DCC Impulses Column

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photos and illustrations by the author

Getting more sound out of your locos

The acoustic design of sound DCC decoder installations are frequently challenging. Getting the right baffling or enclosure is important. See my August 2012 column, ***How Do I Get The Sound Out?*** (http://model-railroad-hobbyist.com/magazine/mrh-2012-08-aug/dcc_impulses - MRH tiny URL?) for some of the basics. What I'm offering in this column is another tool in the toolbox, multiple speakers.

There are several reasons for wanting more than one speaker in an installation:

- Better bass reproduction – doubling the number of speakers can add an octave of bass. One speaker upgraded to two is frequently good; two to four can help; more than four is usually a lost cause.

- Adapting to the available space is sometimes easier with two (or more) speakers - two rectangular speakers in the hood of a road switcher diesel or a small car (figure 1) are frequently possible and usually sound good.

- Distributing the sound over several units, such as:
    - Steam loco and tender - in reality tenders don't make much noise, but they are one of the best places to put speakers in models.
    - Multiple Diesel units with a single sound decoder - "MU hoses" can carry audio between units to distribute the sound across a lash-up.

1: N-scale Kato baggage car with (an older) DSX sound-only decoder and two speakers to improve bass response

Starting out let me say that I'm going to deal with multiple **identical speakers** in this column. I've tried larger (woofer) and smaller (tweeter) speakers with crossover networks in models. Even in G scale, where I could use a 4-inch in the tender and a 1-1/2-inch in the smoke box, I found the results were less than what I wanted and certainly not worth the effort or expense. In that case, the 4-inch provided a depth of sound that was only diminished by trying to add a "tweeter".

Decoder Specifications

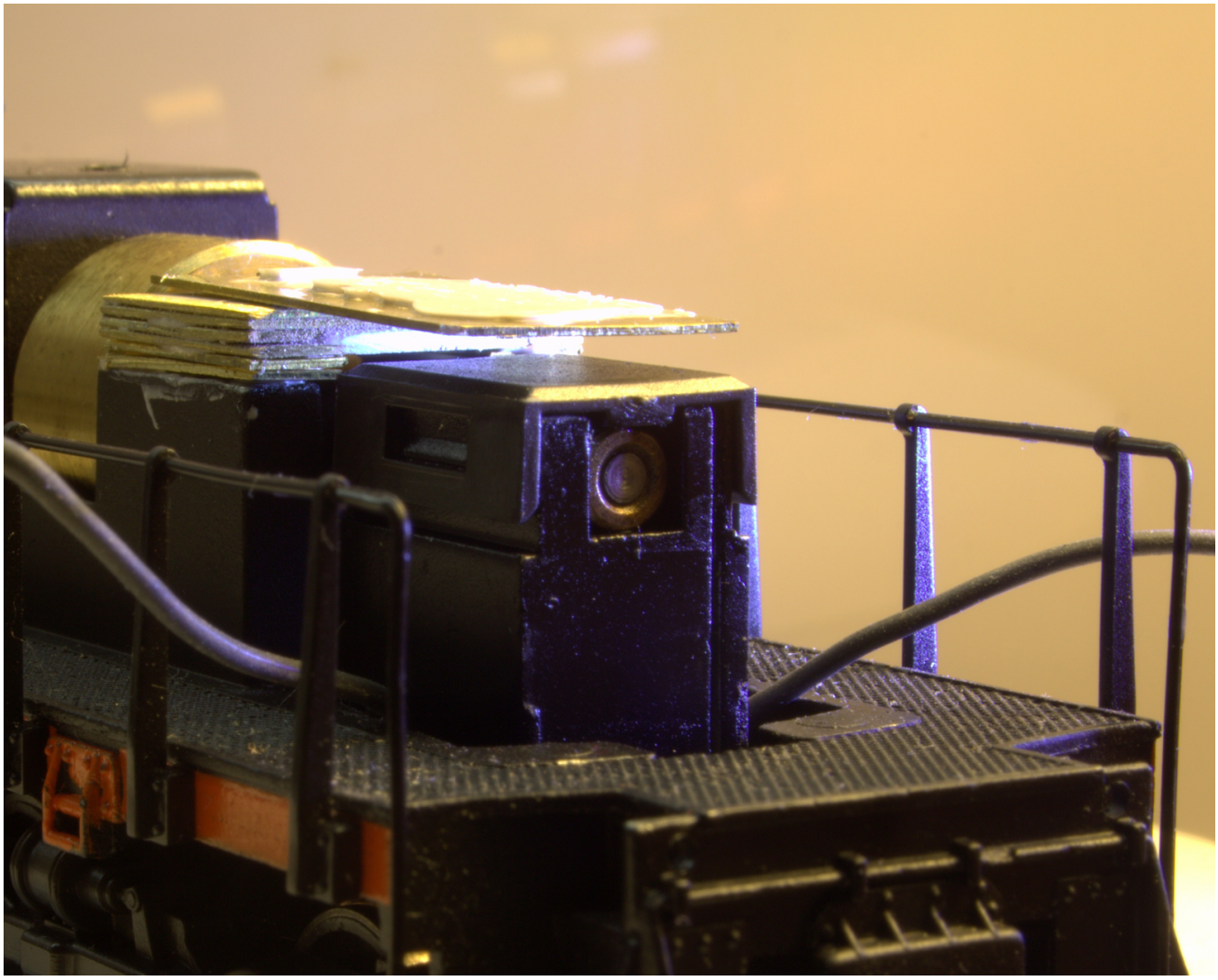
Your decoder was designed to provide a certain amount of audio power into a specific load impedance. A very common rating is 1 watt into 8 ohms. Does this mean that you can't have different load impedances? No. But the amplifier will change based upon the load. Some of these changes may be good. Some may be fatal to the amplifier or the speaker(s).

Lower impedance (4 ohms, for example) will **increase** the load on the amplifier, making it work harder. It may be able to provide more power into the lower impedance: for example 1.5 watts into 4 ohms. The cost of this increased power is more heat in the amplifier. This added heat might damage or destroy the decoder, depending upon the amplifier design.

Higher impedance (say 16 ohms) will **reduce** the load on the amplifier, but the amplifier may not be able to push as much power into the lower load: 3/4 watt into 16 ohms would be a common result. Generally, higher impedance loads are not harmful to the decoder; you just reach a point where the diminished audio power isn't compensated by the increased efficiency of adding more speakers.

I recommend checking with the decoder manufacturer before you contemplate any impedance other than the rated load, be it a single value or a range of loads.

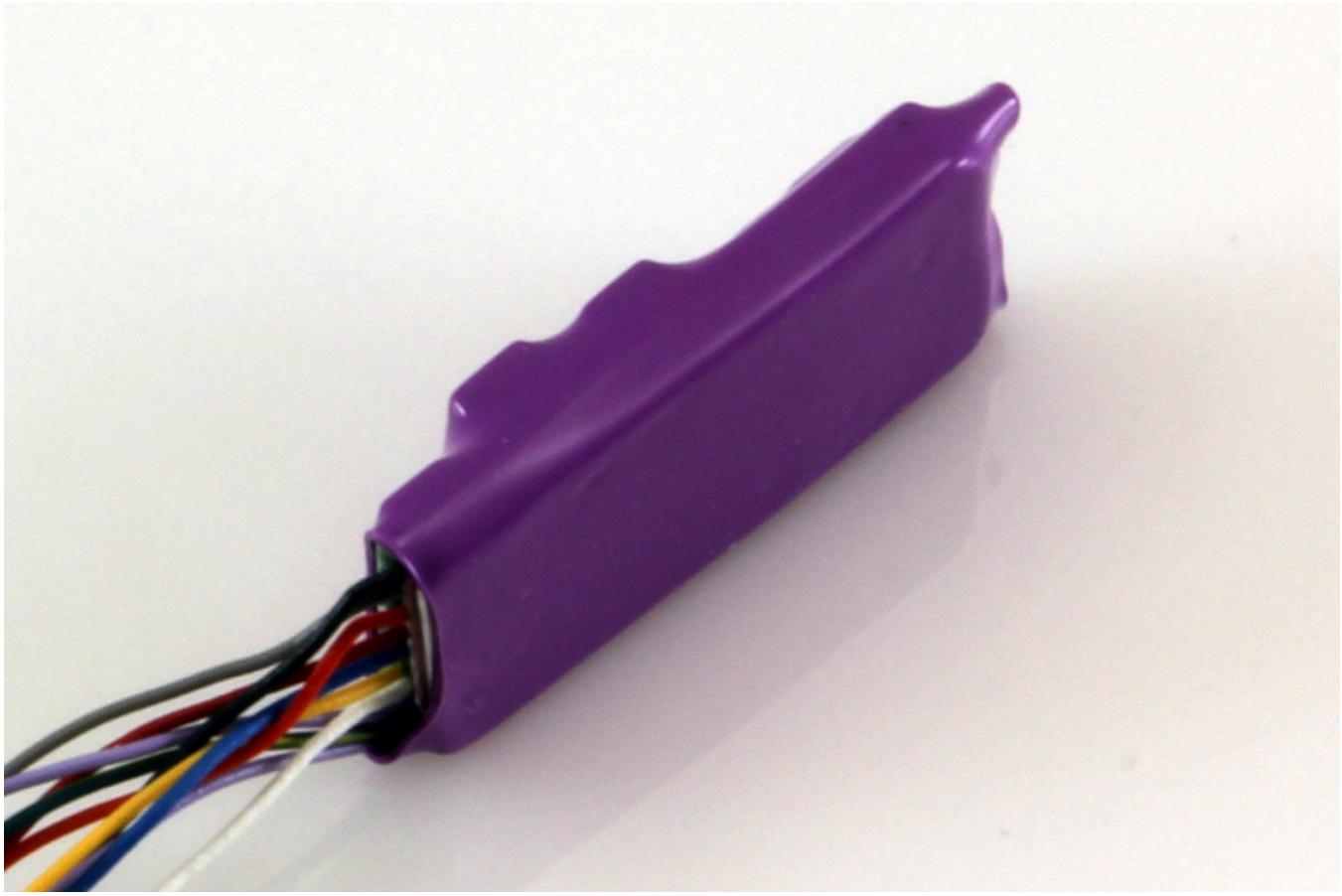
Heat



2: Atlas HO S-2 loco with brass riser and plate for mounting a TSU-750 Micro Tsunami decoder - the brass conducts the heat from the decoder into the frame of the loco - glued together with thermally conductive epoxy.

Be aware, as we make smaller and more powerful (both electrically and feature-wise) decoders, heat generated inside the decoders becomes more of an issue. How the heat will get out of the decoder should be a design criterion in every installation. With small sound

decoders, it becomes very important. If you are contemplating pushing the envelope on load impedance (4 ohms on a decoder rated for a nominal 8 ohms), then heat may become an even bigger issue.



3: TSU-750 Micro Tsunami, showing flat side where the internal heat sink is located – this should be attached to a metal surface to remove heat from the decoder.

Figure 2 shows a mounting plate for a TSU-750 micro Tsunami I built out of brass sheets held together with thermally conductive epoxy (see my December 2012 column - mrhmag.com/dec-2012-dcc-impulses). Brass sheets (0.032 thick) were cut to the size of the top of the frame where the driveline went between the motor and the front gear tower. They were stacked up until they were tall enough to clear the gear tower at the limits of its height when pivoting and swinging. Then a single sheet was glued extending forward to provide a decoder mounting location. In the photo, a bit of white epoxy is visible where the decoder mounts. I had mounted and decoder on this stack and removed it by light prying. The Alumina Thermal adhesive broke cleanly away from the decoder shrink tubing. A dab of thermally conductive epoxy and the decoder will be back in place – flat side against the brass plate.

So how does this work? The components inside the decoder that need to be cooled are connected through thermally conductive foam to a metal plate that is held in place with

the shrink tubing. That makes one side of the decoder flat. This flat side (right side in figure 3) is held down to the brass plate (2) with thermally conductive epoxy. The heat is conducted from the decoder into the brass plate and into the frame of the locomotive. The heat that is conducted away in this fashion will help keep the decoder cool.

With that technical stuff aside, let's get started planning an installation.

What will physically fit?

Sometimes things just work out. When you open up a loco to put sound into it, you find a pre-made opening for a standard size speaker (or two) and you are good to go.

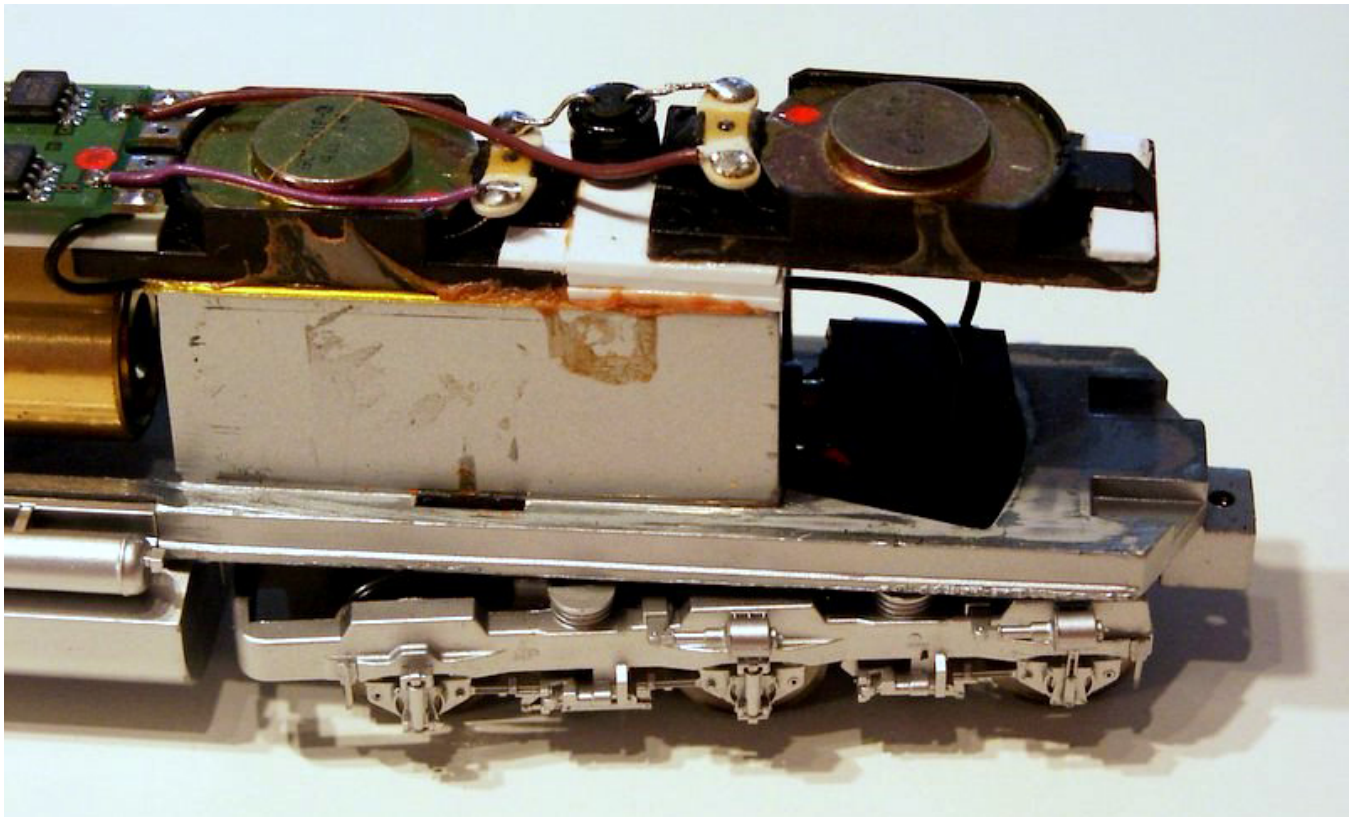
When converting older locomotives, frequently the installer is left with the task of designing the acoustics as well as the normal issues of an installation.

4: Line array of four identical speakers - wired in a series-parallel combination, the resulting unit is rated at 8 ohms and 8 watts.

For example, I was asked to install sound into an O-scale F3A. The top of the shell had a lot of fan grill openings, but the space below them was a long rectangle. To maximize the sound, I used the array shown in figure 4. A total of 4 (27 mm diameter round high-bass) speakers were assembled onto t sheet of thick (0.08 to 0.10 inch thick) black plastic. This was sealed to the roof of the locomotive so that the sound would be forced out the top of the loco and the negative pressure (see my August 2012 column, if you don't understand the term) gets routed through the loco and out the openings for the trucks.

Similarly, I had room for two 16 x 35 mm rectangular speakers in an Athearn Genesis SD-75M HO-scale locomotive, as shown in figure 5.

Okay, once you decide on what sort of acoustic baffling you are going to use and what size speakers will fit, it is time for the electronic side of the design.



5: Two 16 x 35 mm speakers in an HO-scale Athearn Genesis SD-75M

Impedance

Okay, you now know what impedance your decoder wants to see and what range it will tolerate. You also know how many speakers you want to use in your installation. For the purposes of this column, I'm going to assume that you are using a decoder that is designed for an 8-ohm load and will tolerate any load between 4- and 16-ohms. So my goal is to provide as close to 8-ohms as possible and not to go outside the 4- to 16-ohm range. See ***Mr. DCC's Workbench*** at the end of this column for more insight into speaker specifications.

There are two ways to wire two electronic elements: series and parallel. How you wire multiple speakers will determine what the total impedance seen by the decoder will be.

Series wiring is where all of the electrons go into one unit and come out and go through the second unit. When you wire two identical speakers in series, the impedance doubles: two 8-ohm speakers in series will be a total of 16-ohms. With three identical speakers in series, the impedance triples: three 4-ohm speakers in series will yield 12-ohms.

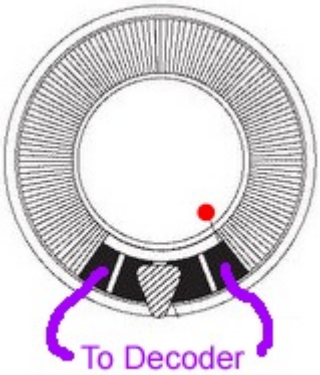
Parallel wiring is where the electrons split and part of them go through each unit and they join up together afterwards. Wiring identical speakers in parallel will halve the impedance: two 8-ohm speakers in parallel will provide a load of 4-ohms.

Polarity

If you are only wiring one speaker to a decoder, the polarity markings on the decoder or speaker are meaningless. Just hook them up and go.

While there are times when you want to intentionally wire speakers out of phase, they are few and far between in model railroading. So, I'm going to discuss how to have the speakers be in phase – meaning that the cones go in the same direction at the same time, effectively doubling the size of the speaker.

If you have any questions, try an experiment. Hook two speakers up in phase and listen. Reverse the leads to one speaker (making them out of phase) and listen. You will probably see a reduction in the low frequency (bass) reproduction and a loss of directionality of the midrange and high frequency sound. The sound will frequently appear to be in a large ball surrounding the locomotive, as compared to a point source between the speakers.



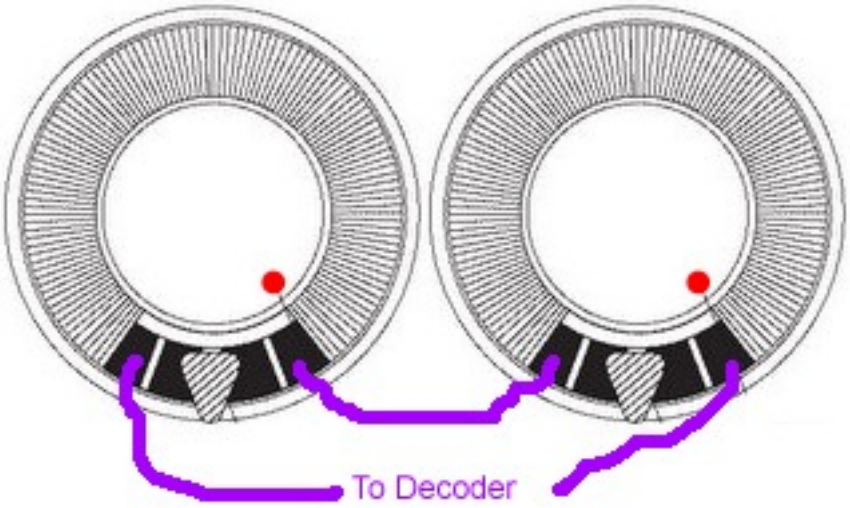
6: A speaker with a polarity mark (red dot in the drawing). The speaker probably will come with one. If not, you may add your own.

Over the years, I've only had one installation where I intentionally wired the speakers out of phase and it was for two switchers separated by a flat car with a speaker in each loco. The "ball of sound" worked better than the point source located in the middle of the flat car in this instance.

Speakers are usually marked as to polarity. If you look at the terminals on the (identical) speakers you are installing, you will probably find some mark next to one of the terminals. It may be a drop of paint or a variation in the shape of the terminal or something. Absent any other indication, just line the speakers up on your workbench, cone side down with the terminals facing you. Take a marker and put a dot next to the terminal on the right. Now you have a mark to use in wiring the speakers.

Two Speakers

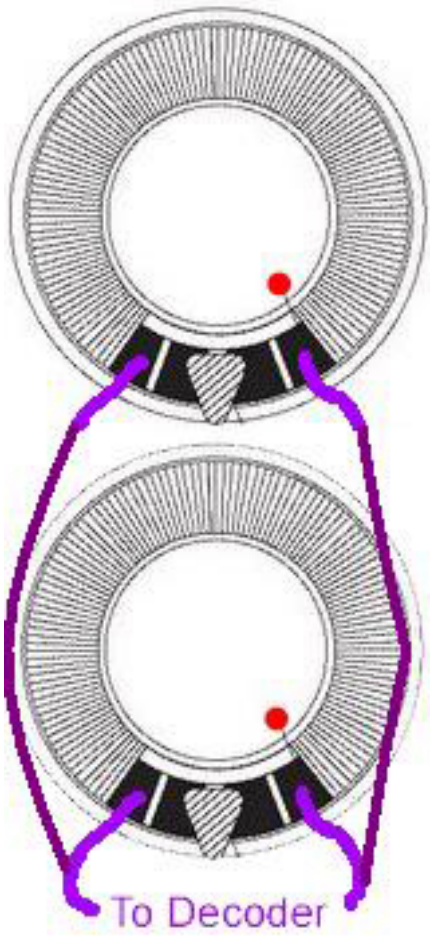
Be sure to know the allowed range of load impedance before selecting and wiring two speakers. Why? As I mentioned previously, when wiring two speakers, you have two choices as to final impedance: double or half the impedance of each.



7: Two speakers wired in series – the final impedance will be twice the speaker rating – 8-ohm speakers yield a 16-ohm load or 4-ohm speakers yield an 8-ohm load.

So, let's look at a decoder that likes 8-ohms, but will tolerate 4- to 16-ohms. If you are really lucky, the speaker size you planned on will be available in a 4-ohm version. Since LokSound has designed their decoders for a 4-ohm target, there are more and more 4-ohm speakers showing up in the DCC shops. That's great. Wire two 4-ohm speakers in series and you have 8-ohms, as shown in figure 7. Note that the connection between speakers goes to the marked terminal on one speaker and the unmarked terminal on the other. This is how the speakers are wired in figure 5. Don't worry; there is a capacitor between the two speakers instead of a wire, as the older decoder needed a capacitor. Modern decoders would just use a wire.

If you cannot find a 4-ohm version of your desired speaker, then use an 8-ohm version and still wire them in series. This will give a 16-ohm load that is usually better for the decoder.

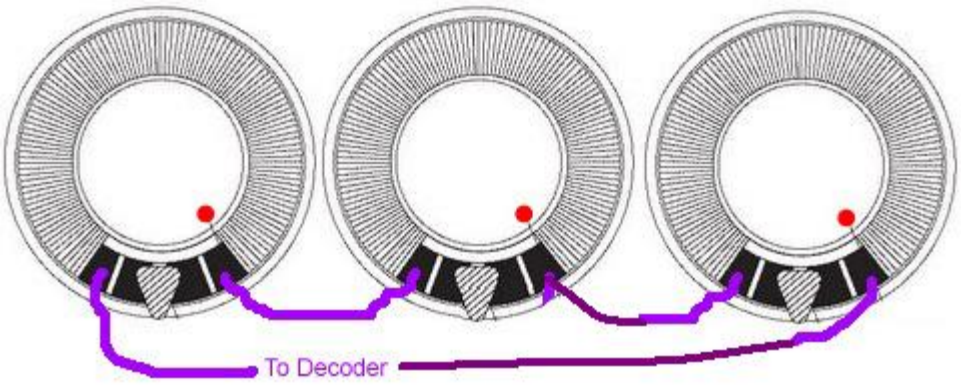


8: Two speakers wired in parallel – the final impedance will be half the speaker rating – 8-ohm speakers yield a 4-ohm load.

One exception to this idea is the current version LokSound decoders (or others) that actually like 4-ohm loads, so wire the two 8-ohm speakers in parallel, as shown in figure 8. That's why I suggested you find out what your decoder ***likes*** and what it will ***tolerate*** before you start.

Three Speakers

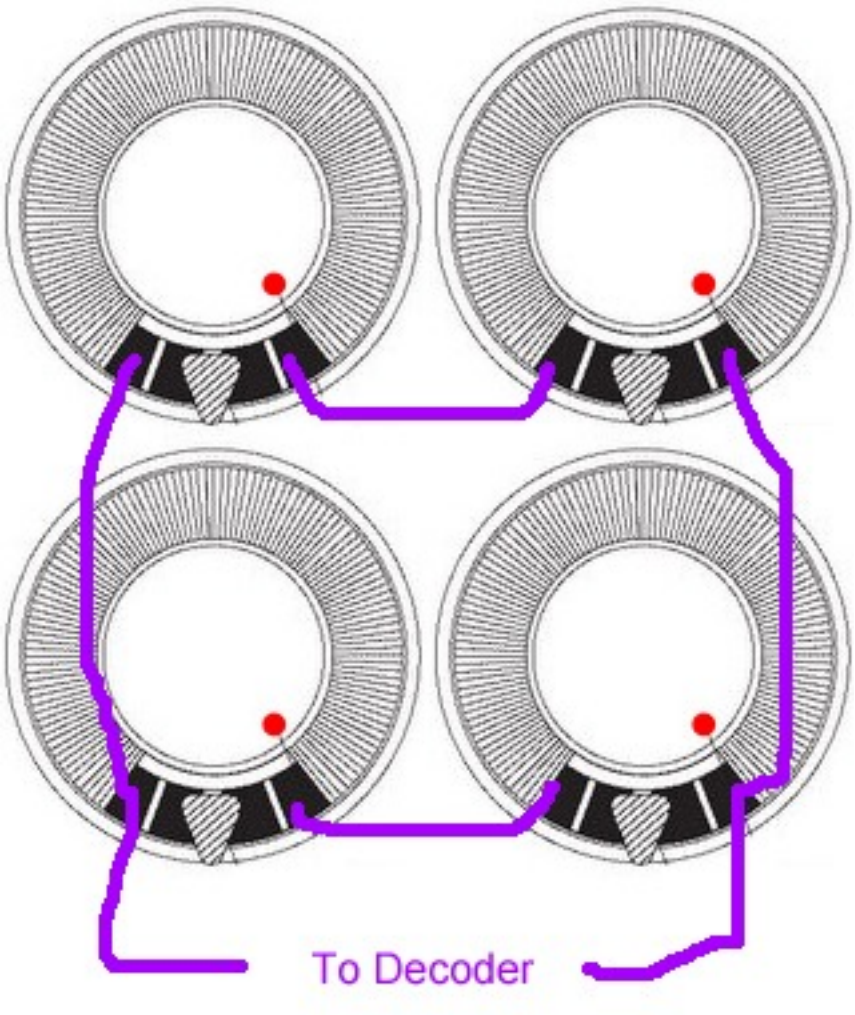
Three 4-ohm speakers in series, as in figure 9, will yield 12-ohms which will work just fine with almost all decoders designed for 8-ohms. I did this in a brass HO-scale Overland narrow hood diesel and the results were amazing.



9: Three speakers wired in series – the final impedance will be three times the speaker rating – 4-ohm speakers yield a 12-ohm load.

Four Speakers

The four speakers shown in figure 4 were wired in a series-parallel fashion. That is, two sets of two speakers are wired in series, as shown in figure 7. Each series group has twice the impedance as the original speakers. Then these groups are wired in parallel, making the final impedance exactly what the speakers started with. So, four 8-ohm speakers wired this way will yield an 8-ohm load. Figure 10 shows the wiring diagram.



10: Four speakers in a series-parallel array – the final impedance will be the same as the speaker impedance – 8-ohm speakers will yield an 8-ohm load.

Power rating

While it is usually not an issue, most speakers are rated for one watt of power and most decoders will only put out a watt or two, the total power rating of an array of speakers will be the rating of the individual speaker times the number of speakers in the array. For example, three 1-watt speakers in an array will handle three watts.

So, now you can see how speakers can be matched to the specifications of your decoders. For a bit more in depth on speaker specifications, check out this month's ***Mr. DCC's Workbench***. There is a bunch of data on my web site. I suggest you start at the speaker page (http://www.mrdccu.com/curriculum/speakers.htm) and work from there.

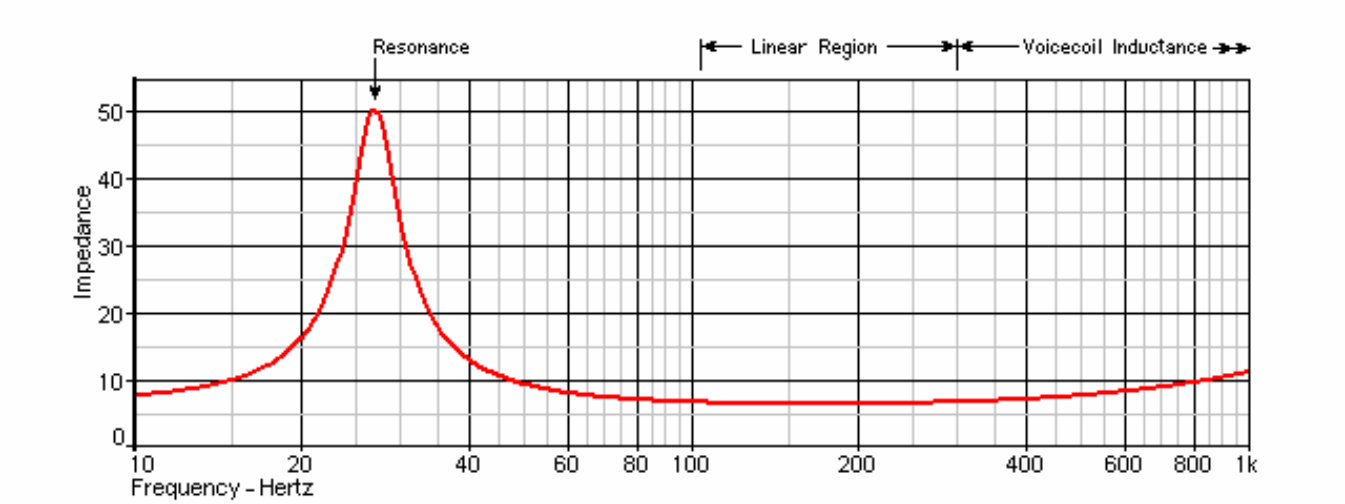
If you found this column helpful, please click on the Reader Feedback link here and rate it **awesome**. Please join in the conversation that invariably develops there about the topics presented in the column. Share your experiences. Thanks.

Until next month, I wish you green boards.

MR DCC'S WORKBENCH

Speaker Specifications

In this column, I've discussed speakers as if they had constant impedance, for example 8-ohms. They don't. Figure 11 shows a plot of impedance vs. frequency for a typical 8-ohm speaker. While this speaker would be too large to fit in our locomotives, the concept is what is important. How do I know that this speaker is too large? It has a resonant frequency in the 35 Hz range. Since one of the major contributors to this resonance is the size of the cone and speakers that fit in locos resonate from 100 to 400 Hz, this speaker is too large. It's just a matter of physics.



11: Impedance vs. frequency for a typical 8-ohm speaker, showing a resonance at about 35 Hz.

What is important to see is that this "8-ohm" speaker ranges from about 6-ohms to 50-ohms. So the decoder will not be seeing exactly 8-ohms at more than a few frequencies. It will be close, though. If you measure this speaker with a DC ohmmeter, you will probably get a reading around 5- or 6-ohms.

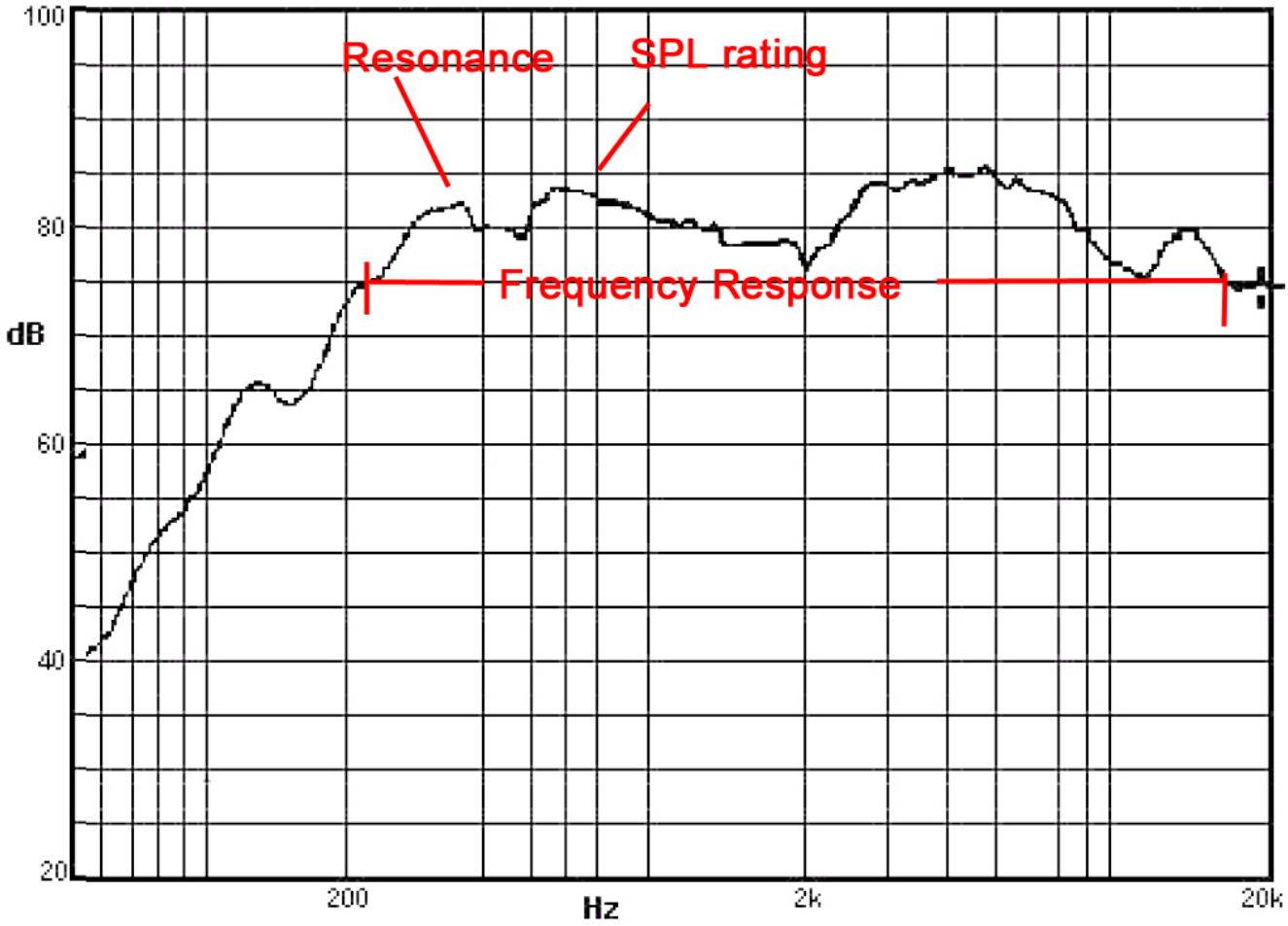
Another specification of speakers is frequency response. One might expect a nice smooth response, not what you see in figure 12.

There are several sound related specifications to take away from this chart.

First, the resonant frequency is the bump about 350 Hz. The lower this number is the better the bass response.

Secondly, the Sound Pressure Level (SPL) rating is usually calculated from the average of the output level at several frequencies around 1000 Hz. This speaker is rated at 82 dB. The larger this number, the louder the speaker will be.

Frequency response is usually calculated as the frequencies where the curve drops below a level 10 dB below the peak. This speaker peaks about 85 dB about 4000 Hz. So, the places where it drops below 75 dB will be the frequency response (about 225 Hz to about 16,000 Hz).



12: Frequency response (sound pressure level or SPL vs. frequency) of a typical speaker used in model railroading (28 x 35 mm – 8-ohms).