Impedance – Basic Notes and Information

Impedance (Z)

Impedance is measured in ohms and can be defined as "resistance" (opposition to the flow of electrical current representing the audio signals). The theory behind impedance can get very technical, so we will only go into enough detail to help you understand the basics. Although impedance is usually only associated with speakers (which is incorrect), impedance is also measured at equipment Outputs (Source) and Inputs (Loads). And then there are Cable Impedances as well (which are not covered in this Handout).

a) Output Impedance: (also called "Source Impedance") Is the impedance (resistance) that is "Inherent" in signal sources. Output Impedances include: Microphones, Mixers, Signal Processors, Electric Guitars / Bass Guitars, Amplifiers (Power Amplifiers / Guitar Amplifiers), Digital playback devices, etc.

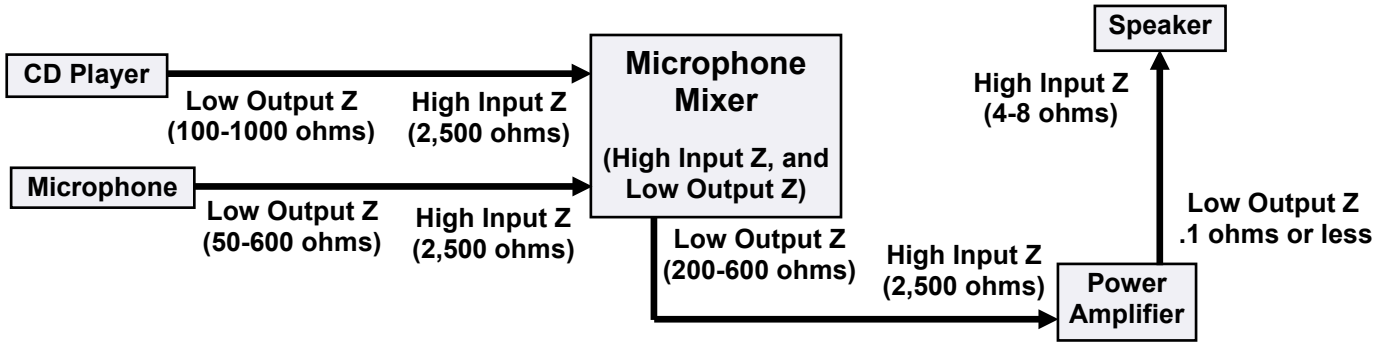
Note: Electric guitars / basses usually have higher output impedances (typically up to 12,000 ohms) due to the nature of magnetic pickups. Many current guitar pickup designs are exhibiting lower output impedances.

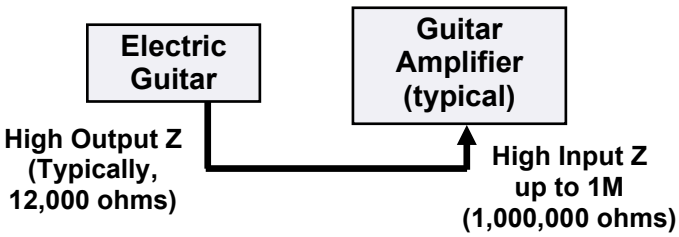
b) Input Impedance: (also called "Load Impedance") Is the impedance (resistance) that is "seen" by the signal source - Input Impedances include: Speakers, Mixers, Signal Processors, Amplifier Inputs, etc.

c) Impedance Matching: Is best described as the "appropriate" connection of Output and Input sources. When the output impedance of the source device is acceptable to the input impedance of another device.

Examples of Typical PA System and Electric Guitar Set-Up Below:

It is important to note that in Sound Systems - Outputs should always be "Low" Impedances, and Inputs should always be "High" Impedances.





Note: Notice that the Electric Guitar output and the Guitar Amplifier both indicate a "High Output Z." This is due to the "Output Z" on the electric guitar being higher as compared to the "Output" Impedances on other audio equipment. Since the guitar's "Output Z" is significantly lower when compared to the "Input Z" of the guitar amp – It is still considered a Low Output Impedance.

Notes on Cable Impedances: Shielded Instrument Cables are high impedance and low power. Speaker cables are the opposite – low impedance and high power. There is no advantage to using a Shielded cable as a speaker cable. One main reason is that smaller diameter cables will have more resistance to the signal flow and can waste an amplifier's energy output. The large diameter of a speaker cable allows better signal flow from the amplifier to the speaker. Using a larger gauge, twisted pair cable for speaker cable is highly recommended. One cable does not fit all applications, which is why so many different cable types and uses exist!

Other Notes regarding Impedances:

- **Outputs – Low Impedance (Typically, 600 ohms or lower, usually 10X lower than Input Impedances).**
- **Inputs – High Impedance (usually at least 10X higher than Output Impedance sources).**
- **Impedance matching (Low Z Outputs to High Z Inputs) allows for a Maximum transfer of Voltage.**

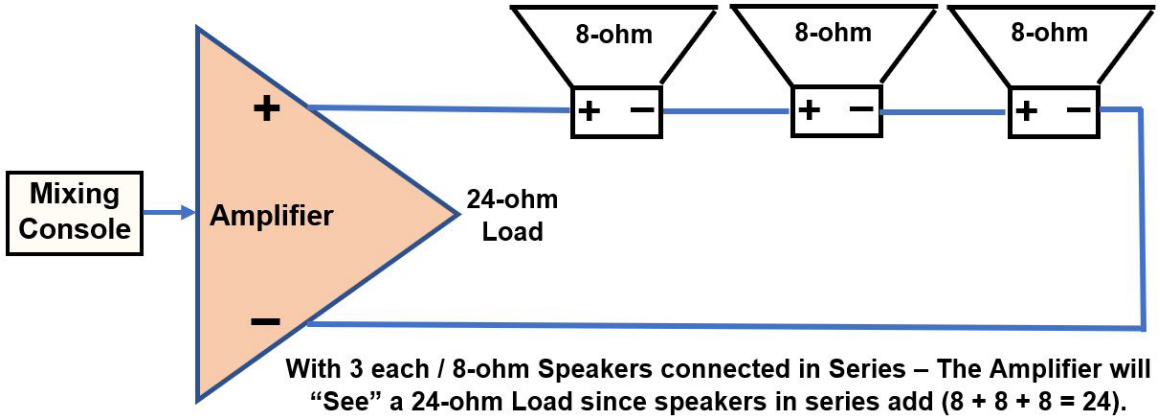
Low Impedance Speaker Systems - (4, 8, 16-ohms) Series & Parallel Connections

Series Speaker Connections

Are wired by connecting the (+) terminal of one speaker to the (--) terminal of the next speaker, and so on.

Typical Series Speaker Connection

Video Clip!



With 3 each / 8-ohm Speakers connected in Series – The Amplifier will "See" a 24-ohm Load since speakers in series add (8 + 8 + 8 = 24).

- **Not used a whole lot with PA Systems (there aren't many amplifiers that like to "see" a 24-ohm load).**
- **It's best to use the same model and impedance rated speakers when using Series configurations.**
- **With Series connections, the speaker impedances add. Ex: if you have 3 each / 8-ohm speakers in series, the total impedance will add up to 24-ohms (3 X 8 = 24).**
- **The formula for Series Connections is Z_T (Total) = Z1 + Z2 + Z3**

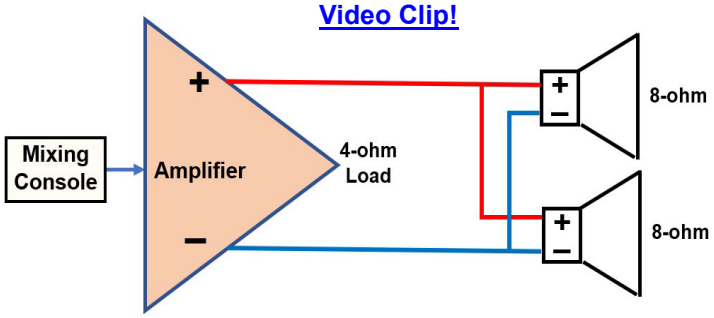
Z = Impedance

Parallel Speaker Connections

Are made by connecting the (+) terminal of one speaker to the (+) terminal of the next speaker, and so on.

Typical Parallel Speaker Connection – Example 1

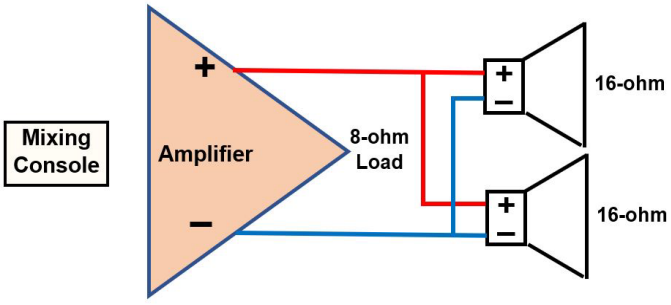
Video Clip!



With 2 each / 8-ohm Speakers connected in Parallel – The Amplifier will "See" a 4-ohm Load.

Example 1: If your power amplifier is rated at 4-ohms per channel, then you can parallel 2 each / 8-ohm speakers on each channel.

Typical Parallel Speaker Connection – Example 2



With 2 each / 16-ohm Speakers connected in Parallel – The Amplifier will "See" an 8-ohm Load.

Example 2: If your power amplifier is rated at 8-ohms per channel, then you can parallel 2 each / 16-ohm speakers on each channel.

- **Parallel Speaker connections are used 99.9% of the time in the audio world.**
- **It is also recommended to use the same model / impedance speakers.**
- **If you follow the "standard" of connecting only 2-each speaker's per amplifier channel, and understand the speaker's impedance rating, there will be no need to use the "Parallel" impedance formula.**
- **The formula for Parallel Connections is not as easy to use as for Series Connections, but there is a simplified method for figuring out parallel connections (see next page).**

Parallel Speaker Connections Formula

$$Z_T = \frac{1}{\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} \cdots \frac{1}{Z_N}}$$

Z = Impedance

Example 1: If your power amplifier is rated at 4-ohms per channel, you can parallel two each / 8-ohm speakers on each 4-ohm channel. This is very likely the most used configuration used in the audio world.

The simplified version of the Parallel Connections formula would be: You have two each / 8-ohm speakers. You would divide the impedance of "one" of the speakers (which is 8-ohms) by the number of speakers (which is 2).

So, 8-ohms divided by 2 = 4-ohms. In Example 1, the amplifier would "see" 4-ohms per channel.

Example 2: If you have two each / 16-ohm speakers, you would divide the impedance of "one" of the speakers (Which is 16-ohms) by the number of speakers (which is 2).

So, 16-ohms divided by 2 = 8-ohms. In example 1, the amplifier would "see" 8-ohms per channel.

Here is some information regarding Series / Parallel Speaker Connections – Video Clip!

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