The Constant Impedance & Constant Voltage systems

Introduction

There are two main types of Loudspeaker distribution methods, these are:

1. Constant Impedance.
2. Constant Voltage.

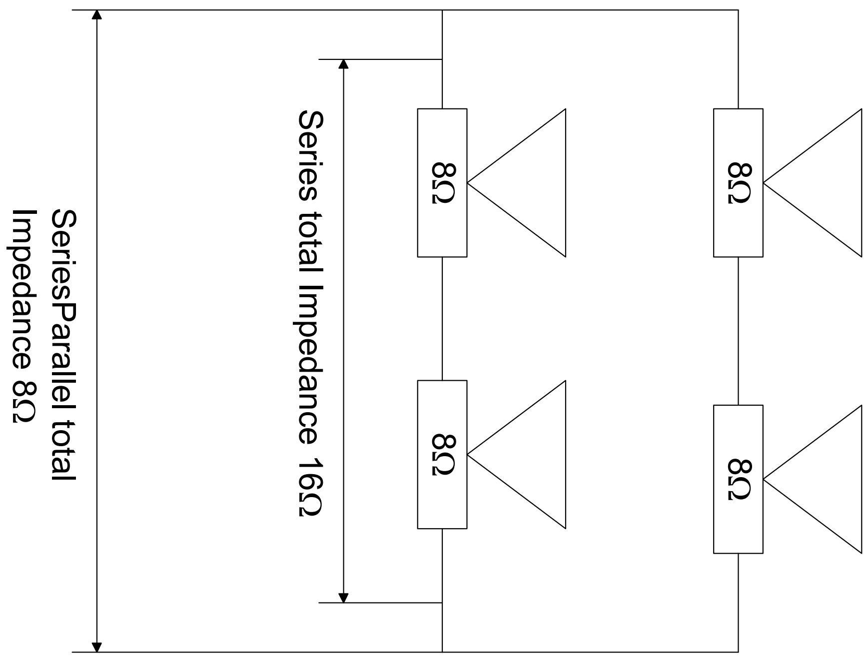
Constant Impedance

Constant impedance is used mostly in domestic and in-car applications, where the output of the amplifier is determined by the number of volts driven into a constant impedance, this is normally 8Ω for domestic Hi-Fi systems and 4Ω for In-car systems. In these types of system it is normal to have a single loudspeaker connected to one power amplifier (a stereo amplifier will contain 2 power amplifiers), hence connecting the loudspeakers is simple, one just chooses a loudspeaker with the correct impedance and connects it to the amplifier.
When multiple loudspeakers are required, the connection become much more complicated. If we have an amplifier which requires an 8Ω load, the impedance must not fall below this figure if it does damage to the amplifier may occur. If the load is higher than the rated load impedance then loss of power will occur. The are proven by the following:

To calculate the output power of an amplifier we use:

$\frac{V^2}{R} = P$ Where V is the voltage output from the amplifier, R is the load impedance and P is the result in watts. By rearranging the above we get $V = \sqrt{RP}$ hence for a 100W amplifier into an 8Ω load V = 28.28 volts, if we then use a 16Ω load on this amplifier the resulting output power of the amplifier will be 50 Watts a loss of half of the power, on a load of 4Ω the amplifier would attempt to deliver 200 watts, the problem being that the amplifier is designed for 100 watts, the amplifier would overheat and ultimately be destroyed.

To get the correct load impedance with multiple loudspeakers, they would have to be wired in a series parallel configuration, the diagram below illustrates this.



Constant Voltage

Constant Voltage system are commonly used in public address and large sound distribution systems. The most commonly used are 50V, 70V and 100V, the latter being the system adopted in the UK, 70V is often used in the USA and 50V was commonly used in the far east.
For the purposes of this document we will use the 100V system unless otherwise specified.
With any 100V line amplifier full output is achieved when the output voltage reaches 100V, the minimum load impedance is dictated by the power output of the amplifier, this is calculated by:
$\frac{V^2}{P}$ the result giving the minimum load impedance, assuming we have a 100W amplifier we would get $\frac{100^2}{100}$ which give a result of 100Ω, the minimum load.

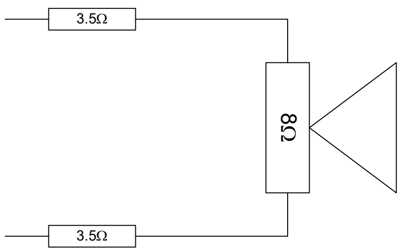
One of the advantages of always knowing the output voltage even though the amplifier power changes is that a loudspeaker can be tailored to any application, if I require a loudspeaker to have an output of only 1 watt, using the above I can calculate that the loudspeaker needs to have an impedance of 10,000Ω. This is the same for all loudspeakers.

In constant voltage systems the loudspeaker circuits are wired in parallel, this makes the installation of loudspeakers very simple and by having tapable loudspeakers the system can be easily tailored for multiple environments and noise levels. The main thing to bear in mind is that the sum of the loudspeaker taps must not exceed the output power of the amplifier.

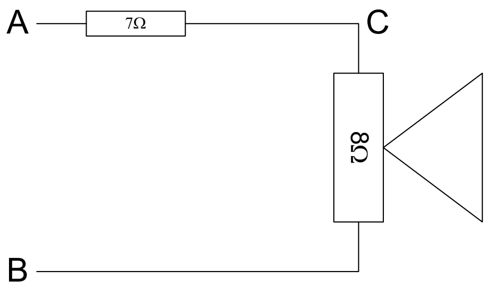
The most significant advantage of 100V line is efficiency especially on long loudspeaker circuit runs. We will consider using a 100W amplifier with a 100W load at a distance of 100 metres from the amplifier wired using 0.5mm^2 cable. Our constants are:

1. The Constant impedance loudspeaker has an impedance of 8Ω.
2. The output voltage of a 100W constant impedance amplifier is 28.28V.
3. The 100V line loudspeaker has an impedance of 100Ω.
4. The voltage output of a 100V line amplifier is 100V.
5. The resistance of 0.5mm^2 cable is 3.5Ω/100m.

The loudspeaker circuit is as follows:



This can be simplified to:



For the constant impedance amplifier we know that at full power the voltage applied to points A & B is 28.28V, we need to calculate the losses in the cable, the easiest way to find this is first to find the current flowing through the circuit with $\frac{V}{R}$ where V = 28.28 and R is the total resistance of the circuit, the result is 1.87Amps, we then need to calculate the volt drop over the cable resistance with IR where I is the current of the circuit and R is the cable resistance, this gives 13.09 Volts, deduct this from the output of the amplifier and we have the volts getting to the loudspeaker of 15.19V (across points B & C), using this to calculate the power into the loudspeaker from the formula above we have 28.84 watts, a loss of over 70% of the output power or in terms of dB, using $20Log_{10}\frac{V_1}{V_2}$ Where V_1 is the input voltage and V_2 is the voltage across the loudspeaker we get a loss of 5.4dB

Calculating for the 100V line system we have a total load of 107Ω, the current through this circuit is 0.93 amps, the loss over the cable is 6.5V, the total energy into the loudspeaker is 87.42 watts, a loss of just over 10% of the energy or 0.58dB.

In conclusion it is fairly clear the 100V line systems are easier to install and are far more efficient than constant impedance systems. However it should be noted that due to the methods currently used 100V line systems will often have a comparatively poor low frequency response when compared to constant impedance systems, this is due to the nature of the transformers used in the amplifiers and loudspeakers.