

SELECTING THE CORRECT SPEAKER CABLE

INTRODUCTION

Cable design, particularly speaker cable, seems to center more around mysticism and fantasy than precise scientific evaluation. Many new entries in the cable field try to emphasize exotic theories, materials and appearance in an attempt to gain market attention. While some exotic cables do, in fact, impart a different "sound", this is due to their limiting and non-linear transfer characteristics rather than to their highly touted "unique" design. Such cables act as equalizers and filters, the opposite of what is required: a neutral and translucent transfer media.

To design speaker cables successfully, one must have profound knowledge concerning the characteristics of the sources (power amplifiers) as well as the characteristics of the loads (speakers) and of what exactly is happening when these two are connected. Often cable designers, even when they are knowledgeable concerning specific aspects of cable design, lack this all-important *combined* knowledge.

Cables must always be designed with due consideration for all performance aspects of the circuitry on both ends of the cable. They must also be designed for a specific application and frequency range (a cable that is designed for medium level DC applications will be hard pressed to perform at high level audio frequencies).

TRANSFER CHARACTERISTICS

A variety of criteria has to be observed, and the ideal cable has an optimal mix of these criteria. The criteria that have the most significant influence on the transmission quality of a cable - the transfer characteristics - are often neglected. There are physical laws that govern the transfer characteristics of a speaker cable. Intelligent optimization and balancing of derived characteristics are the ingredients to achieve superior results.

CONDUCTION

While many speaker cables boast a formidable outside diameter, the majority of such cables contain inordinate amounts of cheap insulating materials, fibres and other non-conductive filler materials. Using such fillers the cable's visual appearance becomes more massive, which may impress some less informed buyers.

Obviously, filler materials are magnitudes cheaper than using materials that conduct well (such as copper), but they cannot in the least degree help signals transfer. Electrons do not travel through plastics, fibres or rubber (all non-conductive materials), so all these impressive-looking garden hose sized cables that are mainly made up of filler materials are really quite useless.

The actual conducting material itself is often quite a minor part of these cables. It is, therefore, a good idea to check the weight of a speaker cable, as it indicates the amount of actual conducting material that is used (materials that conduct well are also heavy).

For today's requirements the conducting area of cables is much too small. These cables reduce the massive damping that is provided by true high-quality power amplifiers below acceptable levels at the speaker end. For accurate performance a larger conducting area than generally used is required. It is the damping *at the speakers* (and not at the amplifier's output) that defines performance. A higher damping at the speaker is synonymous with more precise control of the diaphragm = more precise reproduction.

However, the typical damping factor measurement alone - which uses a static sine wave signal of 1W - is far from being the only criteria. In actual use speakers require higher levels than 1W from the amplifier and are fed with harmonically complex and dynamically changing music signals. More realistic measurement standards must be developed, as values obtained with currently used measurement techniques are not of much use.

True no-compromise precision transfer cables are mandatory for quality installations, as only with these can optimal performance be guaranteed.

CROSS SECTION AND DAMPING

Amongst several important characteristics, the factor which is most commonly neglected in today's speaker cables is unimpaired signal transfer. Many of the hard-earned and unique qualities intrinsic to FM ACOUSTICS power amplifiers are severely restricted by the use of limited capacity cables. The pristine signal from the amplifier must be transferred to the low-impedance speaker load with minimal resistance and interference.

In a well-designed cable the capability is defined by its transfer characteristics (*). One of the most important (and also most neglected) factors is the amount and quality of the conducting material used: the more copper content, the lower the intrinsic losses and - important but rarely mentioned - the less interference can enter the cable.

The damping with which the amplifier controls the speaker rises in direct proportion to improved conduction. Lowest-loss transfer results in massive improvement in the dynamic control of the diaphragm.

Only few cables are designed with due consideration

of these important aspects. Most other cables cannot provide lowest-loss transfer, thereby reducing the accuracy of the entire audio system.

As a straightforward example of the importance of conductor cross-section, the table below illustrates how the resistance and the cross-section dimension of a cable influences the total damping factor. The damping factor - measured at the speaker terminals - is shown in relation to various cross sections of correctly designed cables. The figures are based on a 5 meter run between amplifiers having different damping factors (see table) and a speaker with a nominal impedance of 4 Ω.

	Typical cables	Forcelines 5	Forcelines 3	
Cable cross section:	0.75 mm ² =AWG18	4mm ² =AWG11	16.5mm ² =AWG5	25.6mm ² =AWG3
Total cable resistance in Ohms:	0.23	0.039	0.01	0.0066
Effective damping factor at speaker if amplifier damping factor is:				
- 1000:	4.3	25	86.1	131.5
- 400:	4.3	24	76.2	110.0
- 100:	4.2	20.5	48.5	60.0
- 20:	3.6	11.2	16.5	17.6
"Cable" damping factor:	4.35	25.5	94,2	151.5

The above table shows the importance of the effective conducting area in an amplifier-speaker combination. If accurately designed, the cable offering the lowest resistance to transfer (the one guaranteeing the highest damping at the speaker) will provide the most precise impulse reproduction and the most accurate low-, mid- and high-frequency response.

With impedances lower than the 4 Ohm load - on which the above values are based - the differences become even more massive. This is the case with many of today's sophisticated speakers, some of which resemble actual dynamic impedances in the region of 1 Ohm! Such real-world impedances demand huge output currents from the amplifier and this current

must be transferred to the speaker with minimum loss and interference (with FM ACOUSTICS power amplifiers peak output currents in excess of 100A are not uncommon!).

With tube amplifiers having low damping factors and high output impedance the differences are obviously smaller, but still noticeable.

The above facts provide excellent arguments for the use of FORCELINES® in serious installations.

Cables that use "Add-On" compensators boxes are to be avoided! One certainly does not want to have an **additional** stage of interference to signal transfer and filters between the amplifier and the speakers! On the contrary, the signal should be able to pass with **as little obstruction as possible** and not be subjected to compensator networks (that even in the best of examples can only be correct for one specific amplifier and one speaker and only at one single frequency!).

Such cables can indeed change the sound of a system and at first glance may seem advantageous by, for instance, filtering higher frequencies or by introducing an artificial phase shift that creates phasiness which often is misdescribed as "more space and air". Thanks to such effects it is possible to impress inexperienced consumers. After the first attraction has worn off the consumer realizes that his investment is producing effects but not accuracy and musicality, often an unnecessary expensive lesson.

(*) The limitation due to wave propagation time that is often reported to influence the signal transfer - and which some cable manufacturers claim to be a major problem area - only starts to play a role far above the audio range; there is no influence on the signal transfer at audio frequencies (this is, of course, only with **correctly designed** cables).

Some cables demonstrate fundamental design flaws and may suffer from above mentioned adverse effects). If a cable is correctly designed, however, the transfer characteristics depend on factors that are scientifically sound.

CABLE CAPACITANCE AND INDUCTANCE

Because of their construction it is possible to optimize the physical placement of FORCELINES®. Amplifier-speaker combinations are sensitive to the possible interaction of the conductors with each other, with passive crossovers, with the speakers and even with the amplifier's output circuitry. In some situations it is therefore advantageous to twist the two conductors, while in others, spacing the two conductors an ideal distance apart, yields improved results.

Both arrangements are possible with FORCELINES®. To accomplish the latter, FORCELINES® come with specially designed clip-on spacers which separate the two conductors and keep them an ideal distance from each other.

MATERIALS

Inspecting FORCELINES® one will find that no costs are spared and more high-quality conducting material is used than in any other speaker cable.

The individual strands and cable geometry are optimized for best signal transfer in the audio (and up to a certain extent, ultrasonic) frequency-band. Further characteristics, several of them proprietary, set FORCELINES® apart from other speaker cables.

In FORCELINES® 5 the weight of the refined copper is 34 kg per 100 meters, while in FORCELINES® 3 the corresponding weight of the extensively refined copper is half a kg per meter.

CONSTRUCTION

Other factors can have a significant influence on system performance: some cables have a steel or iron core and a copper or silver coating. This is obviously much cheaper than using pure copper. It must be remembered, however, that steel is not that good a conductor and - worse - it is magnetic (and influenced by magnetism). Such cables are prone to intermodulation and non-linearity and are to be avoided. Quality cables must only be made of specially purified linearized copper.

It is better to select a cable whose individual strands are in contact with and not insulated from each other (as, e.g. in "Litz" wire). At the cable termination those insulated strands that are not in direct contact with the connectors at the end of the cable, do not actually make contact to the terminators and therefore cannot assist the signal conduction.

GOLD

It is a popular belief that gold provides the ultimate conduction and is the best connecting material. This probably comes from the emotional value with which gold is regarded. While gold is not the best conductor, it **is** a good contact material for very low voltage and current but it is **not** ideal where high current and voltage must be conducted. Other materials and combinations are better conductors and/or better suited as high current contact material.

Therefore, it makes no sense to gold plate speaker and amplifier output connectors, spade lugs or other cable terminations that carry high levels (above a few Volt).

CONNECTORS

A cable is only as good as its connectors and this is an area where massive improvements are possible. The typical five-way binding posts and standard 4mm banana plugs are by no means satisfactory when highest accuracy power transfer is required. Few of the connectors currently used by amplifier manufacturers can guarantee acceptable performance. They often make insecure contact and have tolerances that are too large. Consequently, they should not be used at the outputs of high-accuracy power amplifiers.

To assure that power amplifiers are capable of pristinely driving the most difficult loads without limitation, the interface between the amplifier and speaker must have the ability to transfer the extremely dynamic output currents and voltage without any losses in signal transfer accuracy or any change in amplifier performance. This required the development of high-precision, lowest-loss connectors featuring ultra low contact resistance and extensive and wide secure contact area.

FM ACOUSTICS' unique FORCEPLUG 200 and FORCELUG 25 connectors were specially designed to avoid the shortcomings of usual connectors. They provide ultra-low resistance contact areas with optimal conduction (the contact resistance is less than 0.0008 Ohm. The result is accurate and pristine signal transfer between the power amplifier circuitry and the speakers. The special coating of FORCEPLUGS and FORCELUGS has been designed to provide optimal results with various materials such as silver, tin and even gold.

PRESSING OR SOLDERING?

When comparing pressed (crimped) and soldered connectors, one must realise that in the case of the pressed connector the cable area that is in actual contact with the connector is much smaller than when a connector is well soldered. In the crimped connector only a small area of the cable's surface is actually making contact with the connector surface. Such surfaces are in reality not at all as smooth as they appear to the human eye. Under magnification the roughness of the surface becomes clearly visible. It looks much like a "cross section of the Alps". With pressed (crimped) cables only a small surface area, (the "peaks of the Alps") is in actual contact with the connector.

When soldering, however, the solder fills out the troughs (valleys), thereby increasing the actual contact area by a huge margin. This is why connectors carrying high power must be **soldered** and **not pressed** (crimped) despite that crimping is much faster and cheaper. FORCELINES® cables are precision-soldered by hand using unique MIL spec (military) materials that guarantee ultra-low resistance, freedom from corrosion and long-term stability.

CONCLUSION

It is a *combination* of various factors that results in the really quite unparalleled performance of FORCELINES®. By installing FORCELINES® one is assured that the connection between amplifier and speaker is **optimal**, and this is so with **any** amplifier-speaker combination. FORCELINES® have been installed in the world's top recording studios and concert halls where not fancy designs are important but optimal verifiable results must be achieved.

Due to their unsurpassed performance, FORCELINES® also provide an excellent solution for system grounding. Cables used for grounding must have wideband transmission because all of the interference and common mode signals that are present on the ground and shield must be optimally transferred to the central ground so that they cannot have any negative influence on audio circuitry. Therefore, it is not good enough to simply take a "massive copper cable" or a "jumper cable" as the frequency characteristics linearity and reflection characteristics of these are not satisfactory.

Each and every mOhm (mOhm = 1/1000 of one Ohm) of lower resistance achieved through proper grounding and earth wiring can bring noticeable performance improvements in critical situations in recording studios, concert halls, broadcast, sound reinforcement and other applications. Interference rejection is improved and the noise from each part of the entire system can be lowered (often by an astonishing degree).

FORCELINES® constitute a truly sound economical investment. The unique construction of FORCELINES® results in optimal lowest-loss transfer characteristics for a wide frequency range.

No bi-wiring is required when using FORCELINES®. In certain systems this further increases savings.

FORCELINES® use heavy-duty, high-temperature resistant insulation material that has ideal di-electrical characteristics. The cables can be operated at temperatures of up to 80° C and are therefore also ideal for very demanding industrial applications.

The FORCELINES® concept of addressing the *entire* high-level signal transfer (source, cable, connectors and load) is unique. For quality applications no other cable/connector interface is comparable.

FORCELINES® by FM ACOUSTICS

You've never heard it so good!



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REPORTS ON FORCELINES®

Upon installing **FORCELINES®** even medium class systems can benefit as is reflected in the statements on the attached sheet

A client who was initially somewhat sceptical:

*"I would like to confirm how much I have been satisfied with your **FORCELINES®** 5 cables. Since installing them I get a much more detailed bass and the high frequencies are incredibly improved. I also believe that the cables' propagation time is shorter. And the timbre is far more natural. This result is very surprising, as my installation is relatively modest and over 9 years old."*

The performance of **FORCELINES®** has been tested by the most demanding professionals. In a carefully controlled test at the reference installation located in Nashville, **FORCELINES®** positively outperformed the cables that so far were regarded as the best. Among the numerous comments were the following:

*"Both cables were exactly the same length and perfectly terminated. Great care was taken that everything was identical, so a true A-B comparison would be possible. The difference between **FORCELINES®** and the other cables was not subtle. That is quite an accomplishment for **FORCELINES®** as so far the other cable has been the most highly touted speaker cable on the market."*

Glenn Meadows, president of Masterfonics

Another comment from the same test:

"There was absolutely no contest. The other cables clearly exhibited current saturation. At low levels the other cables were just about acceptable, but at middle or high levels it sounded like the source had gone into tape compression."

World-renowned engineer-producer Tom Jung of DMP Records made the following comment after installing **FORCELINES®** in his reference system:

*"I have been going through many changes with my reference monitoring system, using different speakers and experimenting with different cables. I've come to the conclusion that FMACOUSTICS cables are excellent. When it comes to speaker cables, **FORCELINES®** are the most transparent cables I have ever heard. They simply add nothing to - nor do they take anything away from - the music."*

"Thank you for making such great cables!"

Tom Jung, DMP

*"I wanted to let you know that we've chosen the FM ACOUSTICS 811 and **FORCELINES®** speaker cables as Dorian's references for our monitoring system! While using the FM 811 and **FORCELINES®** cables, I am able to hear substantially more detail and graduations in tonal color, as well as more of the subtle spatial cues that we use in selecting and placing our microphones in setup. I am more able to discern from what surface a particular reflection is coming, and what coloration to the sound that particular reflection it is producing, more quickly, and with less guesswork. With **FORCELINES®** cables the 'window' through which we look into the recording seems to be 'cleaner'. What this all translates into, is better recordings from Dorian.*

*In addition, one of the more impressive features of the FM 811 **FORCELINES®** combination is their ability to control loudspeakers in the low end of the audio spectrum where time-coherent current delivery and speaker control are most critical. Our organ recordings with Jean Guillou and our orchestral recordings with the Dallas Symphony are particularly challenging to amplifiers and their ability to control woofers. The FM ACOUSTICS amp and cables produce a seemingly bottomless and distortion-free low-end, with absolute control of the loudspeakers."*

Craig Dory, president of Dorian Recordings

An electronics engineer described his experience as follows:

*"As an engineer I thoroughly understand signal transmission and I have taken all steps necessary to ensure optimal signal transmission in all parts of my system. Then my friend recommended that I try **FORCELINES®** and, since I am retired and have the time to do so, I made very careful long-term comparisons. What I heard was simply arresting. There is no cable that provides anywhere near the performance, the emotional detail, and the deep clarity that are present when using **FORCELINES®**. In my opinion the designers have almost performed magic. I do not like that particular expression but there is really no other word which better expresses the effect achieved. **FORCELINES®** have become the blood veins of my system."*

Nick Namish, Regina, Canada