ISCE Training Note No. 4.2

Wiring of loudspeakers

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The basic loudspeaker drive unit is a low impedance device with an impedance usually between two and fifteen ohms. But in this Training Note, 'loudspeaker' means one or more drive units already encased or mounted ready for use within a sound reinforcement, public address or PAVA (public address – voice alarm) environment. These loudspeakers fall into three generic types which require a different approach to each other when considering their wiring. The three types are **a) low impedance, b) 100 volt line** — which have a transformer in the box, and **c) active** — sometimes referred to as 'powered', which have one or more amplifiers in the box as well.

a) Low impedance

These have an impedance varying from two up to fifteen ohms, usually 4 or 8 ohms .Advantages are that there are no transformers or other equipment to detract from the original sound quality and there is a very wide selection to choose from. The major disadvantage is that to use them in a multiple loudspeaker installation they must be wired in a series/parallel configuration in order to present a suitable impedance to the amplifier. Another disadvantage is that to ensure sufficient output from the loudspeaker, the wiring needs to be of very low resistance. To achieve this, a very thick wire must be used. (See appendix) This of itself can present a further problem as these heavy, thick cables are difficult to run discreetly at the installation site and may not meet with the approval of the client.

b) 100 volt Line

Here the amplifier output is designed to produce a maximum output of 100 volts to the loudspeaker cable or 'line', and each loudspeaker has its own transformer to match to the high impedance line.

The major advantage of this system is that the turns ratio of this transformer can be arranged to produce the appropriate power required for the circumstances for which a particular loudspeaker is being used. Thus the cable can feed one loudspeaker in a small room requiring (say) one watt of audio and, using the same cable, supply another next door requiring significantly more power.

The transformer ratio can be varied by taps on one or both windings of the transformer, thus providing a method of varying the input power to the loudspeaker, albeit somewhat crudely. A further advantage to this system is that as the line voltage is high, the current required for a given power is low, and much thinner cable can therefore be employed compared with a low-impedance system. This type of cable is of course also easier to install and hide, thus pleasing the client.

When planning, do not ignore calculations of the cable voltage drop for a large installation using large cable lengths. Remember that, although the voltage drop due to the cable is significantly less using this 100 V line method, even a quite modest installation requiring a total of one hundred watts passes a total of one amp down that cable! (See appendix) A way of minimising the voltage drop is to wire the loudspeakers in a ‘ring main distribution’ configuration, similar to that used for wiring 13 amp mains sockets. Care should be taken to avoid running loudspeaker cables parallel to other services, such as telephones, where interference by induction could take place. Cross other services at right angles and separate runs by at lease 20 cm where possible. It is good to use cable with twisted cores, which helps to minimise the magnetic field radiation.

The disadvantage of this 100 V line system is that a (quite costly) high-quality transformer is required for each loudspeaker, and overall sound quality must suffer if an inferior unit is employed. Thus installations which require very high quality reproduction usually avoid this type of loudspeaker. In addition there is not quite such a selection of loudspeakers or amplifies to select from.

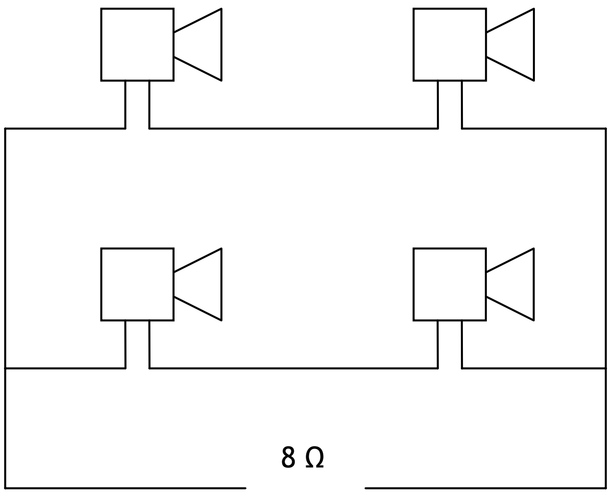
c) Active

These are designed as a complete unit incorporating one or more power amplifiers as well as the drive units. Thus design parameters can be optimised by the manufacturers to produce a smooth frequency response. A disadvantage is the necessity to provide an independent power supply for the amplifier. This is usually the local mains supply of 120 or 230 volts AC. Some smaller units are supplied with a small independent supply incorporated within the plug top, which may require separate mounting so select your unit with care. Compliance with the Low Voltage Directive is of course a requirement. Another disadvantage is the considerable weight of these loudspeakers. The method of mounting must therefore be very secure.

Signal distribution is at a low level, usually balanced about earth. at zero level (0.775 V) or thereabouts from a fairly low impedance source, 50 to 100 ohms A lightweight twin screened cable is used to supply the signal the pair incorporating a slow twist to minimise pick up of interference. The signal can be run over almost any length, even over several kilometres although when such distances are used the signal feed needs correctly terminating at the end of the run to prevent audible echo effects. Not all active loudspeakers are provided with this facility. It is possible to use unscreened twisted-pair cable to distribute the signal but it is common practice to use a twin screened cable to minimise interference. If so care, must be taken when earthing the screening to prevent the creation of hum loops. This is usually done by directly earthing the screen at the sending end only, and earthing it through a special low-inductance capacitor at the receiving end if necessary to prevent pick-up of radio signals.

The input stage of some of the cheaper models may be unbalanced. It is far more difficult to counter interference and ‘ticky hum’ especially when running feeds over long distances these and they should be avoided if at all possible. Use balanced-input products.

Appendix: Wiring of a multiple low-impedance loudspeaker installation



Illustrating how to wire four 8 ohm loudspeakers in a series/parallel arrangement to preserve the impedance.

DISCLAIMER (we have to do this)

In a signal cable, the loop resistance must not be significant (less than one-tenth) compared with that of the loudspeaker(s). For example, a 2.5 mm^2 cable, 50 m long has a loop resistance of approximately 0.8 ohms. If the four loudspeakers shown above are in a cluster fed from the amplifier through this cable, the amplifier 'sees' a load of (8 + 0.8) = 8.8 ohms, but cannot produce a significantly higher voltage across this load than it can across 8 ohms.

Power is volts-squared divided by resistance, and if you work it out, you find that the amplifier power is 10% lower into 8.8 ohms than it is into 8 ohms.

Now suppose this lower power is, say, 88 watts (conveniently!), and remember that power is also current-squared times resistance. So the current is $\sqrt{10}$ amps, or 3.16 amps. That current is flowing through the 0.8 ohms of the cable, and it produces a power loss of (10 x 0.8) = 8 watts. We lost nearly 10 watts (97.8 W down to 88 W) at the amplifier due to the higher load resistance, and then another 8 watts in the cable. We are down to just 80 W, and the total loss is18 W, or 18.4% of the amplifier power.

What does that do to the sound pressure level? Here is where decibels are our friends. 80 W divided by 97.8 W is 0.82, which is ('10 lg', because it's power), -0.9 dB, and that is also the loss of sound pressure level. The loss in watts looks like a lot, but the loss of sound pressure level is barely audible, so our rule of thumb of 'less than one-tenth of the load resistance' is realistic.