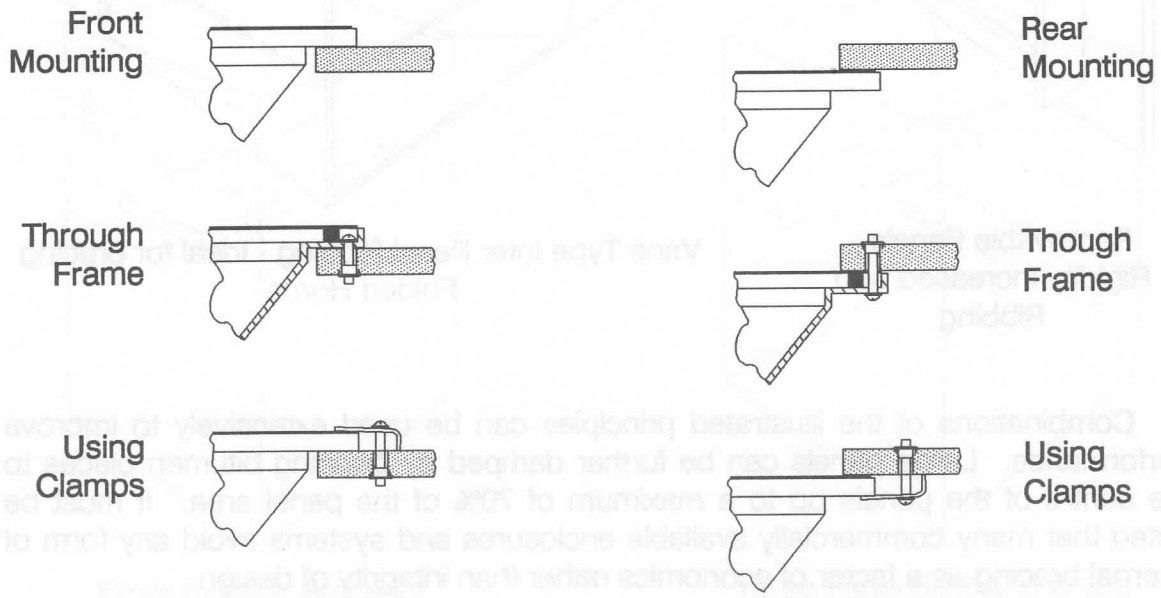
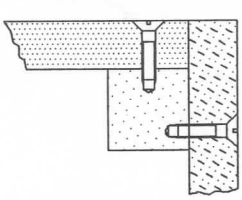
Construction and Assembly

The method of securing the loudspeakers should be determined first; factors that influence this choice are loudspeaker accessibility, type of grille protection required, ease of manufacture. Tee nuts and screws should always be used to secure loudspeakers into baffles. It is usually convenient to make and finish the loudspeaker baffle first. The cut-out diameters can be derived from the relevant manufacturer's specifications, (note that these can be different for front and rear mounting). The work should be undertaken in the following sequence:

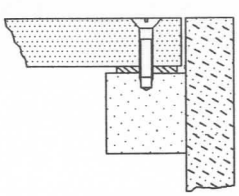


First mark out the positions of the Tee nut holes and loudspeaker cut-outs. Produce cut-out by using a power jigsaw or similar. Drill holes slightly larger than the Tee nut shank, then hammer the Tee nuts into position on the INSIDE FACE. Check that the loudspeaker fits, and the Tee nuts line up with the holes in the frame.

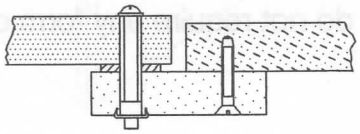
Next the method of jointing corners should be chosen. Butt joints can be used extensively for small cabinets. These should be liberally glued with a PVA type woodworking adhesive, and either screwed, pinned or machine tacked. For more heavy duty and larger applications the reinforced butt joint as illustrated should be used. Again the joint should be liberally glued and screwed from both faces at every 4" to 6" (100mm to 150mm), ideally using machine drive screws and a power screwdriver.



Standard corner reinforced joint

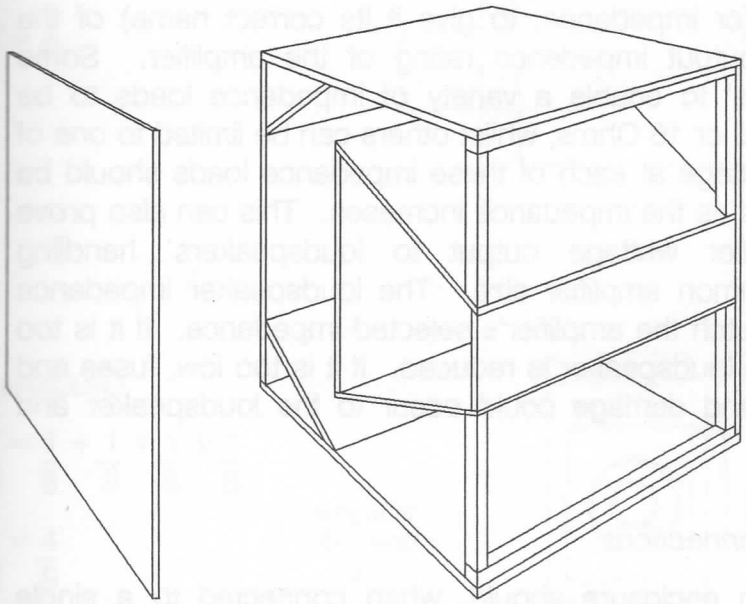


Method of jointing for removable panels



Method of jointing for removable panels

On a complex design with many internal panels, ie. a folded horn or scoop bin, one side panel should be carefully marked out with the positions of the all the internal panels to ensure correct alignment. The cabinet should be 'built' on this panel ensuring all corners are sealed before finally 'closing' the cabinet with the other side panel as shown.



Fully construct and make airtight internal panels prior to 'sealing' with final side panel.

Sealing

It is important that all joints both internally and externally are completely air tight, as air leaks cause spurious noises. This applies to all forms of design, whether sealed, reflex or folded horn. If in doubt about a particular joint, additional adhesive can be added after assembly and left to cure to seal any gaps. For removable access panels, self adhesive domestic draughtproofing foam tape can be applied to one of the surfaces. The thinner sections available can be used to form gaskets for handles and electrical connecting panels, etc. Likewise the loudspeaker can be sealed to the baffle with this material if a proper sealing gasket was not supplied with it.

Prior to connecting and fitting the loudspeaker it is wise to check the impedence of the unit, if possible with a resistance meter. The D.C. resistance should be within +0 to -15% of the nominal load, (refer to impedance notes). Ideally use an audio frequency generator, or alternatively music programmes at a low level, to check that all components are working correctly before committing to a full power trial.

As a final foot note prior to completely sealing the enclosure, check for cleanliness. If there is any debris or wood particles within the enclosure these should be removed with a vacuum cleaner, as ultimately, these could find their way into the loudspeakers and possibly cause premature failure.

1.5.2 Impedance

Loudspeakers
Loudspeaker Matching
Crossovers

All amplifiers are designed to operate with a specified resistive load, and it is important to match this correctly for optimum performance and not to cause damage. Total resistive load (or impedence, to give it its correct name) of the loudspeaker is equal to the output impedence rating of the amplifier. Some amplifiers provide multiple 'taps' to enable a variety of impedence loads to be utilised, these are commonly 4, 8 or 16 Ohms, whilst others can be limited to one of these. The amplifier output wattage at each of these impedance loads should be noted, as usually this decreases as the impedance increases. This can also prove useful when matching amplifier wattage output to loudspeakers' handling capabilities, when using a common amplifier size. The loudspeaker impedance should, as close as possible match the amplifier's selected impedance. If it is too high, the power delivered to the loudspeaker is reduced. If it is too low, fuses and thermal cut-offs can operate, and damage could occur to the loudspeaker and amplifier.

Multiple Cabinets to Amplifier Connections

The total impedance of an enclosure should, when connected to a single amplifier or both channels of a dual channel amplifier should be the same. This means that the power into each cabinet is the available power divided equally between the cabinets. Any number of loudspeakers or systems can be connected to one amplifier provided that they are wired so that the total impedence is a correct match.

The multiple units can be connected together by one of three methods, ie. series, parallel, or a combination of both series/parallel. The value of the impedance is given the notation (Z) and is calculated by the following formulae:

Series Connections: $Z_{total} = Z_1 + Z_2 + Z_3 + Z_4 + \text{etc.}$

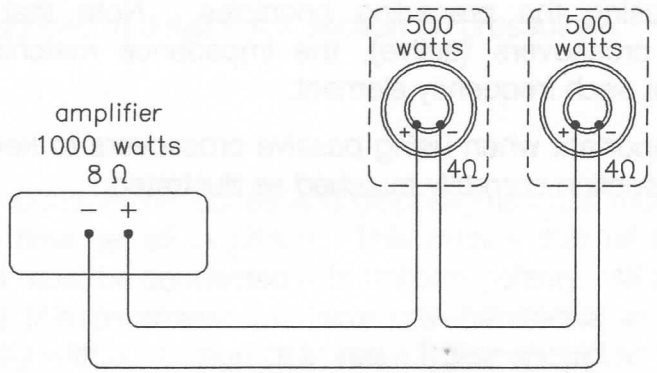
Parallel Connections: $\frac{1}{Z_{total}} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} + \frac{1}{Z_4} + \text{etc.}$

EXAMPLES:

SERIES:

$Z = 4 + 4$

$Z = 8$



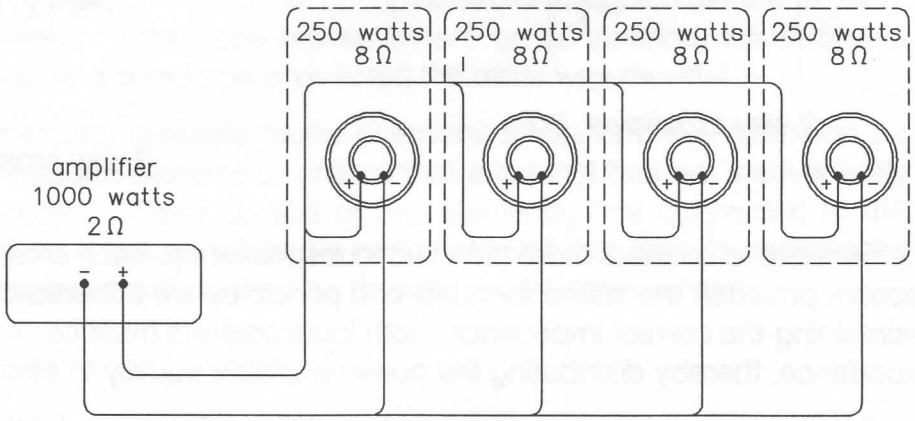
PARALLEL:

$$\frac{1}{Z} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8} + \frac{1}{8}$$

$$\frac{1}{Z} = \frac{4}{8}$$

$$Z = \frac{8}{4}$$

$Z = 2$



SERIES - PARALLEL:

Series Element:

$Z = 8 + 8 + 8$

$Z = 24$

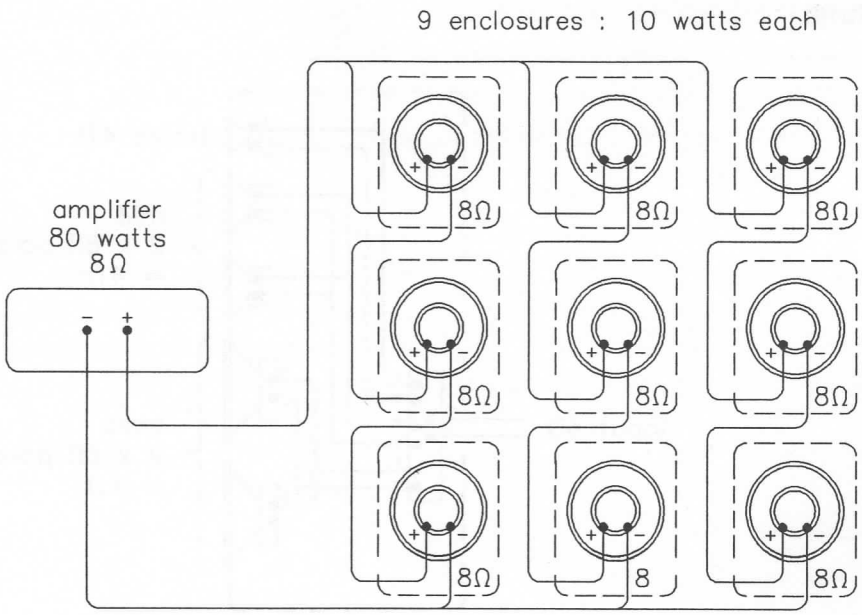
Parallel Element:

$$\frac{1}{Z} = \frac{1}{24} + \frac{1}{24} + \frac{1}{24}$$

$$\frac{1}{Z} = \frac{3}{24}$$

$$Z = \frac{24}{3}$$

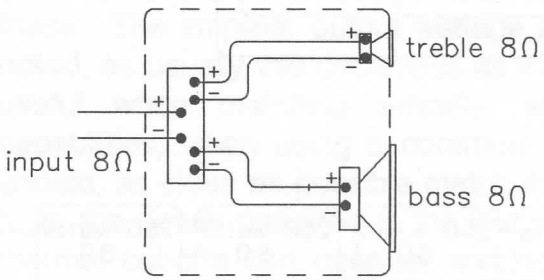
$Z = 8$



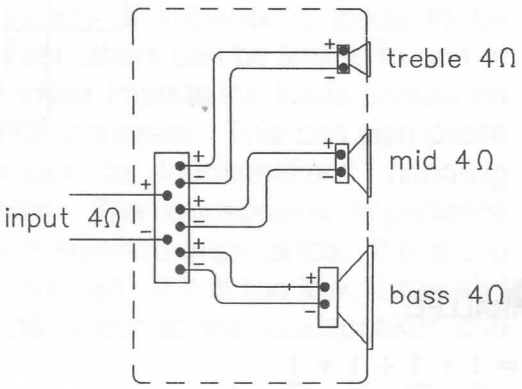
Internal Cabinet Connections

The impedance of the loudspeakers within each cabinet should also be matched using the preceding principles. Note that for applications utilising electronic crossovers (active), the impedance matching is to the appropriate amplifier for each frequency element.

It is important when using passive crossovers to keep the impedence of each crossover section correctly matched as illustrated.



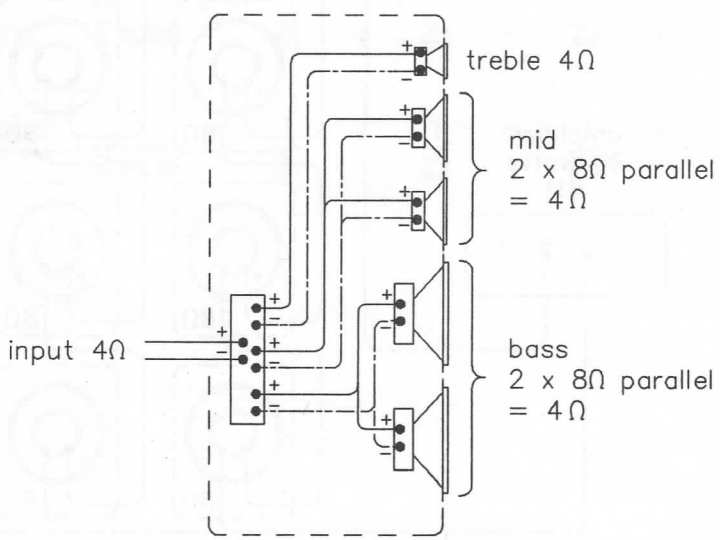
2 way crossover 8Ω



3 way crossover 4Ω

It is possible to connect more than two loudspeakers to each crossover output section, provided the stated formulae and principles are adhered to, thus maintaining the correct impedance; both loudspeakers must be of the same impedance, thereby distributing the power available equally to each.

So, to summarise, in a three way system of 4 ohm total impedance, it is important that each of the three sections, ie. Bass, Mid and Treble, should have an impedance of 4 ohms and if any section comprises more than one drive unit, they are connected in a manner that will still present a total impedance of that section of 4 ohms.



3 way crossover 4Ω - 5 loudspeakers

Note that should a reduction in sensitivity be required for Mid or Treble sections, the practice of higher impedance mismatching should not be utilised, as this changes the crossover frequency and behaviour. The correct method of constant impedance attenuation is described in detail in the section on crossovers.

Polarity

In any sound system, all loudspeaker cones and diaphragms must move in the same direction at the same time, ie. all in phase. This means that all cabinets, loudspeakers and electronics must be connected with uniform polarity. All elements within a system that require this parameter will have one connector or terminal marked as the positive, usually with a '+' sign or in red. These should all be wired so that they relate back to the system's input positive terminal. Any cone or diaphragm that is connected out of phase detracts from the optimum sound output. The phase of a loudspeaker can be easily checked by using a 9V battery by connecting the battery positive (+) to the loudspeaker positive (+) with the result of forward cone movement. If the cone moves inward on connection, this indicates the unit is out of phase and should be connected the other way round.

There are commercially available 'pulse checkers' to perform this operation on large multi enclosure sound systems to ensure that a cabinet has not inadvertently been wrongly connected. These consist of two elements, one connected to the pre-amplifier to produce a test signal, and a hand held unit that detects and checks each individual loudspeaker and connection throughout the entire system.

1.5.3 Power Distribution

In order to design a system it is important to ascertain the expected power distribution between the various sections of the system. For an electronically crossed or active system, this will allow the selection of the correct amplifier power requirements and therefore the loudspeaker's power handling for each section of the audio range as designed.

For a passive system likewise, the proportion of power to each part of the crossover output section can be determined.

The power distribution for the audio spectrum is best represented by the percentage power about given frequencies. The figures quoted are for 'normal' play-back programme.

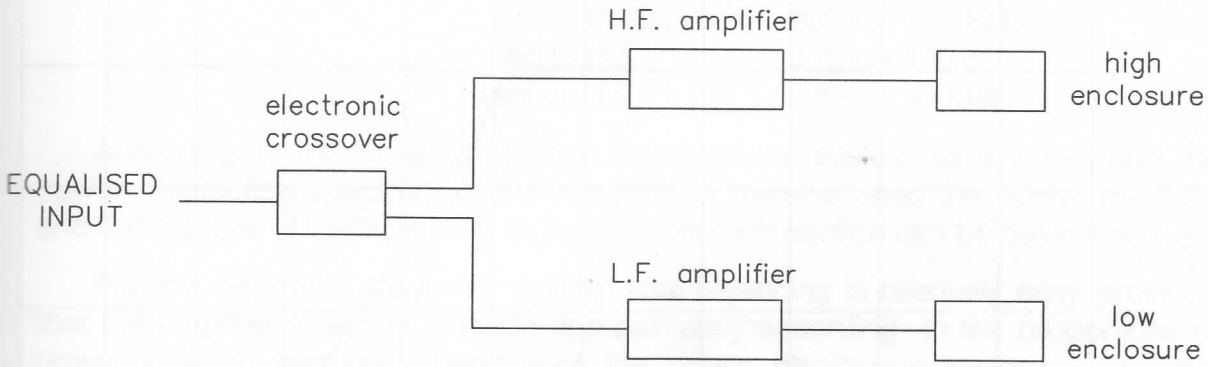
Crossover frequency	% power below crossover frequency	% power above crossover point
150	20	80
200	28	72
300	45	55
500	60	40
1000	75	25
3000	80	20
5000	90	10

Generally, for discos, the proportion of bass content up to 150 Hz will be excessively equalised as can that above 5 KHz. So it is useful as a safety measure to design a good excess of power handling capacity of loudspeakers in these frequency ranges particularly for active systems where the system balance can be more readily changed.

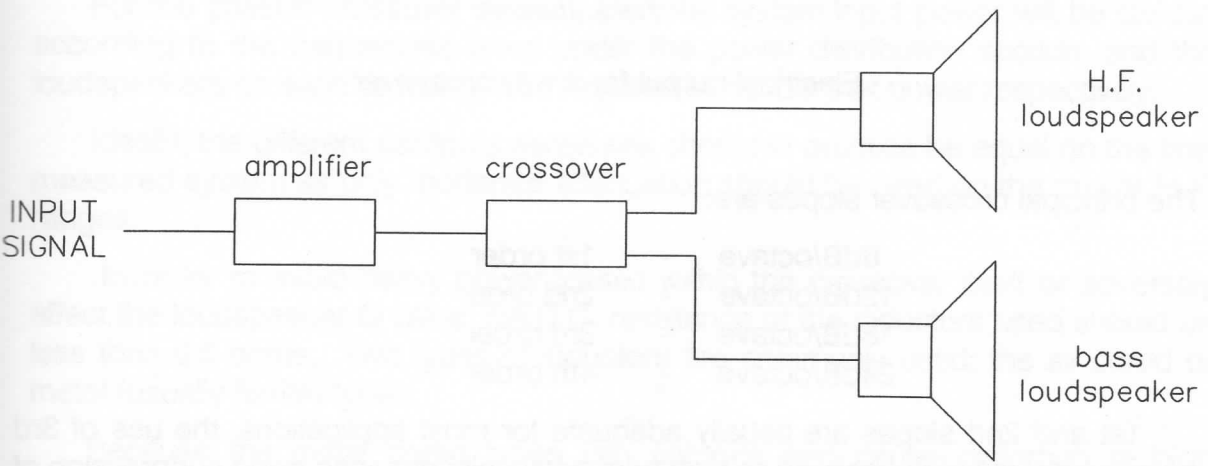
In recent years the digitisation of the play-back material means higher sound pressure levels of reproduction can be achieved without distortion effects; large amplifiers have become less expensive and more common, so low frequency systems are even more prone to be overloaded, particularly when large headroom allowances are made to deal with improved transient reproduction capability.

1.5.4 Crossovers

The audio spectrum can be divided into elements or bands for amplification or reproduction via loudspeakers, using active or passive crossovers that utilise circuits for splitting the audio signal. Active crossovers divide the low level signal prior to amplification:



Passive crossovers divide the signal after amplification:



Apart from single diaphragm full range drivers, all loudspeaker enclosures or systems utilising multiples of loudspeakers covering different parts of the audio frequency spectrums need the input or line-signals dividing between various components.

For systems up to 500 watts, it is viable to use passive crossovers, ie. crossovers that divide the signals at the full power amplified stage. Over 500 watts, the design of passive crossovers becomes expensive, in order to keep the insertion losses reasonable, and are therefore not viable. Systems of 500 watts and over should use an active crossover which divides the signal before amplification, and are lossless.