Investigating the effect of the conductor geometry on the performance of Loudspeaker cables.

Computer simulation is widely used in engineering to model "reality" in a "virtual" environment. Here we have modelled several speaker cables with differing conductor geometry, to explain why we make Isolda cable the way we do.

The test circuit of an amplifier, various cables and an electrical model of a loudspeaker shown in Fig 1. The amplifier, various cables and a typical loudspeaker speaker. The amplifier is a typical solid-state class A or AB with the standard stabilising network. The speaker model is the industry-wide standard electrical circuit for a typical two-way moving coil speaker. The task is to compare the voltage at the speaker terminals with the voltage at the amplifier when a step waveform is applied. Ideally, these two voltages should be the same. A step waveform is utilised as it simulates all audio frequencies (and more) and is easily repeatable. The simulations are done with the SPICE general-purpose, open source analogue electronic circuit simulator.

Cables with widely spaced conductors, exhibit low capacitance and high inductance, whereas cables with closely spaced conductors exhibit higher capacitance and lower inductance. In the extreme case where the cable comprises two closely spaced, wide conductors, the inductance is very low and the capacitance is very high (Townshend). From these electrical parameters, the nominal characteristic impedance Zc, can be calculated. For the purposes of this test the simplified equation is used i.e. the square root of L/C.

There is a Zobel network between the amplifier source and the cable to mirror the output stage of typical audio power amplifier. The dummy load is the "industry standard" loudspeaker equivalent electrical circuit.

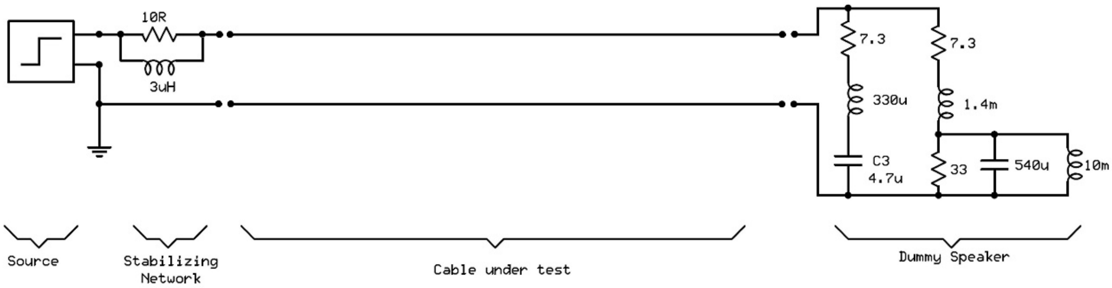


Fig 1. Test circuit.

The cables under test are each 10 metres in length.

The electrical properties of the cables are.

Widely spaced, high inductance and low capacitance.

L, 1.3uH/m C, 6pF/m R, 88mohm/m Zc, 335ohms

Closely spaced, medium capacitance, lower inductance.

L, 520nH/m C, 58pF/m R, 42mohm/m Zc, 95ohms

Plaited, higher capacitance, lower inductance.

L, 230nH/m C, 135pF/m R, 19mohm/m Zc, 41ohms

Two flat strips closely spaced, very high capacitance, very low inductance.

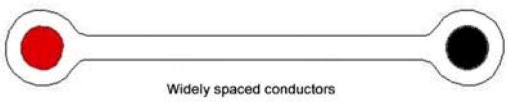
L, 0.35uH/m C, 9.4nF/m R, 27mohm/m Zc, 6.1ohms

Note: the electrical model of the loudspeaker provides a load impedance of 6/8 ohms.

In the following graphs, the mauve trace is the step input signal. The red or blue trace is the signal at the speaker terminals. The red trace is the simulation using when using lumped parameters and the blue trace is for distributed parameters. The horizontal timing is 500ns per division.

The term lumped is used when the electrical parameters are added up into one “lump” for the total cable length to be measured and distributed is used when the electrical parameters value per unit length is used. It has been argued that distributed parameters (i.e. transmission line) can only be used for long multi km lengths and at RF only, however, basic theory shows transmission lines are independent of frequency and apply at DC. (See our website)

The first simulation is typical of the widely spaced conductor design.



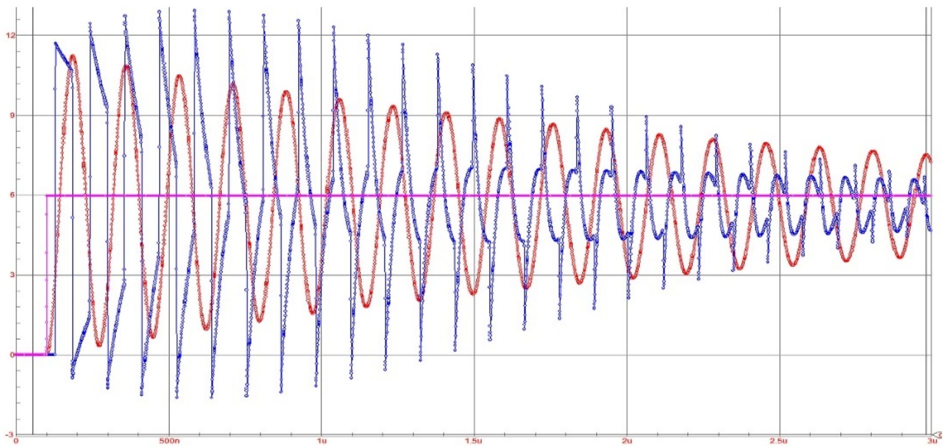
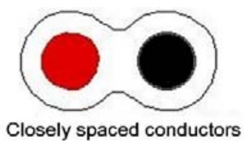


Fig 2. Simulation, widely spaced conductors.

Figure 2 shows clearly the multiple echoes and ringing in the cable, extending to 100 micro-seconds and more. The duration is short, but this ringing is continuous when playing music.



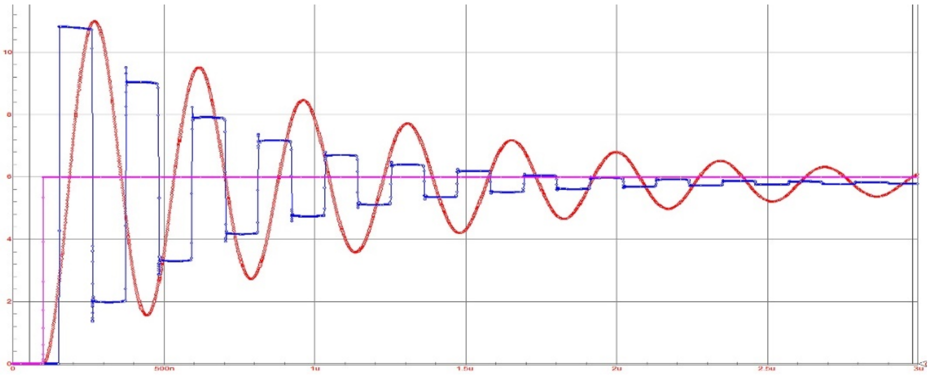


Fig 3. Simulation, closely spaced conductors.

Figure 3, Simulation, closely spaced conductors, shows fewer multiple echoes/ringing in the cable, extending to 10 micro-seconds plus.

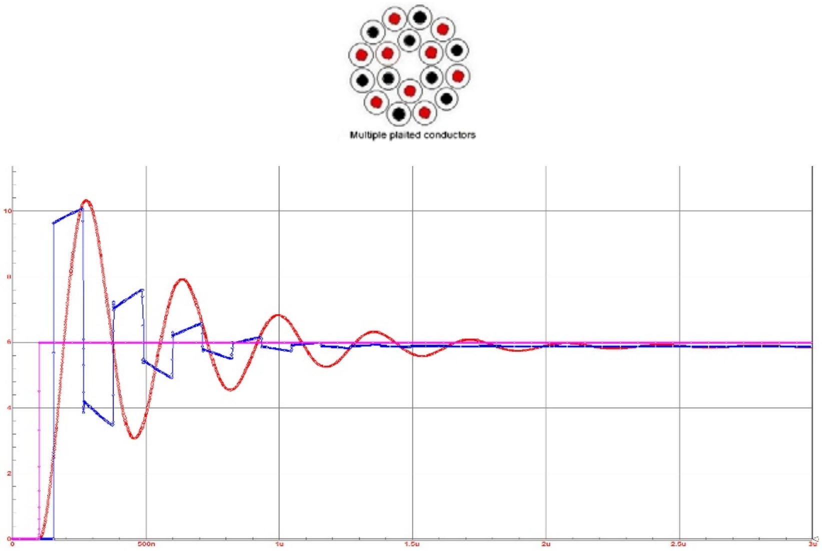
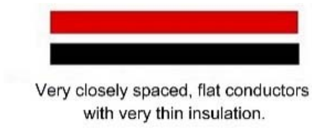


Fig 4. Simulation, multiple plaited conductors.

Figure 4, simulation, multiple plaited conductors, shows fewer multiple echoes/ringing in the cable, extending to between 3 and 5 micro-seconds.



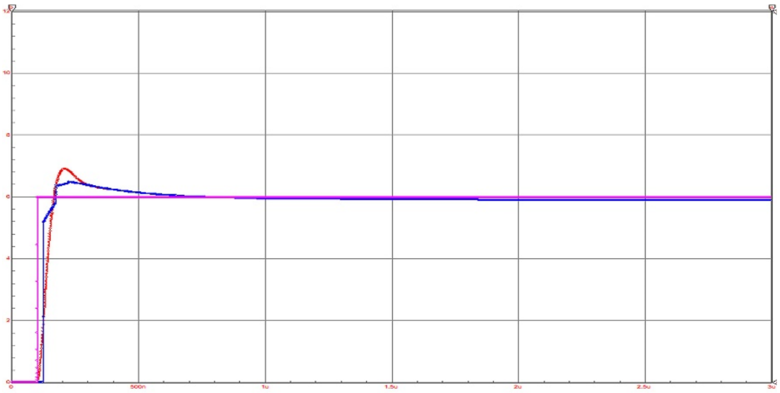


Fig 5. Very closely spaced, wide conductors (F1 Isolda).

Figure 5 very closely spaced, wide conductors shows almost no multiple echoes/ringing in the cable, with a 1 microsecond settling time compared to the cables with different constructions.

We believe that it is the close matching of the loudspeaker load of 6 ohms with the characteristic impedance Zc of 6.1 ohms with the Townshend Isolda and F1 Fractal cables, which amongst other things, that give the cable the unmistakable, amazing natural sound.

Critics insist that transmission line behaviour only occurs in 40km long cables at RF, but this is disproved by the simulation when distributed behaviour is analysed and shown in the blue traces above. Note also, there is very similar correlation between distributed (transmission line theory) and lumped analysis (conventional theory).

It is also argued that the impedance of a loudspeaker is not constant over the audio frequency range. The largest deviations from nominal are at very low frequencies i.e. below 200Hz, where the reflections do not affect the sound.

The effect of the multiple echoes, caused by every musical transient, in the higher impedance cables is heard as an increase in edginess, a marked blurring of the sound and an increased noise floor. When matched cables are used, the lack of noise in the musical presentation can be clearly (not) heard.

See

1. The Townshend F1 Fractal speaker cables
2. Cable theory for sceptics
3. YouTube “Geometry matters.” All 4 videos