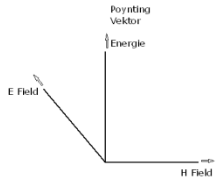
Consideration of a high-capacity foil cable:

Newly discovered ancient knowledge. The old RF-developers already knew the benefits of long-planar lines and have been used (electronic) Eonen (times) thin flat wires in their RF circuits. The capacitive coating of this pipeline architecture is defined and outweigh the inductive coating. I believe that the induction of a line covering a lot of disadvantages and the capacitive coating also brings advantages. These phenomena, I will subsequently examine in more detail.

a. Energy guide way:
   Contrary to popular belief, the electrical energy is not transmitted in the copper conductors but the energy transfer happens in the dielectric only. Anyone who had studied physics or electrical engineering, knows the Poynting vector, the three finger rule.

   $\vec{S} = \vec{E} \times \vec{H}$ $\quad \vec{S} = \frac{1}{\mu_0}(\vec{E} \times \vec{B})$ $\quad |\vec{S}| = \frac{1}{Z_0} \cdot E^2$ usw.

   The Poynting vector must be perpendicular to the vectors of the E-field and the H-field stand. A differ from the right angle would mean a loss of electromagnetic energy. This will be done in the speaker, but not in the speaker cable.
   Physically speaking, the energy density is highest there, where the electric and the magnetic field is greatest.

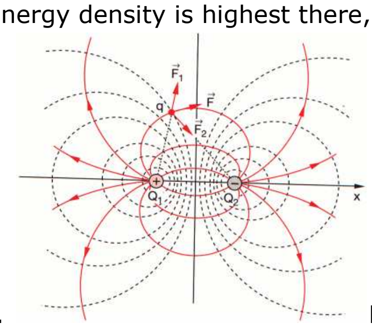
   

   Bild 1
   Red line = electric field, gray line = magnetic field, (+) (-) Identifies the current flow direction (signal current and the return power line). This image demonstrates very clearly the highest energy density is located between the two conductors.
   With a little imagination, it is now abundantly clear, the farther the two conductors (signal and return power line) are separated from each other (cable geometry), the more information can by external electric fields are transferred to the energy or information added in the line (Keywords EMC, Electromagnetic compatibility). The noise sensitivity of the surrounding areas is great. Just think of the whole wave salad that surrounds us every day. Radio, television, mobile telephones, amateur radio, marine, military and police radio and much more. What's that supposed to impact on a loudspeaker line, you have to ask themselves. A power amplifier has an output impedance by 0.1 ohms or even smaller. But this is only true for very small frequencies. Think about the technical details relating to the damping factor. Very good values are an attenuation of 10000th. But the best power amplifiers have such values only at 100 Hz. At 1 KHz, this value decreases even in the area to 1000'er. At 20KHz, I no longer want to know these values. For frequencies > 100KHz and higher, we are already at various impedances of 100 ohms and growing up.
   Yes, but what interested HF frequencies (MHz - GHz). A lot is happening but nothing more. The transistors, especially power transistors have no more gain at frequencies > 10MHz. Also true, but unfortunately transistors are not dead at frequencies > 15MHz. The PN junctions are now diodes. PN junctions in transistors are diode at high frequencies. Diodes are known to be used in RF circuits as demodulators. Of course also do this the transistors in an NF-circuit. The consequences, demodulation products in the amplifier, this will be mix more or less to the NF-signal (audio signal). This is again audible. Here, I give you concern. RF signals are not broadcast in itself. RF signals are modulated in large part with audio signals. Television pictures also have shares in the audible range (frame rates as an

example). All of these modulation products mingle quietly to the audio information that you want to transfer to their speakers, and transfigure the sound.

a. inductive versus capacitive surface coating:
How do I increase the capacitive coating of the pipe? The capacity can I increase by very small distances between signal and return power line and by reaching the surface. Even through the insulation material (Dielectric) can increase the capacity, as I used to isolate very high Epsilon-r. At this point needs to be mentioned, however, that a very high Epsilon-r also disadvantages caused by memory effect of the displacement current with itself and should be a not too high. So, increasing the area is the better way.
What is a size bigger than a film with the same cross section of a round wire ..... All clear??
Sun also decreases the inductive and resistive coating.
The capacity results from epsilon_0 * epsilon_r * (area / distance). The geometry of a foil is simply the best. If you use several layers, so many foils of each other, return current/ signal return/ return current/current signal/return current. Would be three times the surface area and thus result in the triple capacity.

b. Advantage of a flat line:
From the previous description, we see why we can increase with a (not only) foil lining the Capacitive a line easily. Now we want the benefits that result from a closer light.

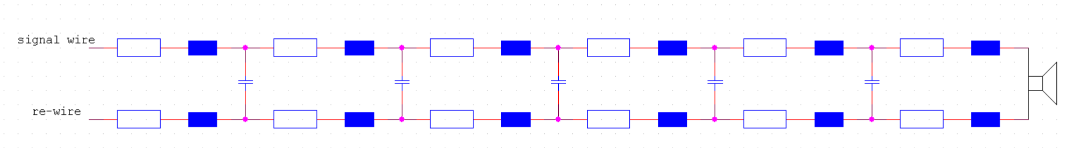


Figure 2 illustrates how a line and its capacitive, inductive and resistive pad looks like.
As I said, the resistive and inductive component of the conductor material used and its cross section. Due to the geometry (large surface area of a foil), we increase the capacitive component compared to the inductive and resistive component. I want to mention, with the number of layers will increase the capacity higher. Limit here is only the price and manageability.
But, there are still other effects, which has very positive effect on the signal.
Let us now consider the time aspect of energy guide way. As we know, the energy is transmitted in the dielectric and have the effect of the surrounding electromagnetic fields discussed on the signal line. By becoming very small distance between the conductors (0.05 - 0.07mm) the effect of the surrounding fields will be smaller and smaller.

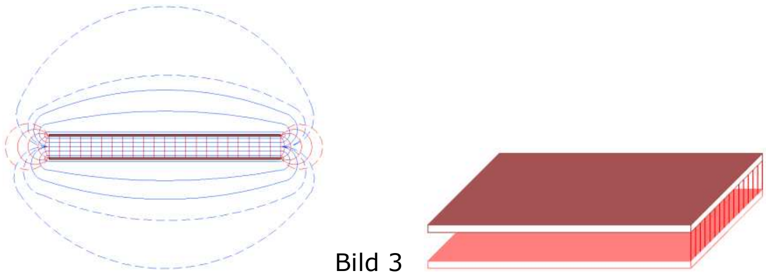


Bild 3

The figure 3 illustrates the field profile for the electric field (red) and the magnetic field (blue) in flat conductors.
Here one that is energy guideway in flat cables and the optimal lot size for the fault insertion is much smaller than in case of cable geometry with round heads look would be possible. But there is one big advantage of the high-dimensional geometries capacitive coating. Think about the image 2, such as distributing the capacitive, inductive and resistive Phenomena on one line.
Let us now consider the line as an antenna. The longer the line is, the more perturbing takes up this line and the lower limit frequency shifts towards lower frequencies. Clear!

Due to the high Capacitive surface of a flat line now also affect the inductive and the resistive coating of the positive direction to the possible em fault insertion from.

A high-frequency disturbance waves now runs along the line, regardless of whether signal line or power line back to the end of the line. Without damping would now this perturbation at the end of the line (impedance fraction) reflects and run to the other end of the line and this process would be repeated continuously. The inductive and the resistive coating of the cable prevents this. However, with conventional cable geometries (normal capacitive coating), the damping would be so low that this wave would be attenuated but reflected. If we were feeding that radio frequency energy on one side, this energy would be radiated. Thus, each line is also an antenna. The capacitive layer is now as high as in the case of a planar conductor sytems, the RF perturbing literally bogged down in the capacitive coating, and do not get to the end of the line, and if at all, very, very strongly damped. Will therefore not reflected and in our NF power amplifier can exert very little negative influence. A clear advantage!!!!
Well good, you might say. But good cables have a shield for this purpose. That's true, but only at low RF frequencies. At very high frequencies (500Mhz and above) a so-called mantle wave is produced on the screen that Surround the cable, and the disturbance waves reach the output of the amplifier anyway. The cause is rupture of the impedance on both connectors (no speaker plug has the same characteristic impedance as the speaker cable used). This is why a foil conductor very much more effective in the Attenuation of the disturbance waves. Mantle waves are not possible here.

c. The skin effect:
The penetration depth in copper at 10kHz is approximately 600µm.
Here is a small table (copper):

50Hz	9,38mm
60Hz	8,57mm
1Khz	2,10mm
10Khz	0,66m
50kHz	0,3mm
100kHz	210µm
500kHz	94µm
1MHz	66µm
10MHz	21µm
100MHz	6,6 µm
1GHz	2,1 µm

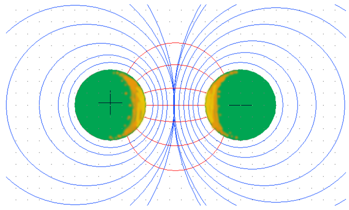
$$\delta = \sqrt{\frac{2}{\omega \sigma \mu}} = \frac{1}{\sqrt{\pi f \mu_0 \mu_r \sigma}}$$

ω	=	angular frequency
σ	=	electrical conductivity
µ	=	Permeability
µ0	=	Permeability of vacuum
µr	=	relative Permeability number of material

In the table, it can be seen without much knowledge that even in the interest audio frequency range the ohmic part very seriously differ. Now it is quite clear, a speaker cable has a completely different resistance at 50Hz than at 50kHz.

They Calculate the specific resistance at 50 Hz and 50 kHz. You will see the difference is large and not homogeneous.

It should be said, a skin effect occurs only on really, if the return line from the signal conductor is infinitely far away. That is in practice not the case. Of course, the current displacement increases with the frequency in the direction of the outer edge of the conductor. However, there is also an additional effect. The current is always pushed in the direction of return line (proximity effect). Ie, the ohmic part thus takes on much more than just by the skin effect alone.



Yellow Zone = high current density

Yes, for heaven's sake, what does this have to do with foil cable?
Now the following argument: a foil with 35mm width and 0.1 mm thickness has a conductor cross-section of 3.5mm². 're Already acceptable. If I use two of these films for the signal line, I already have a cross section of 7mm². Is it ok, right? But, once you look at the table for the penetration depth as a function of frequency. Compared to a round, thick wire, I have a foil resistive ladder a completely homogeneous portion of the spectrum in the line. The cable is only 0.1 mm thick. Therefore, I have at 50Hz the same wire cross-section as at 100kHz. Only at > 500kHz the resistive skin effect ratio declines by a little. That's a big advantage.
The skin effect, but it responds with stranded wire, they'll say. In my opinion, stranded wire can only be effective against the skin effect, would all be insulated all wires to each other (see use in RF technology). The speaker cables with many fine strands and a large cross-section, so we all know, are completely ineffective, since the individual strands together are naked and without isolation. At the joints, there is a resistive contact. Phenomen especially because I would not more explain. In practice, you can hear it very clearly the fault. A question on this subject; why does not matter in the high-frequency technology un-insulated stranded wire?
So, does this tiresome subject.
Foil cable are a real and effective alternative.

d. What to do with the perturbation energy?
That is the question which will make those who paid attention in physics class. Clearly, according to physics, we can’t destroy energy but convert only. That happens here too. Through the foil geometry and the high capacitive coating results in a very low wave resistance. Assuming the insulation between the foil is not greater than 50-70µm, which falls well far below 1 ohm impedance. The wave resistance decreases in the areas of resistance of (*) copper. Therefore, the proportion of energy through the resistive copper is converted into heat and not as a perturbation to the output of the power amplifier fed to demodulation. Thus, the fault energy is converted into heat energy rather than reflected. Thus, the connector and the resulting impedance break at this point are no longer relevant. Together with the points stated in the previous effects described why an foil cable in several layers is a best practice in energy guide way and noise suppression, and is therefore well suited for transmission of information.
All these effects lead naturally to a calm, balanced and sophisticated sound image with minimal error.
A high on the foil cable!!!!!

*(*)*Silver foil would have a negative impact at this point due to the higher conductivity in the noise suppression. Rather, in the transformation of the electromagnetic perturbation energy into heat energy, since the wave resistance will be low as well. However, this is very difficult Realizable.

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