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## **SPEAKER WIRE**

BY

**JOHN F. ALLEN** 

H/GH PERFORMANCE STEREO™



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## SPEAKER WIRE By John F. Allen

I can hardly think of another audio subject that evokes more snickering, groans and rolling eyes among audio engineers than the topic of speaker wire. In the 1970s, special speaker wires began to be marketed with substantial claims for improved sound quality. Almost immediately audio enthusiasts seemed to divide into two camps, one convinced that these claims were true, the other saying that such claims were overstated at best. While the debate still goes on, little seems to change. People have tended to stay with the same positions that they decided upon years ago.

Initially I was one of the skeptics. My feelings about expensive speaker cables were surely strengthened over time as three different manufacturers gave me a set of their wires to try. One of these sets was mailed to me anonymously. Perhaps someone forgot to include a cover letter. Needless to say, I have no idea where it came from. In fact, I do use one of the sets of special speaker cables I was given. At the time they arrived, the custom made pair sold for \$720.00. I compared the sound I heard with both my inexpensive wires and the \$720.00 wires. After several weeks of this, I could find only one cymbal crash in one recording where I thought I could hear a slight difference. What's more, I couldn't really tell if the difference was an improvement or not. However, because they are here and the connectors are so beautiful, I still use the \$720.00 speaker cables in my home system.

Some ten or more years ago, there were at least two well done studies that tested a variety of speaker wires, from the wildly exotic to the ordinary lamp cord available at any hardware store. One was published in the Journal of the Audio Engineering Society and the other was a report to the Boston Audio Society done by the late physicist Peter Mitchell. The tests performed for the AES paper led to the conclusion that a pair of stranded No. 12 gauge wires was every bit as good for connecting speakers as the more expensive and exotic stuff.

Mitchell's experiments were, as usual for him, especially fascinating because he compared wires in pairs, with one type of wire on one side and a different type on the other. These wires were connected to a transformer at the far end. The common mode rejection of the transformer would cancel any similarities between to two types of wire being compared and leave only the differences, if there were any. These tests found no significant improvement when using fancy speaker wires instead of ordinary stranded pairs. There 2

was one exception where a particular brand of speaker wire did produce measurable differences. However, these differences were not found to be meaningful for audio.

Today, there are many who still worship at the alter of some extremely expensive speaker cables, some of which are the size of small fire hoses. So which is it? Does elaborate and expensive speaker wire make a difference, or is it just a lot of silly hype? In my experience, the answer is a little of both. And in movie theatres, with their long runs between the amplifiers in the booth and the speakers behind the screen, the type of wire chosen does matter -- although not necessarily the way some might think.

A prime goal for a sound system designer is to make the best possible connection between the speakers and the amplifiers. Ideally there should be no resistance, inductance or capacitance introduced by the speaker wires. One's first thought might be that the best way to achieve this is to locate the amplifiers behind the screen. Electrically, this approach makes sense. However, it is not very practical because it makes servicing the sound system very difficult. In addition, the dust and dirt that collects behind a movie screen creates the worst possible environment for power amplifiers that need lots of clean air blowing through them to stay cool.

To illustrate, imagine a typical movie theatre installation where a pair of stranded No. 12 wires is proposed for each of the screen speakers in an auditorium that is 80 feet long. For the sake of access and cleanliness, the amplifiers are in the booth. We need to chose a wiring scheme that retains the properties of short runs, no matter how great the distances are between the amplifiers and the speakers. In addition to the 80 foot length of the theatre, additional lengths of wire are required in the booth to reach the amplifiers in their racks. Behind the screen, there is also the distance from the various speakers to the point where the wires appear, typically somewhere above the top of the screen. A good rule of thumb for determining the length of wire needed for the screen speakers is to add 75 feet to the length of the theatre -- even more in very large theatres. Thus, an 80 foot long theatre would typically require screen speaker wire runs of about 155 feet.

When selecting speaker wire, one of the first things to consider is resistance. This is because resistance between the amplifier and the speaker, has a negative effect on the speaker's performance. The reason is connected with a rather obscure thing known as the damping factor. The damping factor refers to the amplifier's ability to control the motion of the speaker's moving diaphragm. The diaphragm must move to produce sound so it's important that it move only as much as the signals from the amplifier demand. This is especially true with low frequency drivers. Their large cones are subject to some rather fast accelerations, then made to suddenly stop and go back the other way. If poorly controlled, the cones can overshoot. When this problem is prevented, the sound, particularly the bass, is typically described as tighter.

Modern solid state amplifiers have very high damping factors, as high as 200 or more. As such they can control speakers pretty well. However, any resistance in the speaker wire will diminish the damping factor. Thus it is critical that we achieve as low a resistance as is practical. To do this we use bigger wire. But how big does it really need to be?

While one could correctly argue that there is no such thing as a speaker wire that is too big, it seems to me that we can certainly live with a round trip resistance of 1/4 ohm for woofers (perhaps a little more for high frequency drivers). In other words, the resistance of the speaker wire from the amplifier to the speaker and back should not exceed .25 ohms. While we can refer to tables to calculate the resistance in wires of different sizes, it's easier to remember that 1000 feet of No. 10 wire has a resistance of around 1 ohm. In addition, if we go up or down three wire sizes, the resistance is changed by a factor of two. So, 1000 feet of No. 7 wire would have a resistance of about .5 ohms, 1000 feet of No. 13 wire would have a resistance of 2 ohms, and so on. Since we usually don't see wire sizes of odd gauges, we can simply adjust these figures up or down a little when working with wire gauges of 6, 8, 12, 14, 16 or 18.

Using this approach, the 310 foot round trip lengths of No. 12 wire proposed for the screen speakers in our 80 foot long theatre, will have a resistance of about .5 ohms, twice the .25 ohm goal. Using the larger No. 10 wire would help by giving us a round trip resistance of about .31 ohms -- close, but not good enough. In this theatre, a pair of No. 8 wires would be just right, giving us a round trip resistance of about .2 ohms.

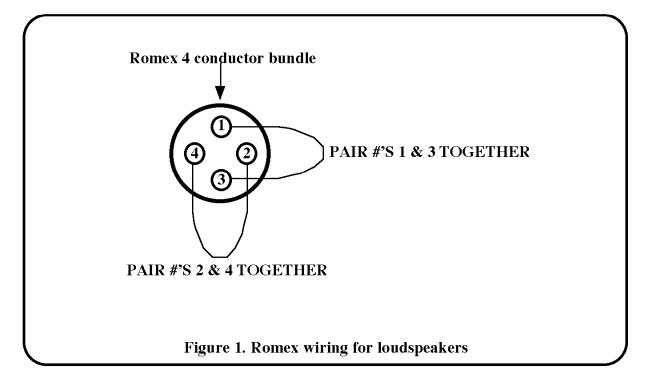
Once the question of resistance in speaker wires is resolved, does it matter what type of wire is used? Should it be stranded, or would solid conductors do as well? Should these conductors be twisted or run straight? The answer to the latter is simple -- the wires should be twisted as this helps reduce pick up of any radio frequencies. This is fairly common knowledge. However, twisting the wires adds considerable length if done too tightly. I normally recommend about a half twist per foot.

The question of solid versus stranded speaker wire is a little more complicated. Perhaps the most complicating issue is the simple fact that many audio technicians have been trained to think that solid speaker wire is simply wrong. Certainly I once thought so. Others have disagreed and advocated that solid wire as actually superior. In the final analysis, the only way to really know whether stranded or solid speaker wires are better is to try them both. Thanks to the insistence of one of my clients, I did just that. Perhaps I

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should say that he did, as, like everyone else I know, I was trained to believe that speaker wire must ALWAYS be stranded.

It turns out that over the long distances encountered in movie theatres, stranded speaker wire begins to lose high frequencies. This was first brought to my attention by Kintek's David Blackmer. He showed me his calculations and a graph that he plotted that predicted a substantial loss of the higher audio frequencies when transmitted over a few hundred feet of stranded THHN wire. I was startled as I had never heard the effect. But then, of course, how would I know? Since the screen and the air itself attenuate high frequencies before they reach our ears, who could tell if the wire was also adding to the losses? In any event, an incremental decrease in high frequencies, no matter the cause, would simply be corrected by the normal adjustment of the treble control. Blackmer suggested that if one used four-conductor, solid, round Romex wire and (this is important) connected the opposing conductors together at each end to cancel inductance, the frequency response would be flat over such long wire runs. See Figure 1, Of course, grouping four conductors in this way also halves the resistance. Using No. 10 conductors would yield the equivalent of a pair of No. 7 wires. If all this were true, the installation of speaker wires in some movie theatres could be substantially simplified at a lower cost.



So came the test. We were fortunate in that we had previously installed a system in a large theatre. The length of the theatre was such that pairs of No. 6 THHN stranded speaker wire were installed. These pairs were twisted, making the installation more difficult and

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time consuming. A new complex was being built in the same area and was to be outfitted with the same speakers as we had used in the earlier installation. The screen speakers in the new theatre were wired with No. 10-3 solid round Romex *with bond*. The round trip resistance of the screen speaker wires in both theatres was about .16 ohms. As anyone who has wired a house will know, the bond wire is a bare conductor of the same size as the other three, but with only a paper covering rather than insulation. As such, a No. 10-3 Romex with bond is a four conductor bundle. What's more, the wires are rotated within their jacket so the installer doesn't need to twist anything. In Europe, this kind of wire is sold with four fully insulated conductors.

When the new theatres were complete, we performed a simple comparison: While playing pink noise through one of the speakers, we connected a real-time-analyzer to the each end of the speaker wires and recorded any losses from one end to the other. Sure enough, we found that at the speaker-end of the stranded wire, the frequency response was down -5 dB at 20,000 Hz, while the frequency response at the speaker-end of the solid Romex wire was flat. The solid wire won the test. In addition to the flat frequency response, the inductance was also minimized. All told, we had made a superior connection between the amplifiers and the speakers. The installation was simpler, faster and the cost of the wire itself was less than the stranded THHN type. Best of all, I had learned something, even if it had been grudgingly.

Since then, I have specified No. 10-3 solid round Romex with bond for all the screen speakers in my installations. While some smaller theatres could be properly served by the smaller No. 12-3 Romex, I usually suggest that installers standardize the a single size of No. 10-3. A wire that may be a little larger on occasion is never a bad thing.

After a while, I became convinced that the sound quality in the theatres wired in this way was slightly smoother. I should stress, however, I could only notice this because I was listening to the same program materials in all the theatres. I doubt I could ever walk into a theatre and know whether the speaker wire was stranded or solid.

Surround speakers may still be wired with No. 12-2 or 14-2 stranded copper wire. It is the most practical. The least expensive spool one can find is as good as the most expensive. In any case however, as I mentioned in a previous article, it is always best to run a separate pair of wires from the booth to each surround speaker. The half twist per foot rule should also be followed.

With only a barely perceptible improvement in sound quality, the use of solid round Romex wire for screen speakers turns out to be mostly a matter of convenience and reducing costs. But however small the gain, better is better. It does provide a superior connection by giving us the properties of a short wire run over long distances, so it makes sense to use it when possible. However, due the sheer number of conductors involved, when the speakers are bi-amplified or tri-amplified, stranded THHN wire of appropriate size is probably the most practical to install. In the event a local electrical inspector will not allow the use of Romex for speaker wires in a movie theatre, even though it is used only for low voltage, I simply use stranded THHN or run the speaker wires in conduit, if the inspector will approve. The choice of speaker wire in motion picture sound systems should not be made out of some conviction, but rather with common sense.

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John F. Allen is the founder and president of High Performance Stereo in Newton, Mass. In addition, he serves as the sound director of the Boston Ballet. He is also the inventor of the HPS-4000<sup>®</sup> cinema sound system and in 1984 was the first to bring digital sound to the cinema. John Allen can be reached by E-mail at johnfallen@hps4000.com.