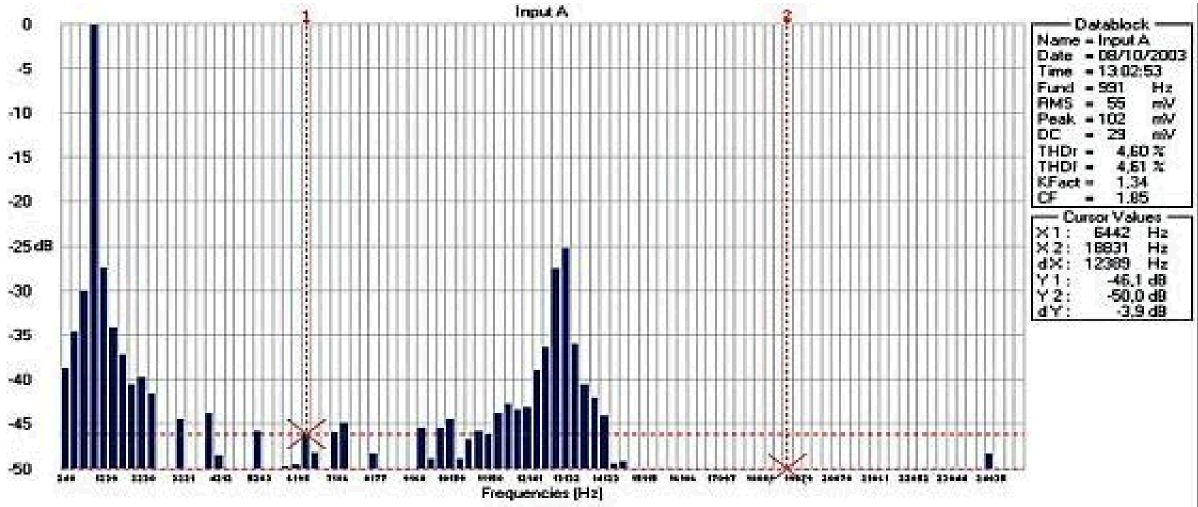
The fourth measurement in the series used the same load and cable as in the previous measurement, but a 250W Yamaha, class A/B amplifier was substituted for the Neva Audio, 50 watt, class A amplifier used in the previous tests. The fifth test simply repeated the fourth measurement with the parallel-conductor OFC cable in place of the coaxial cable. Figures 5 and 6, respectively, show the performance with the coaxial cable and the 4mm^2, standard OFC loudspeaker cable. Comparison of Figures 5 and 6 with Figure 4 and 2, respectively (ie compare 5 with 4 and 6 with 2), shows that the interference signal measured at the loudspeaker terminals is affected differently by each amplifier, and that the difference in the interference patterns from cable to cable is also influenced by the amplifiers to which they are connected.

Given the obvious interdependence of all the parts of the circuit, the findings help to explain why such a lack of consistency exists between reports of the beneficial effects of using certain loudspeaker cables. It would appear to be the case that certain cable benefits can only be claimed for certain amplifier/loudspeaker combinations, and that any perceived audible improvement heard on any one combination may not necessarily be able to be expected when the cable is used on any other combination.

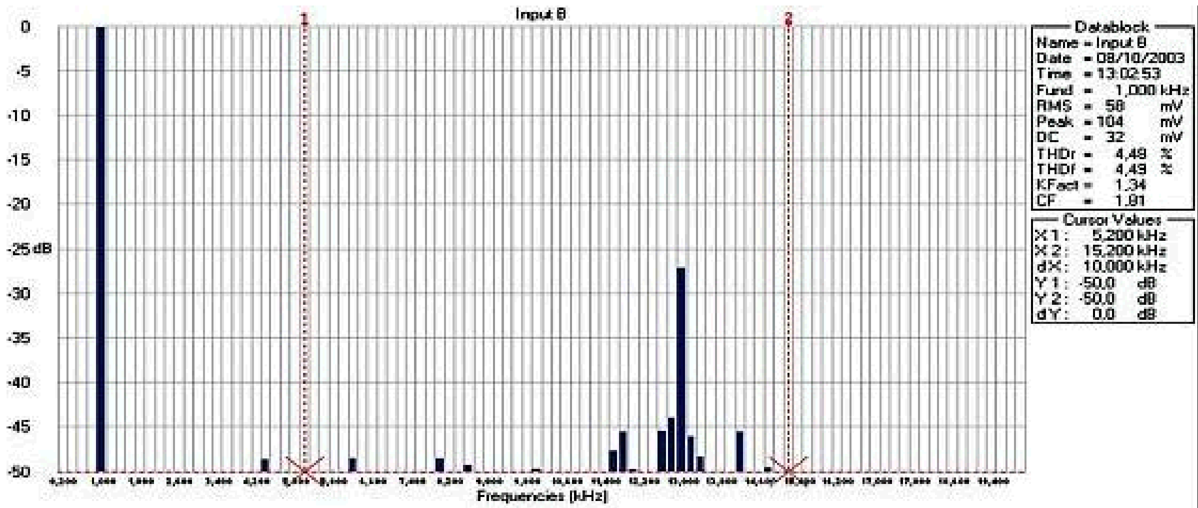
Figure 5 Yamaha amplifier / Cordial coaxial / TAD 2001



a) Input A – voltage at the loudspeaker: Input B – voltage at the amplifier

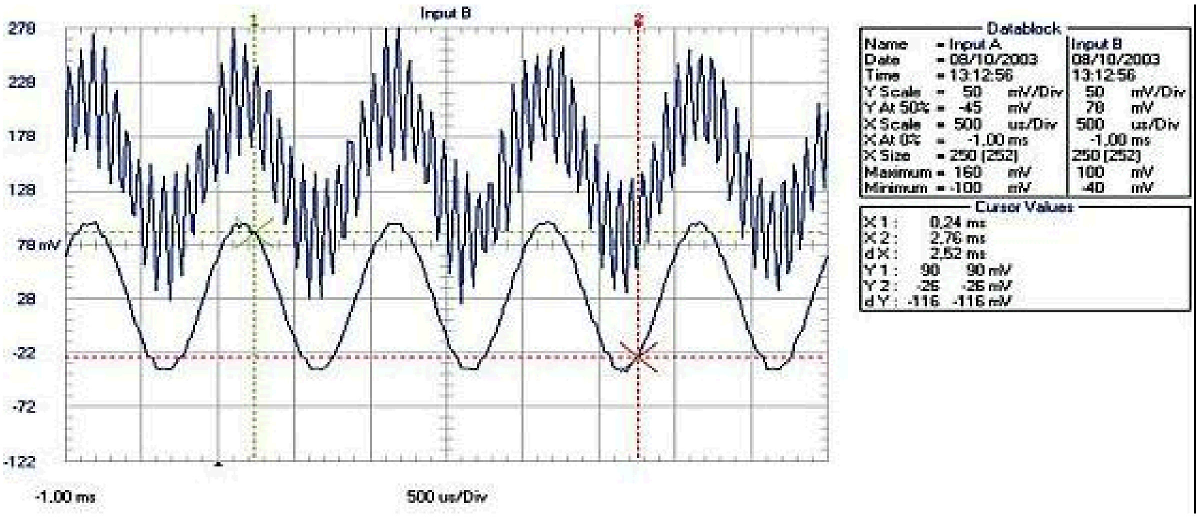


b) Noise spectrum at the loudspeaker terminals

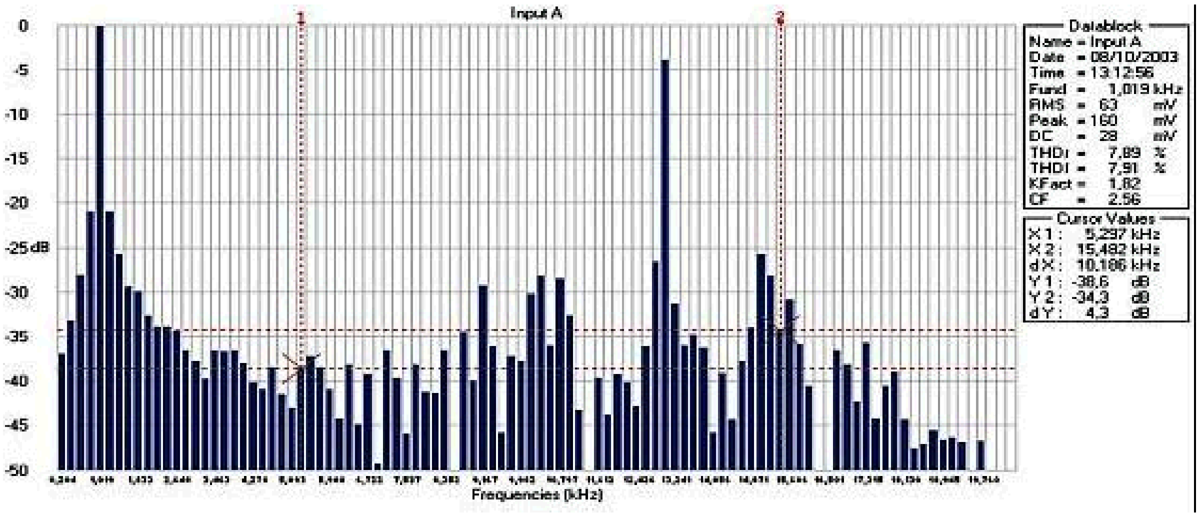


c) Noise spectrum at the amplifier output terminals

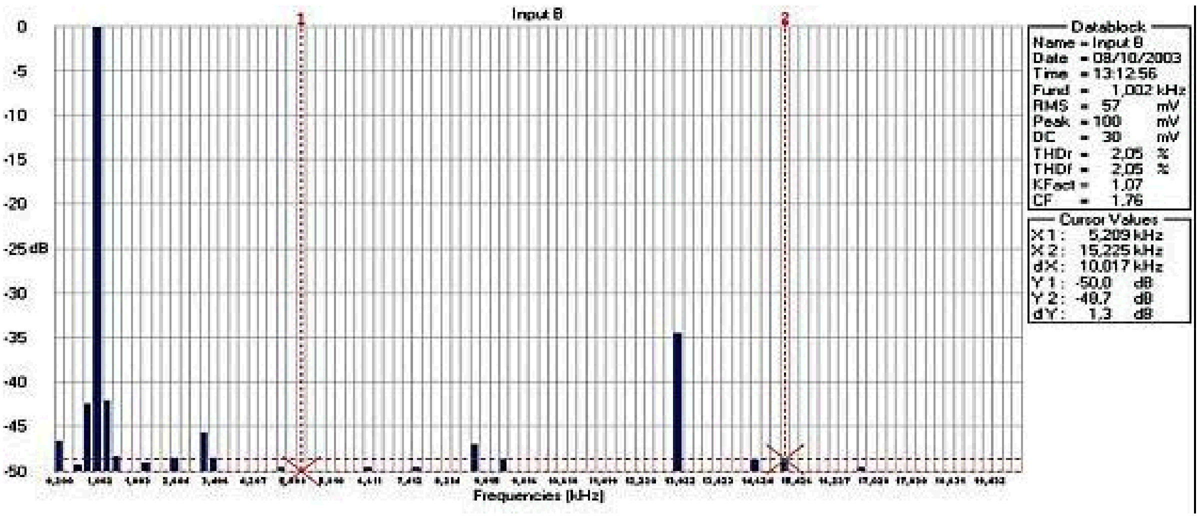
Figure 6 Yamaha amplifier / standard OFC cable / TAD 2001



a) Input A – voltage at the loudspeaker: Input B – voltage at the amplifier



b) Noise spectrum at the loudspeaker terminals



c) Noise spectrum at the amplifier output terminals

4. SCREEN GROUNDING AND SHORT CIRCUITS

It is perhaps also worth reporting some rather unexpected results from the day before the previously reported tests were made. During the testing of the measurement system, a 28m length of screened, twin loudspeaker cable was used. Normally, the cable, with conductors of 2.5mm^2, is connected with the screen grounded only at the amplifier end of the cable, as per the manufacturer's recommendations. However, for these tests, the cable was connected, initially, without any screen connection. The result is shown in Figure 7. The next measurement was taken with the screen grounded at the amplifier end, in the normal fashion, and the result is shown in Figure 8. There is little significant difference in the interference between Figures 7 and 8. Just for curiosity, the measurement was repeated with the screen connected at both ends, effectively shorting out the negative signal lead. Figure 9 shows the drastic reduction in the interference signal appearing at the loudspeaker terminals.

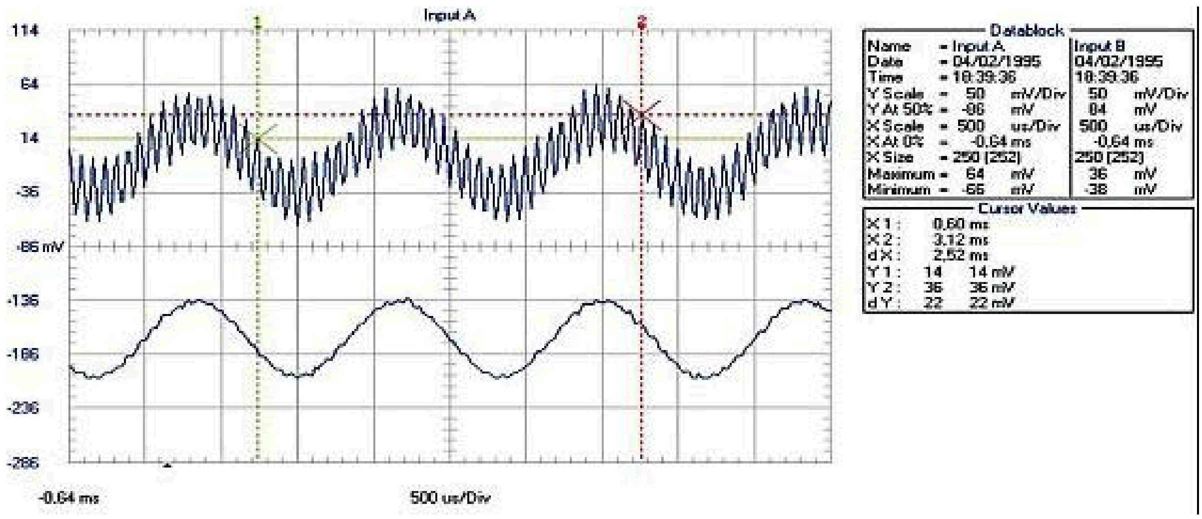


Figure 7 Supra cable, no screen connected: Input A – voltage at the loudspeaker: Input B – voltage at the amplifier

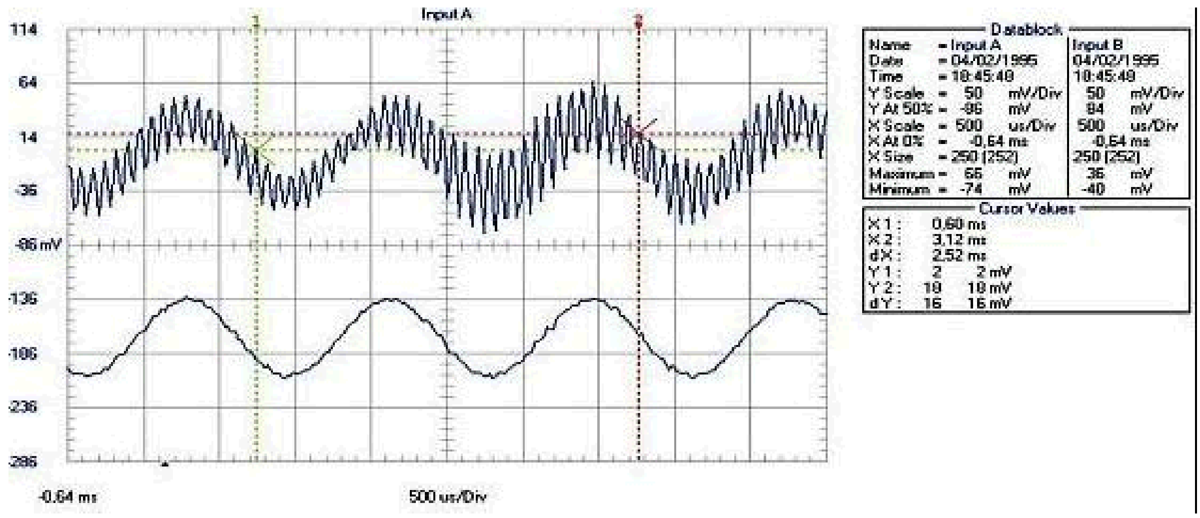


Figure 8 Supra cable, screen connected on amplifier chassis: Input A – voltage at the loudspeaker: Input B – voltage at the amplifier

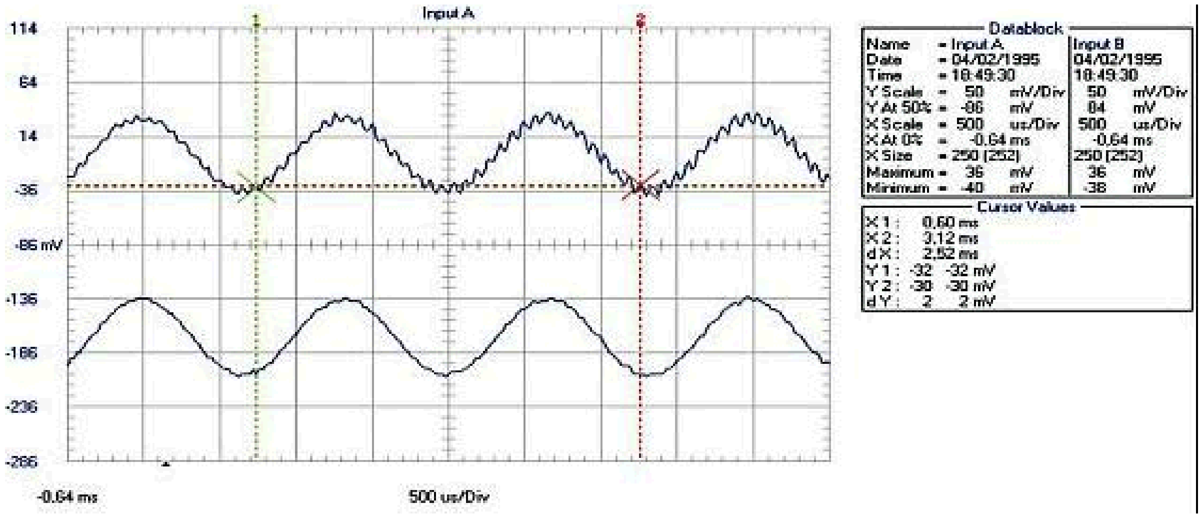
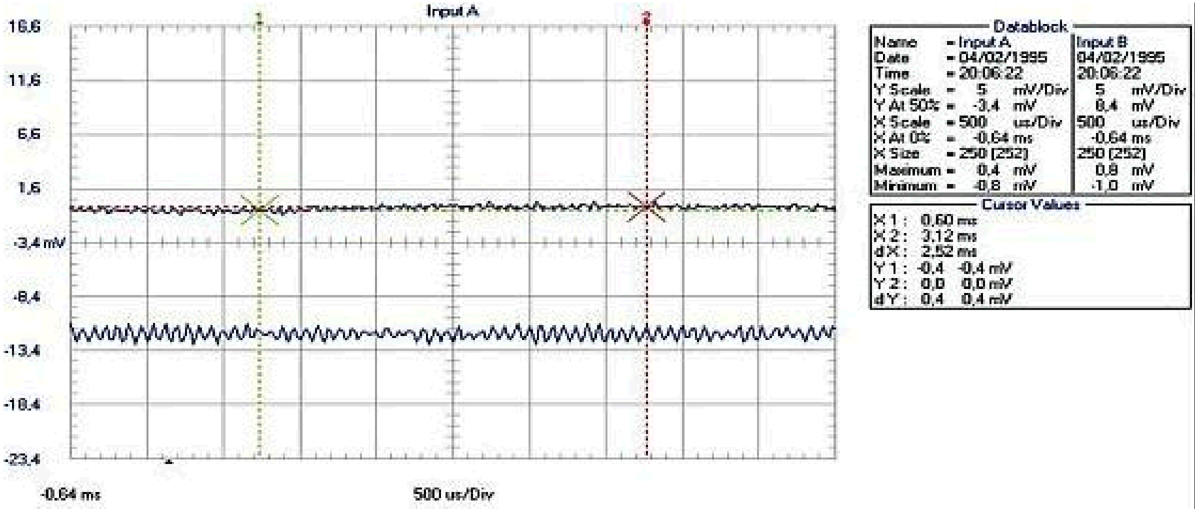


Figure 9 Supra cable, screen connected at both ends: Input A – voltage at the loudspeaker: Input B – voltage at the amplifier

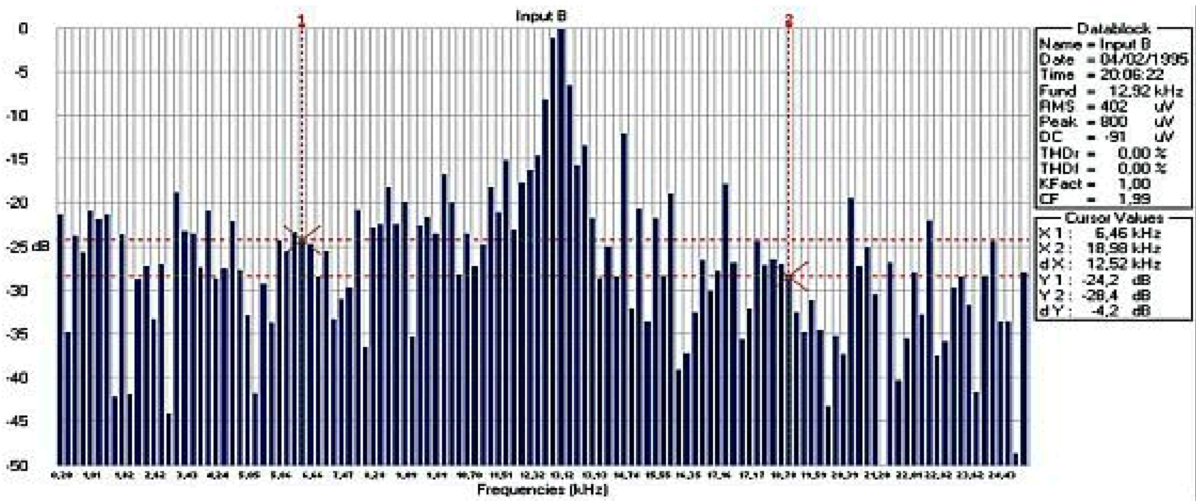
A test was also carried on the system to assess any effects of amplifier grounding on the measurements. Figure 10 shows the noise voltage across the loudspeaker terminals and the current in the circuit; as per Figure 1 but with no amplifier and the cable shorted at the amplifier end.

It can be seen that the residual interference pick-up in the cables, without the amplifier connected or any ground reference, is in the order of only 0.5mV rms. The circuit consisted of 28 metres of twin, screened cable, short circuited at one end, and with the other end connected to a TAD 2001 compression driver, of 8 ohms nominal impedance, in series with a current-sensing transformer. The screen was left floating for this measurement. From the evidence presented in Figure 10, it would seem doubtful that this passive noise pick-up is solely responsible for the effects noticed in the previously described measurements.

Figure 10 28m Supra, screened, twin cable (2.5mm² conductors, no screen connection), TAD compression driver, amplifier end disconnected and short-circuited



a) Input A – output on secondary of current sensing transformer: Input B – voltage across loudspeaker terminals



b) Spectrum of the noise pick-up across the compression driver

5. DIFFERENTIAL AMPLIFIER TESTS

A further series of tests was carried out with the aid of a differential amplifier; a schematic diagram of which is shown in Figure 11. The differential amplifier allows one signal to be subtracted from another and the resultant difference to be amplified for storage or analysis.

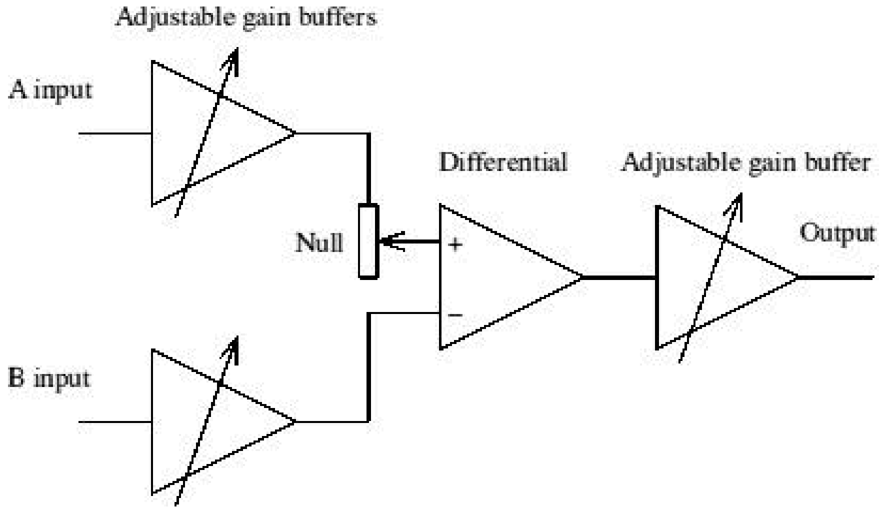


Figure 11 Schematic Diagram of Differential Amplifier

The “A” input to the differential amplifier was sourced from the output terminals of the power amplifier, whilst the “B” input was taken from the terminals of the load loudspeaker. In this set-up the load loudspeaker was a Yamaha NS10. The cable to be measured was then connected between these two inputs to the differential amplifier.

In order to commence use of the differential amplifier the output had to be nulled. This was done by connecting the two inputs together and applying a signal. The amplifier was then trimmed for minimum output signal. This minimum signal does not have a ’flat’ spectrum (see Figure 12) so all of the cable measurements should be referenced to this trace, as it is the difference that we are interested in, in this case.

The resulting traces were achieved by taking a “transfer function” between the differential amplifier output and the amplifier output signal, using a SMAART Live system. This gives a spectral plot of the output from the differential amplifier which is signal independent. It must be noted that this output is greatly magnified, and in this case not referred to any scale.

A further set of traces were also taken with the LF cone blocked. These show the effect of the loudspeaker system resonances on the losses in the cable.

It is worth noting that the differential amplifier has unbalanced inputs, which means that the ground wire of the loudspeaker cable is partially bypassed by the screen of the comparator leads. However, in order to minimise external effects, it was decided not to add extra balancing circuits or transformers to the circuit; it was considered that the loudspeaker cable resistance would be sufficiently low to not be excessively disturbed by the partial bypass.

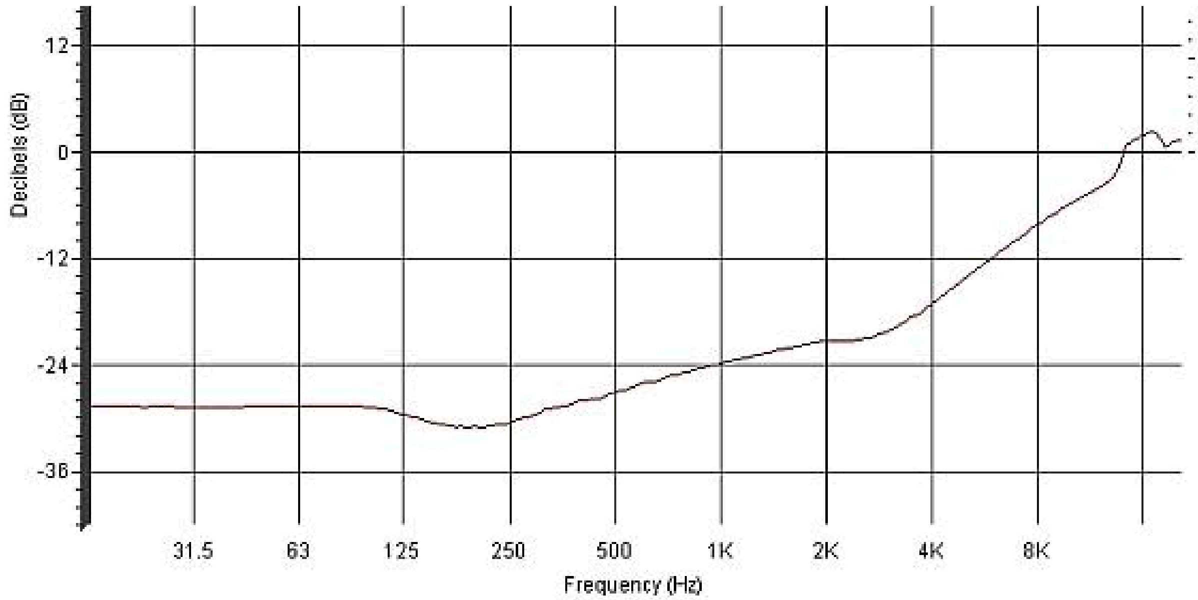


Figure 12 Spectrum of 'Nulled' Differential Amplifier Output (arbitrary dB scale)

Figure 13 shows the spectrum of the difference between the voltage signals at either end of 2m of $6mm^2$ figure-of-eight high quality loudspeaker cable. Figure 14 is as Figure 13 but for the same length of the screened $2{\cdot}5mm^2$ cable referred to above. A comparison between these traces and that of Figure 12 show that the screened cable exhibits lower losses than the figure-of-eight over the entire bandwidth of the test.

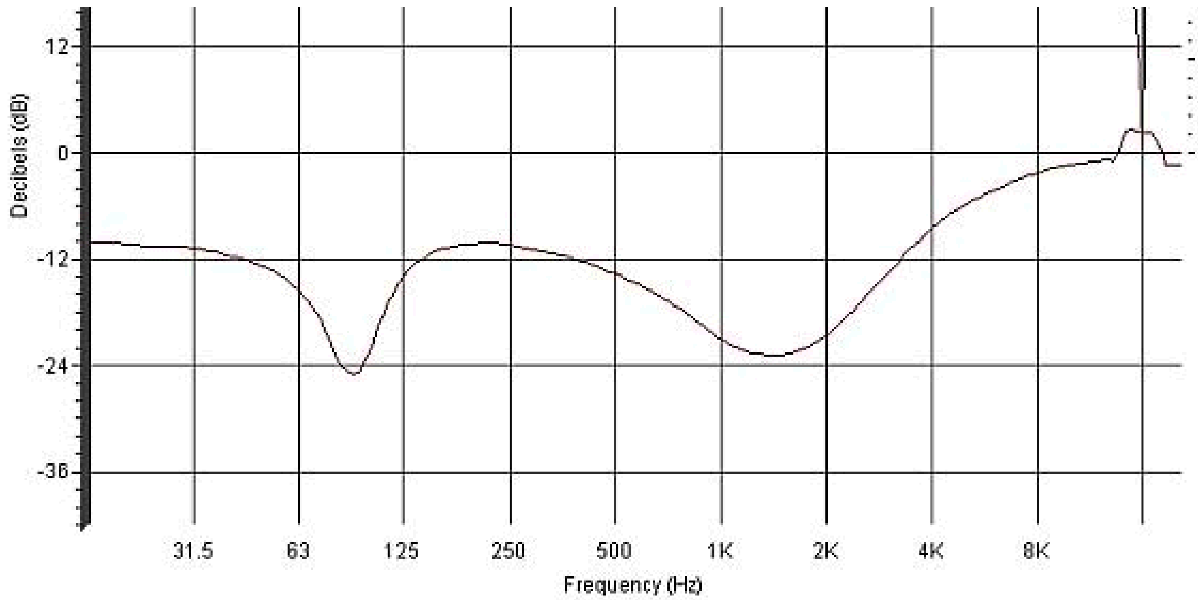


Figure 13 Spectrum of the Difference between the Voltage Signals at Either End of a $6mm^2$ Figure-of-Eight Cable

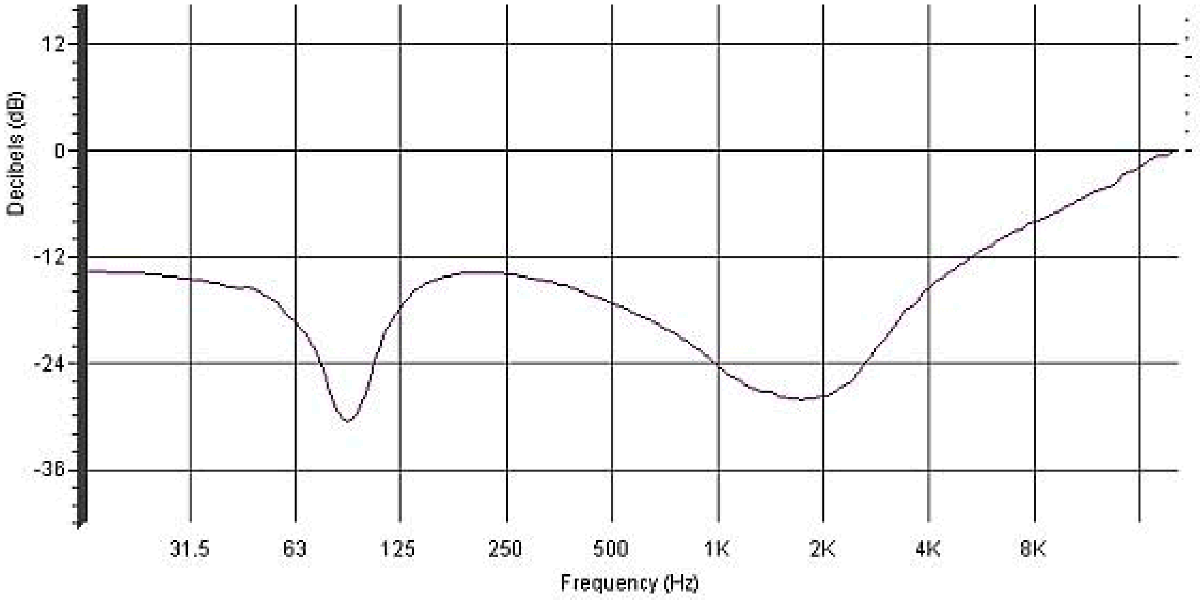


Figure 14 Spectrum of the Difference between the Voltage Signals at Either End of a 2·5mm² Screened Cable

Figure 15 is as Figure 13 but for CAT5 (bell-wire gauge) data cable. The losses due to this cable are 15 to 20dB greater than those for the other cables over most of the bandwidth.

Figure 16 is as Figure 13 but with the woofer of the load loudspeaker blocked. The change in impedance of the loudspeaker is seen to change the losses exhibited by the cable.

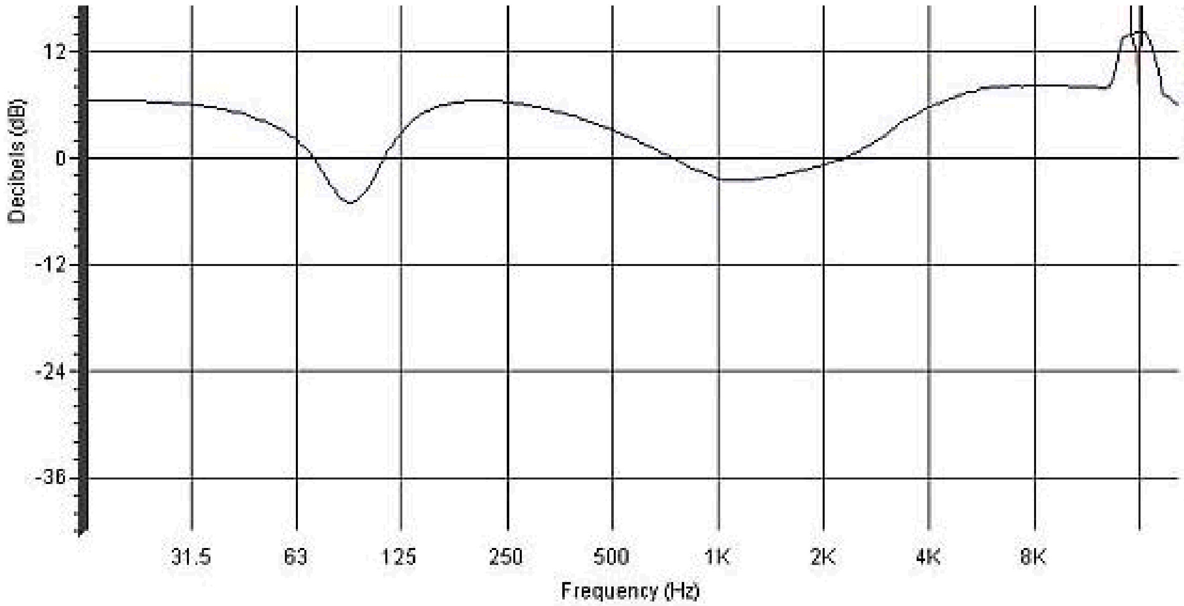


Figure 15 Spectrum of the Difference between the Voltage Signals at Either End of a CAT5 Data Cable

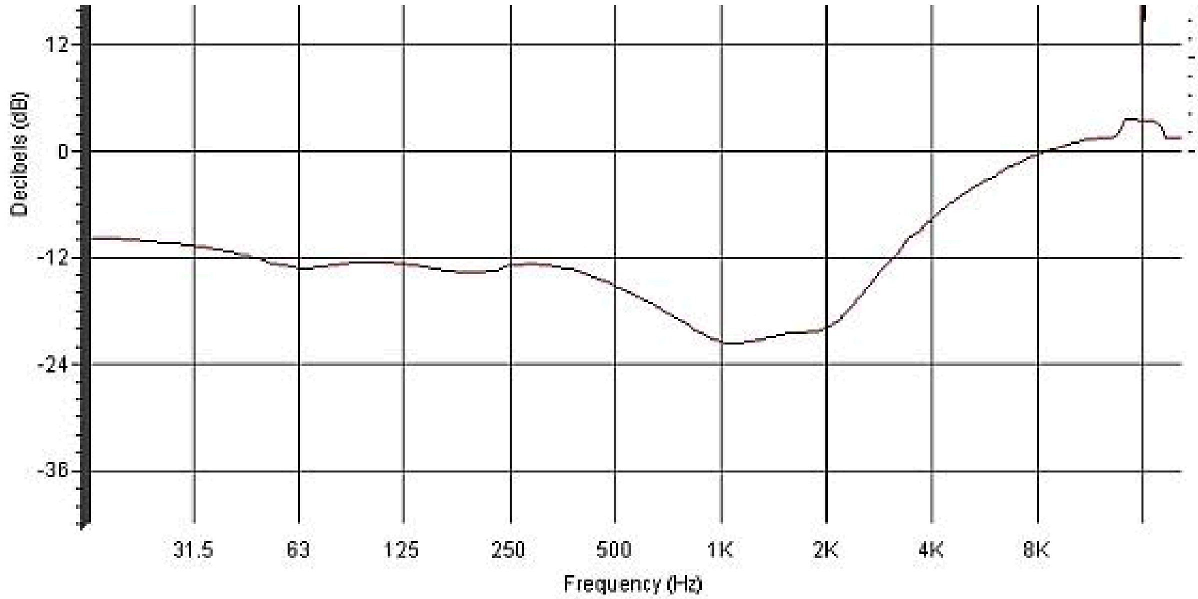


Figure 16 Spectrum of the Difference between the Voltage Signals at Either End of a 6mm^2 Figure-of-Eight Cable with the Woofer of the Load Loudspeaker Blocked

6. DISCUSSION & CONCLUSIONS

The subject of the perception of the audible effects of the use of different loudspeaker cables continues to be a controversial one. Nevertheless, it is hard not to take into account the reports from countless audio professionals and enthusiasts who claim that some cables do sonically perform better than others. Indeed, all the authors of this paper claim to have heard some differences between cables, albeit almost exclusively in high definition, highly controlled monitoring environments. It is also difficult to dismiss the fact that the combinations of amplifier and cable which had been at the core of a monitor system well known to the authors over a period of ten years, was a combination which exhibited very low levels of interference in the tests presented in Section 3 of this paper. This fact merely “fell out” of the results. It had most definitely not even been considered when the measurements were first undertaken. Whilst this fact, in itself, cannot be taken as proof of anything, it is at least an indicator as a lack of interference would seem to be a prerequisite for high resolution monitoring. The differential amplifier tests show that the use of screened cables for interference suppression does not, necessarily, compromise the losses in the cable. Indeed, the screened cable in this example out-performs the conventional cable in this respect despite having a smaller cross-section.

Given the number of variables in the circumstances under which loudspeaker cables are used, there may never be any absolute winner in terms of finding the best cable for all circumstances. On the other hand, this state of affairs should not be used as an excuse for not persuing the factor which may be relevant only in specific circumstances. Perhaps with more hard information about specific cases, patterns will be found which may lead to more general conclusions which cannot easily be reached through the current jungle of misinformation. Hopefully this paper will have contributed a little more to the search for facts which can be linked to the subjective and objective assessment of loudspeaker cable performance.

Some conclusions can be drawn from this work:-

- The high frequency interference signal is present in the voltage across the voice coil but is not present in the current through it.
- Any effects of the interfering signal on the performance of an amplifier / loudspeaker combination are likely to be reduced through the use of screened loudspeaker cable.
- Any effects of the interfering signal are likely to be more important when very low level signals are fed into high-efficiency loudspeakers than when higher levels are fed into lower efficiency devices.
- Screened loudspeaker cables can exhibit comparable transmission properties to conventional figure-of-eight cables.

7. REFERENCE

1. Newell, Philip; Castro, Sergio; Ruiz, Miguel; Holland, Keith; Newell, Julius; “The Effects of Various Types of Cables on the Performance of High Frequency Loudspeakers”, Proceedings of the Institute of Acoustics, Reproduced Sound 18 Conference, Stratford-upon-Avon, UK (November 2002).