MERLIN PA HIRE

Impedance & Load Matching Made Easy

When using amplifiers and speakers it is important to understand how they work together to get the most from your amplifiers and speakers. Problems that could occur is overpowering the speaker (damage to drivers), amplifier overheating loss of amplifier headroom restricting level before clipping occurs.

Firstly I will give a simple and clear definition of what impedance is then secondly explain how we use it to work out load matching for PA systems.

The latter part of this article will give some examples and questions to aid understanding.

Impedance! What is it?
Impedance is the opposition of A.C. (alternating current) in a circuit that combines resistance (R), Capacitance (C) and inductance (L). R is a resistive load, C and L are what is called a reactive load. These components are found in a speakers voice coil and crossover networks. The total opposition is called impedance shown using the letter (Z). Impedance is measured in ohms. The impedance can be worked out if you know the values of R, C & L. Shown in formula (i).

Formula (i)

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Where R is the resistance, X_L is the Inductive reactance $X_L = 2\pi fL$ and X_C is the capacitive reactance $X_C = 1/(2\pi fC)$, f = frequency.

Using Impedance and Speaker Power
Speakers are given a rating of nominal impedance and power handling. Impedance in ohms (Ω) and power in watts (w). Watts is the transfer of energy in joules per second. 1 watt = 1 joule per second.
Standard speaker impedance values are 4Ω and 8Ω. The impedance of the speaker is the load that the amplifier will see when powering the speaker.

Amplifiers when presented with a load of 8Ω will power up to a certain given amount of power with a reference. If the same amplifier is presented with a 4Ω load then it will see less of a load and can deliver more power.
Amplifier manufacturers give a specification of what the amplifier will deliver in power terms (watts) to a given load (impedance).

When choosing an amplifier to power a speaker it is worth making sure that it can deliver the required power for the speakers rated power and impedance. This what is known as load matching described later.

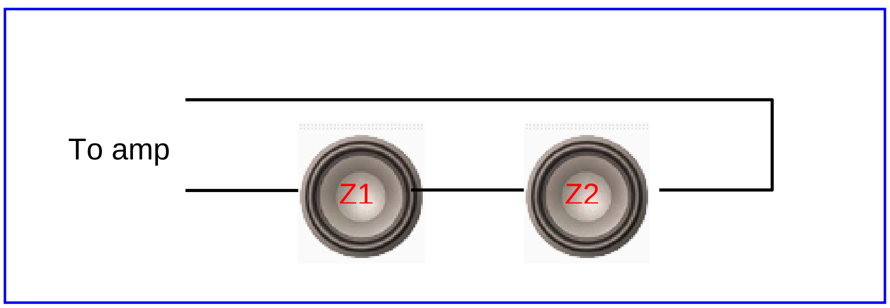
Parallel and Series speaker Wiring Configurations
Wiring up speaker and knowing what configuration they are done in is important so you know the total load and can choose the correct amplifier to power the speakers successfully.

Most commonly used in PA systems is parallel wiring as speakers often have two sockets on the wired in parallel to link to another speaker if necessary. Series wiring is more used when using multiple speakers in one enclosure or for installed PA systems.

To work out the total impedance for parallel and series speaker wiring is slightly different. The way to work out series is simple you just add up the individual speaker impedances to get a total as shown in fig 1. Parallel speaker wiring is slightly more complex and is shown in fig 2.

Figure 1.

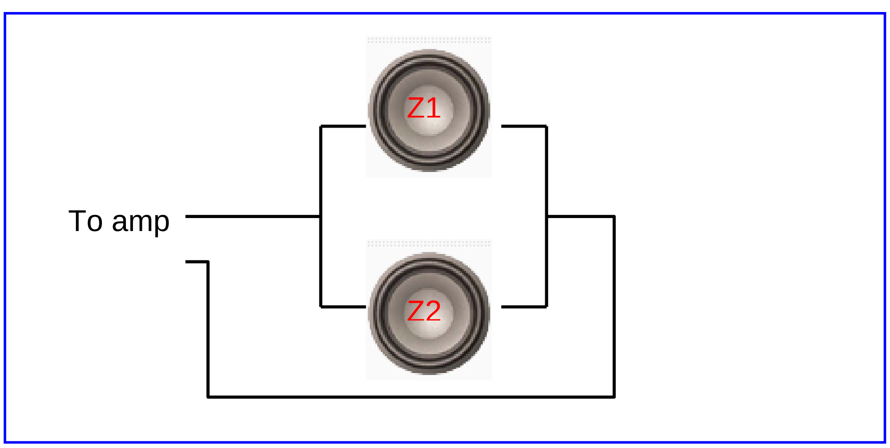
Speakers wired in series (i.e. in a chain)



If each speaker in the series circuit above is 8Ω then the total would be 16Ω.

Figure 2.

Speakers wired in parallel



If each speaker in this parallel circuit above is 8Ω then the total load that the amp would see is 4Ω. If a third speaker was added the load would be reduced to 2.67Ω.

The formula to work out the total load for series and parallel circuits are as follows. Formula (ii) is for speakers when wired in series, formula (iii) is for parallel wired speakers. Z = Impedance for individual speakers, Z_T = Total Impedance.

Formula (ii)

$$Z_T = Z_1 + Z_2 + Z_N$$

Formula (iii)

$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

Worked Example

For series configured speakers its fairly obvious you just need to add up the speakers impedances to get a total load.

8Ω Speakers To be used.

ZT = Z1 +Z2 +Z3

ZT = 8 + 8 + 8

ZT = 24Ω

Parallel configured speakers takes a little more working out, if we want to wire up two 8Ω speakers then we take formula (iii).

1/ZT = 1/Z1 + 1/Z2

1/ZT = 1/8 + 1/8

1/ZT = 0.125 + 0.125

1/ZT = 0.25

1/0.25 = 4Ω

If we want to place a third 8Ω speaker in parallel then simply you know that two speakers is 4Ω, so just place a 4Ω and an 8Ω into formula (iii).

1/ZT = 1/Z1 + 1/Z2

1/ZT = 1/4 + 1/8

1/ZT = 0.25 + 0.125

1/ZT = 0.375

1/0.375 = 2.67Ω

Example of Load Matching
Here a specification will be given for an amplifier and also for a speaker. The example will work through how the each speaker will receive the correct amount of power.

The specification of the amplifier to be used will power as follows:

2 x 1300w @ 8Ω
2 x 2300w @ 4Ω
2 x 3200w @ 2Ω

The speaker that will be used is an enclosure with a total power rating of 1000w and an impedance of 8Ω

If we took two speakers and linked them in parallel we would require 2000w and an impedance of 4Ω. So the amplifier would power this no problem with a little headroom left which is ideal. Headroom needed for speakers will be left separate from this article.

If we took three of these speakers and linked them in parallel we would see a total load of 2.67Ω.

Therefore each speaker would get approximately 1000w which is once again ideal.

References:

Success In Electronics (Tom Duncan)

Audio Engineering for Sound Reinforcement (John Eargle & Chris Foreman)

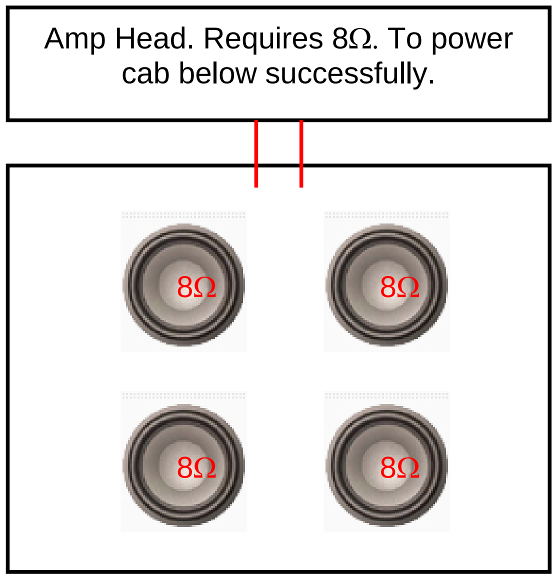
Homework Question

You need to wire up a guitar cab. The cab has four speakers in it. Each speaker is rated at 8Ω. The total load that the correct amp head needs to see is 8Ω from the guitar cab.

Using the picture below (fig. 3) to join up the speakers to get a total of 8 ohms total. Connect the cables to the two red cables joining the cab to the head.

Show your working out of how you achieved the required impedance. Including formulas.

Figure 3.



$$Z_T = Z_1 + Z_2 + Z_N$$

$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

Clue! You need to use both series and parallel wiring configurations to get the required load.