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Wiring Loudspeakers in Series and Parallel

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This article explains how to wire loudspeakers in series and parallel to achieve higher power handling capacity.

The specification for our ShockWave2/ShockWave sound modules calls for a loudspeaker with an 8 Ohms impedance. The power rating of the loudspeaker(s) must be chosen to handle the full power output capability of the sound module on the chosen supply voltage.

What does 8 Ohms mean?

The 8Ohms refers to the loudspeaker's electrical impedance. Impedance is a term similar to resistance, but contains additional elements of inductance and/or capacitance. To simplify the discussion here we will assume the loudspeakers' impedance is resistive across its operating frequency range. This is a gross simplification but to go beyond that is outside the scope of this article.

The ShockWave2/ShockWave modules are optimized for an 8 Ohm loudspeaker. Since I = V /R where V is voltage, I is current and R is resistance (or impedance), and $P = V^2/R$, where P = power, if you increase the speaker's impedance to say 16 Ohms, the current will half and the audio output power will also half, given the same voltage.

Therefore while it is possible to use loudspeakers with greater than 8 Ohms impedance, they will not sound as loud since they will receive less power.

On the other hand if you use a loudspeaker less than 8 Ohms above about 17 volts, the output amplifier on the sound module will have to pass greater current and will begin to shutdown automatically in the interest of self-preservation.

Loudspeaker Power Ratings

Loudspeaker Power Ratings can be very misleading and many manufacturers will state claims such as XX watts of "music power" or "peak power". They do this so as to claim higher power rating for their products than a continuous sine wave or "RMS" rating. For now we do not need to know exactly what RMS or "Root Mean Square" means, but it is essentially the average of a steady sine wave signal. "Music Power" or "Peak Power" is much higher due to the peaky nature of a music or voice signal.

Many sounds used in model sound effects systems are very repetitive and rhythmic such as engine sounds which also have a significant low frequency content (for the rumbling sound of the engine). When an engine sound is playing continuously, as it would be in most models, the power output is actually not all that peaky and is not far from the RMS value. Therefore loudspeakers need to be chosen with an RMS, or continuous, rating that matches the rated power output of the ShockWave2/ShockWave sound module.

As mentioned above, Power $P = V^2/R$ so as the voltage doubles, the power output will quadruple!! This is why the power output on a 12Volt supply is 10 watts, but on a 24Volt supply the power output can be as high as 40 watts.

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Loudspeaker Mechanics

We will describe briefly how a loudspeaker works and what the principle components are. The loudspeaker cone is attached to a ”voice coil” – a coil of several turns of wire around a tubular former that is attached to the cone. The coil is located in the gap of a powerful circular permanent magnet. Electric current flowing through the coil from the amplifier creates a magnetic force which causes the coil, its former and the cone to move in and out like a piston. The piston effect then pressurizes the air which we perceive as sound.

In order to make a loudspeaker sound louder, the air pressure that it creates – SPL or Sound Pressure Level – (measured in decibels above the threshold of hearing) has to be higher and so the cone must move more air and the cone excursion in and out has to be greater. This means the coil and magnet have to be deeper and the wire of the coil must handle greater current so it must be thicker wire. Therefore the size of the magnet becomes larger, both in depth and diameter.

These are the basic laws of physics and cannot be circumvented. This is why a small 2” speaker can only handle a few watts of power and why you cannot get a **LIGHTWEIGHT** 4 inch speaker that can handle much above 20 watts.

There are 4” loudspeakers that can handle 40 Watts or more, but these are intended for car audio or home audio applications where weight is of no concern, so they have very large magnets and frames and are very heavy for their size.

Model boats and tanks generally do not have such stringent light weight requirements as do model aircraft and in many cases a model boat requires several pounds of ballast to get the waterline down to the correct level, so instead of adding lead dead weight, you can add a heavy loudspeaker!

Model aircraft do not have that luxury and their loudspeakers must be chosen for high efficiency and low weight.

Using Multiple Loudspeakers in Series and/or Parallel

Given the above laws of physics constraining the physical design of speakers, it often makes sense to use more than one speaker so as to share the total power between them.

Wiring of multiple speakers must be done **VERY CAREFULLY** so as not to finish up with too low an impedance and not to wire them up in anti-phase to each other where they will cancel each other out instead of adding to the total sound output!!

We supply 8 Ohm and 4 Ohm speakers in the 4 inch 20 watt variety and 4 Ohm speakers in the 5” 30 watt size. The logic here is that on supply voltages of 17Volts and below, a single 20 watt speaker can handle all the output power of the sound module so a single 8 Ohm can be used. On voltages above that, say 24V or 6S LiPo packs, the power output is close to 40 Watts so you will need two or more speakers. Since 4 Ohm speakers are more readily available than 16 Ohm ones, you use two 4 Ohm speakers in series to get the desired 8 ohms total.

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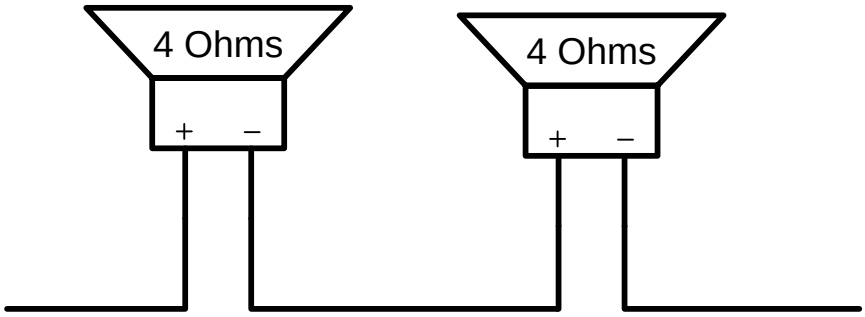
What is Series and Parallel Wiring?

When any two or more electrical devices are wired in series they are wired with one lead going to the next, daisy chain fashion like the old fashioned strings of Christmas lights where, if one bulb blew, the whole string went out. Series wiring is used where you want to keep the current the same, but use a higher voltage. This is equivalent to having a higher resistance, or impedance.

Parallel wiring is where each electrical device is wired across the other and both wires from each device go to the power supply. In this way the voltage is the same, but the current is much higher. This is equivalent to having a lower resistance or impedance.

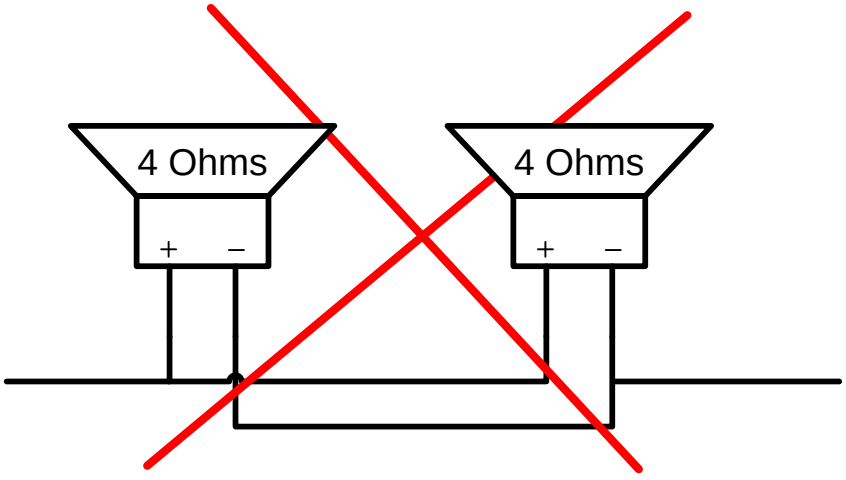
The diagrams below show two speakers in series and in parallel :

Figure 1 - Two 4 Ohm Loudspeakers in Series



Two 4 Ohms speakers in series – 8 Ohms total

Figure 2 - Two 4 Ohm Speakers in Parallel



Two 4 Ohms speakers in parallel – 2 Ohms total

You can see that the two 4 Ohm Speakers in parallel makes a total of 2 Ohms which far exceeds the drive capability of the ShockWave2/ShockWave sound module. You would need two 16 Ohm speakers in parallel to get a total of 8 Ohms.

My Speakers Don't Have +/- Markings On Them

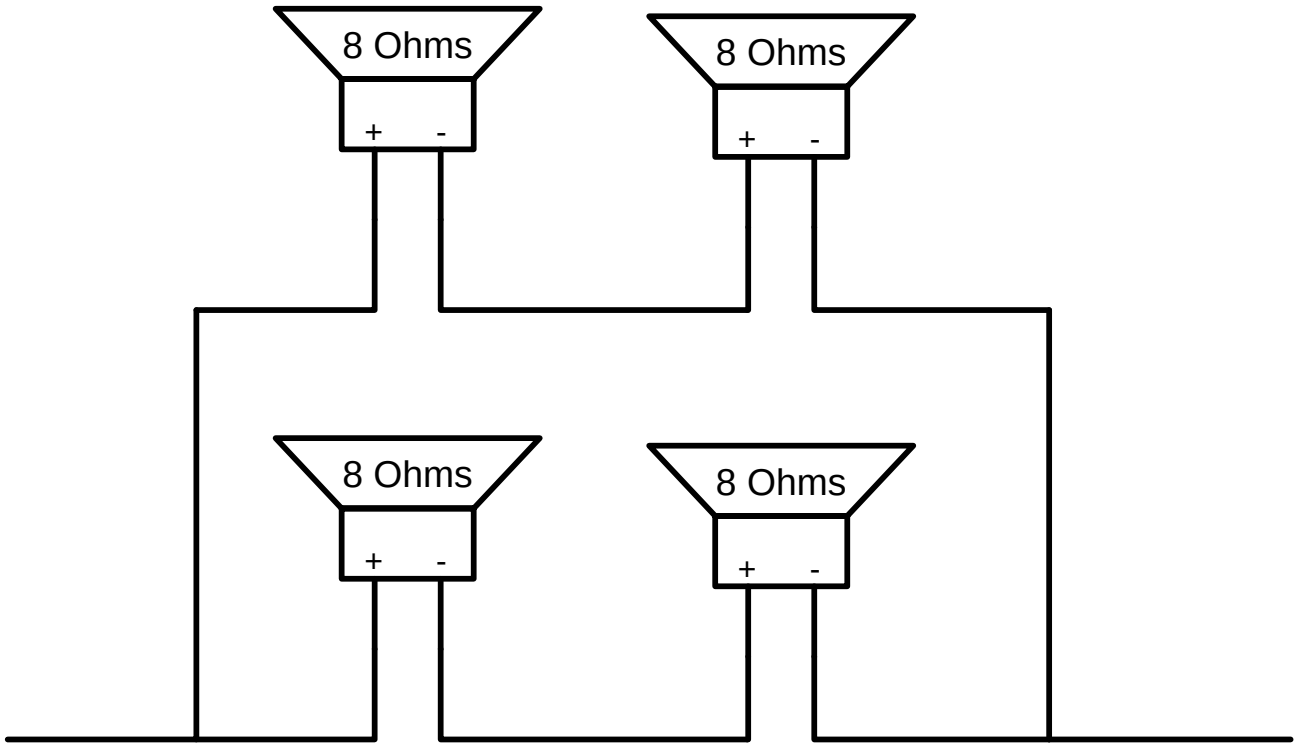
The +/- markings above are shown to illustrate that speakers are polarized. Many speakers don't have actual +/- markings on their terminals. Instead the terminals are usually of different shapes and/or sizes. The same principle applies, for series wiring the large terminal of one goes to the small terminal of the other. For parallel wiring each terminal goes to the same terminal on the other.

If you reverse the connections to one of the speakers in either of the above diagrams, the impedance will remain the same, but they will operate in anti-phase or in opposition to each other and will try to cancel each other out!!

Large Arrays of Speakers

To get very large power handling capacity, it is possible to use several smaller loudspeakers than one very large loudspeaker. This is also sometimes easier to install in a model. This is when you need both series and parallel wiring at the same time.

Figure 3 - Series/Parallel Wiring to Get High Power Handling Capacity



Four 8 Ohm speakers in series/parallel – 8 Ohms total

In such a configuration it is **DOUBLY IMPORTANT** to make sure that correct polarities are observed throughout the array.