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EAGLE *from sound services*

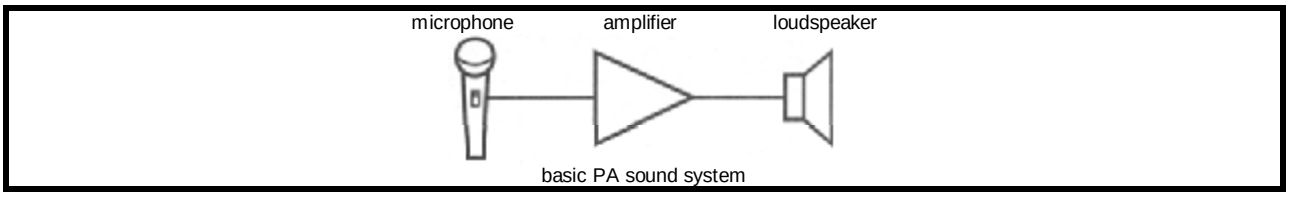
A sound basis on which to give sound advice

EAGLE The Basics

There are two main categories of Public Address or PA sound. Essentially, they are Sound Reinforcement and Distributed Sound.

The former caters for the enhancement of 'live' sound to a localised audience such as in theatres, cinemas, concerts, clubs, and so on. Here the audience will almost always be in the vicinity of the sound source. High powered amplification, relatively large loudspeaker systems and sophisticated mixing/equalisation capabilities will be the general requirement.

Distributed Sound, however, will carry the sound through a number of speakers placed so as to reach people who may well be remote from the source. The site may be quite large, and very many speakers required over a large area. Examples might include multi-storey office blocks, warehouses, sports stadia or a large factory complex. The reverse may also apply whereby a single source and only one speaker is involved, perhaps as might be found in a doctor's surgery to waiting room system. Sound may be distributed through such a system so that only certain areas hear certain part of the broadcast. This is called zoning and will be explained in greater detail later. Voice announcements, background music and alarm/emergency signalling may be required to reach all or selected zones.



basic PA sound system

Many of the basic principles will apply to both of the above methods. Indeed, a basic PA sound system consists of a single microphone, one amplifier and one loudspeaker. Generally speaking, systems will invariably be more sophisticated than this. Variations will involve the number and type of sound sources (microphones, music, etc.), the size and number of areas to be covered (the amplifier power requirement) and any selective zoning as mentioned above.

In the following pages, it is hoped you will gain a basic understanding of the above, thus enabling you to design PA systems which will do precisely what your client requests, using the correct equipment for a specific task.

EAGLE Microphones

The sound waves that we hear consist of changes in air pressure. A device which converts these pressure changes into electrical energy is, for our purposes, a microphone.

Many different types exist, for different applications. We will limit ourselves to the most popular types, of which the **moving-coil or dynamic microphone** is probably the most common. Here a coil is attached to a small diaphragm which is made to move in sympathy with sound waves directed to it. The coil is suspended in a magnetic field. The resultant motion produces an electrical output in similar principle to that of a dynamo, generator or alternator. The output voltage is, however, very tiny - in the region of a few thousandths of a volt.

The coil normally has a low resistance and is referred to as a low impedance microphone. Electrically, it will usually be balanced about earth and using twin-core screened cable, relatively long (> 100m) balanced line, low impedance cable runs may be used without great detriment or interference problems. Unbalanced high impedance types are also available which can only be used on short cable runs (<10m). These high impedance microphones suffer from electrical interference and are not recommended for professional use.

Ribbon microphones are seldom used these days. They are invariably balanced low impedance types but tend to be somewhat delicate and suffer if mishandled or ill treated mechanically. For this reason, they are not recommended.

Capacitor or condenser microphones generally provide superb quality audio and can be used over long cable runs. They require some form of power supply, either from internal batteries (an inconvenience) or from the amplifier/mixer itself. This is known as Phantom powering.

Polar Response or the way in which a microphone picks up sound can also vary, and careful selection is needed to ensure the correct type is chosen to suit the customer's needs. There are two common types of pickup response - Omni-directional and Uni-directional.

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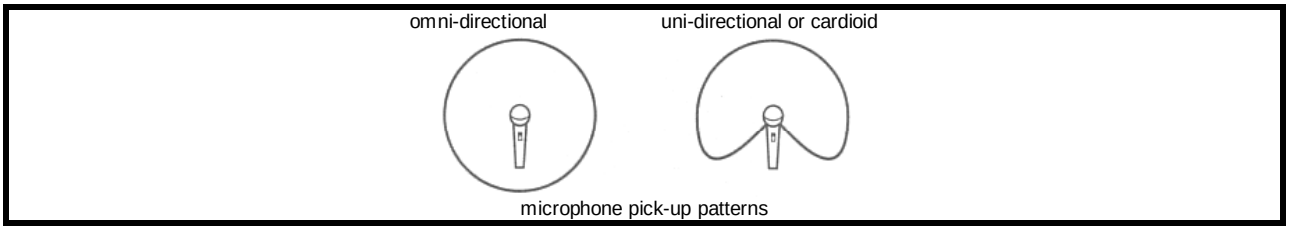
Omni-directional microphones will pick up sound from all directions equally. They might be used anywhere that sound needs to be heard from all around, such as a meeting or conference table. Unwanted sounds may also be picked up.

Uni-directional or cardioid microphones, as the name implies, pick up sound from one direction only, usually directly in front. Sound from unwanted directions may be rejected to a large extent.

The latter is by far the most popular type and in this category, the cardioid polar response is common. The heart-shaped appearance of the pick-up pattern is useful for its capability to reject rearward sounds by some 70%. This helps to reduce acoustic feedback or howl, and can equally help to reduce audience noises, background music, telephones, etc.



microphone pick-up patterns

Amplifiers

An amplifier is a device which raises the very tiny signal already shown to come from a source such as a microphone up to a much larger signal with which a loudspeaker might be driven.

In its most basic form, it will have an input, an output and a power supply (mains or battery or both). More usually, a number of inputs will be offered to accommodate the various types of sound source (microphones, radio tuners, cassette players, CD players, etc.) Similarly, outputs may vary from the low impedance speaker output designated in the common form of 4 - 8 -16 ohm often found in domestic, concert/club PA and DJ situations to the 100 volt line found in UK professional installations. Equipment for international markets may have terminals to suit 70 volt, 50 volt or even 25 volt lines.

An amplifier consists of two main parts, each contributing to the signal processing in a different way. The first section is the pre-amplifier. Here the signal source is electrically matched to the rest of the system and will usually include controls for level/volume and tone/equalisation. These tone controls will be adjusted for maximum clarity and fidelity in each individual situation. The tiny signal previously mentioned is lifted for further processing. Generally sources such as CD players, tuners and other amplifiers will be high impedance, and would be fed to dedicated inputs, or to the Auxiliary inputs. PA microphones will be low impedance, balanced line, and will be fed to inputs invariably designated Mic.1, Mic.2, etc. Master controls to alter the overall sound will also be incorporated. Several pre-amps may be used to accommodate a number of varied sources.

The second section is the Power Amplifier. Here, the low level signal received from the pre-amp section is boosted by a factor of perhaps as much as 50,000,000 times the power level! (Yes, that is 50 million times!) Outputs are measured in watts. A simple small system might be 5 or 10 watts, whereas a large sophisticated system might need several thousand watts. Concert systems in the order of 100kW are not unknown. As a consequence, high voltages and currents may well exist, and care must be taken with regard to installation and personal safety.

Loudspeakers

Believe it or not, a loudspeaker is electrically the reverse of a microphone. The now much boosted high level electrical signal is converted back to sound pressure, but at a vastly increased level. This should, of course, be a faithful reproduction of the source originally fed into the system.

There are some applications where the loudspeaker might be used as both source and reproducer (e.g. intercom and talk-back). Although large concert and club PA systems tend to use low impedance speakers, all commercial distributed sound systems will use the 100 volt line method. It must be stressed that the two are incompatible and neither will work satisfactorily with units of the other type. The essential difference is that each speaker in a l00V line system will have a transformer added to it, to match it to the 100V line feed. Each transformer will have a number of tappings, whereby the individual speaker power can be adjusted to suit the local environment and needs, as shown in fig 6.

Any number of speakers may be wired to such a system, provided that the sum total of all the speaker power tappings does not exceed approximately 90% (speech) or 80% (music) of the amplifier rating in watts. Wiring is simple, all in parallel, and long cable runs may be used with relatively low losses. This provides an efficient distribution system.

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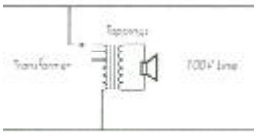
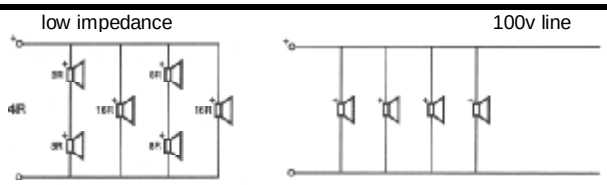


100v line speaker

Complex series/parallel speaker combinations would be needed, together with similarly complex wiring if a system were to be installed using a low impedance network. Compare the diagrams shown in fig 7 which illustrate the above. In addition, cable losses would be very significant when using the low impedance network in a commercial sound distribution system.



loudspeaker wiring and connection

Loudspeaker Selection

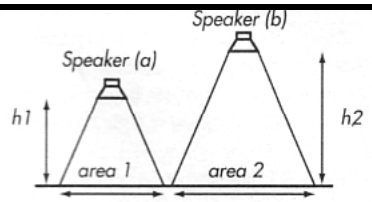
The style and type of loudspeaker selected is a critical factor in the performance of a complete PA system. Choose the wrong speaker and it will not perform as the client wishes. The most common types are the cabinet speaker, the ceiling speaker, the column speaker and the horn speaker. Some other types will be mentioned.

Cabinet Loudspeakers - These units can, in fact, be heard from all around and are strictly speaking omni-directional, but to an extent they exhibit directional properties not unlike the cardioid response shown earlier. This is due to the fact that more of the sound is projected directly in front of the cabinet, with considerably less to the rear. In distributed PA, this seldom causes any problems, but can contribute greatly to acoustic feedback/howl in club and concert PA systems.

Physical size, power handling and coverage area are the main deciding factors which govern selection of these types. In distributed systems, a large number of low powered units is preferable, whilst for concert and DJ systems, a small number of high powered cabinets is the norm. This is because the DJ or concert requires much greater sound levels and generally prefer the source to appear to come from one direction as far as the listener is concerned. Neither of these factors is relevant in distributed PA.

Ceiling Loudspeakers - These units are intended for false or suspended ceilings where they may be flush mounted in a suitable ceiling tile, as in offices, restaurants, stores, etc. They blend inconspicuously with the decor in this way and are particularly suited to background music, where they give a good account of themselves. Often, a flame-retarding metal dome is supplied for the rear of the unit, so as to comply with local fire regulations.

The response for these units gives a circular 'footprint', which means the higher the ceiling, the fewer units are required to cover a given floor area (within reason). This is illustrated in fig 8. Again, a larger number of low powered units gives a superior performance to a smaller number tapped at higher powers.



footprint against height of ceiling loudspeakers

Column Loudspeakers - These are usually found in applications such as lecture theatres and churches to which their well-defined radiation pattern is best suited. They exhibit a very wide pattern in the horizontal and narrow in the vertical plane, as depicted in fig 9. Care should be taken in the siting of these units, so as to ensure the sound projection covers the audience fully. Units will usually be mounted above the audience and tilted toward them in a fashion similar to that illustrated in fig 10.

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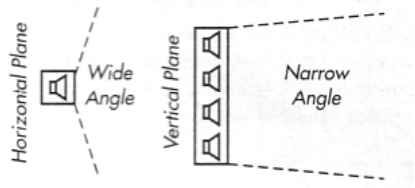
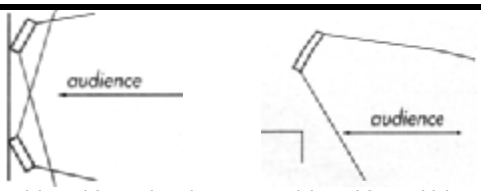


radiation pattern of column loudspeakers



(viewed from above) (viewed from side)
coverage area of column loudspeakers

Horn Loudspeakers - Horn speakers are well suited to noisy environments, such as workshops, train stations, outside yards, sports stadia, etc. A well defined dispersion pattern is exhibited and their inherent highly efficient design means they can usually be heard above machine noise and other high ambient noise problems. They are unsuitable for music, being rather 'toppy' in sound, but this factor actually aids the projection of speech over considerable distances.

The efficiency of horn speakers is denoted in their specification in terms of decibels. A more detailed explanation is given later, but suffice it to say here that a horn may be 10dB - 20d8 more efficient than a similarly rated cabinet speaker. This means in effect that the horn can be up to four times as loud as a like-powered conventional speaker. When specifying horns, therefore, careful note must be made of the Sensitivity rating, rather than the power rating, the former being a far more important factor.

Suspension Loudspeakers - These may be of three quite different types, exhibiting very different properties. Firstly, a wedge shaped design featuring two speakers facing in opposite directions. They are well suited to background music applications and tend to be used in high ceilinged shops, stores, quiet warehouses, etc.

Secondly, the Pendant or Ball speaker, as the name implies, has an orb-like appearance and contains a downward-facing speaker. Again, background music is well reproduced and the aesthetic appearance blends in to a greater extent in shops and stores.

Thirdly, Sound Diffusers are very similar to the pendant/ball type, but the dispersion pattern from the downward-facing speaker is designed to be projected all around, more in the horizontal plane than the pendant speaker. Usage would be similar to the above.

Sound Projectors - Usually of a tubular format, these units may contain one or two speakers. Sound is dispersed from one or both ends of the tube in a pattern not unlike that shown as a footprint for the ceiling speaker in fig. 5, but in a horizontal direction. Situations such as corridors, warehouses and offices may be covered. They reproduce background music satisfactorily.

EAGLE Planning & Design

As much information as you can possibly glean from your client is required in order to ensure that what you supply is as near as possible to what they want. Often a client's wishes are technical impossibilities, and it is necessary to assess what can actually be achieved within a realistic budget. Information needed to design a system will include the following factors:-

- Areas to be covered (viz. length, width and height, indoor or outdoor).
- Ambient noise level in different locations of site.
- Background music or speech only areas.
- Number of microphones and their priority.
- Varied sound sources (tuner, cassette, CD, satellite receiver, etc.).
- Number of independent zones.
- Interface with external equipment (telephone or intercom systems, fire alarms, timed signals, etc.).

Some of the above topics have already been mentioned. Explanations of the other issues follow.

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The requirement for background music affects the selection of amplifier power rating in that the amplifier must not be loaded to more than 80-85% of its rating for this purpose. For speech only, this can be increased to 90%. An important distinction exists between Foreground music and Background music. The former might be found in boutiques, etc., where a continuous relatively high sound level is required. This warrants more specialised 'disco' style equipment intended more for this purpose. Background music, however, will usually allow a conversation to take place, without the music being intrusive.

Choice of loudspeakers is as previously outlined. However, the relative siting of speakers can be an important factor. Generally, it is bad practice to install cabinet speakers opposite each other. Staggering along opposite walls produces a much more even distribution. This point is especially important when using horn speakers.

Areas may be selective as to programme material delivered. An example might be a large department store, where background music is required in the shopping areas, but not in the offices. Furthermore, security announcements might only be required to reach specific floor(s), leaving the remainder uninterrupted. More importantly, fire or emergency announcements will be required to cover all areas. All these requirements are easily met by loudspeaker zone switching relays, operated by suitable buttons or switches on the paging microphone.

Similarly, more than one microphone may be required. In the example above, they might be sited at the Manager's office, Customer Services desk, loading bay and the checkout supervisor. The amplifier must be capable of accepting all these inputs, together with any other sources as mentioned in 5. above. An order of precedence may be required whereby certain sources must override those of a lesser priority. Fire alarm interfaces and emergency announcements are an obvious element here. This feature is known as Priority Paging and means that any important messages will automatically mute or suppress the background music and any other announcements of a less important nature.

EAGLE Noise

Noise is a subjective topic and will be assessed differently by different individuals. In audio engineering, however, noise is a definable, measurable entity. In practice, ambient noise would be measured with the aid of a sound level meter. Different scales are available for different purposes, details of which are beyond the scope of this text. For general audio use, 'A' weighting is appropriate. In effect, the response of the meter is tailored to reflect that exhibited by the human ear.

The decibel (dB) is the unit used and is a ratio of relative sound levels following a logarithmic scale. An increase in the number of dB's results in a multiplication of sound intensity. eg. 87d8 might appear to be `just over' 84dB. In fact it is twice the intensity!

By way of an example, the relative efficiency of horn speakers was mentioned earlier. Typically, a cabinet speaker might have a quoted sound pressure level (SPL) of 95d8. A horn may be rated at 115dB or even 125dB. The former is an increase of 20dB or 100 times, the latter 30db or 1000 times!

These measurements are usually standardised as being taken at a distance of 1 metre with 1 watt drive. This may vary with some manufacturers. As can be seen, careful perusal of the technical specification of various speakers is needed for selection, power rating not being of prime importance at all.

Printers, machines, drills, lathes, compressors, phone conversations, etc., are all forms of `interference' which the proposed system must overcome. The sound level produced by a PA sound system needs to be at least 6dB above the background noise. The chart provides an approximate guide to relevant levels.

By adjusting the transformer tapping on an individual speaker, a considerable degree of localised intensity variation can be achieved.
For example, in a situation where the general system design means that all the speakers in a particular area need to be set at 1 W and this results in poor coverage adjacent to a printer, then the speaker close to that printer may be set at, say, 2W or even 4W, to overcome the specific localised noise.

This flexible approach allows 'fine tuning' of a system after commissioning, so as to ensure that the customer really is satisfied with the installation. It also underlines the preference for installing a number of speakers tapped at a low level, rather than a small number set to a higher power. The latter method may sometimes be suggested in the interests of economy, but will never operate as well in practice and will invariably result in the dissatisfaction of the client.

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fig 11 - Relative noise levels in decibels:

120	Threshold of pain. Jet taking off @ 60m
115	Pneumatic drill, Express train passing through station
110	Impossible to converse. Disco (on dance floor)
105	Live orchestra
100	Inside tube station
95	Machine shop, print shop
90	Difficult to converse. Ventilation equipment room, club.
85	Busy supermarket
80	Loud voice needed to talk. Traffic noise, church choir.
75	Noisy office
70	Speech @ 30cm, typing pool, theatre, department store.
65	Speech @ 1 m
60	Typical office, normal talking, near motorway
55	Background noise, hotel lobby, restaurant
50	Light traffic @ 30m, quiet office
45	Tearing paper @ 1 m
40	Average residential area, quiet house
35	Soft music
30	Countryside
25	Library
20	Leaves rustling
15	Broadcasting studio
10	Quiet whisper @ 1 m
5	silence?
0	Threshold of hearing. Minimum audible sound

EAGLE Additional Points

Having now assessed the types and quantities of speakers required to meet the specifications, simply add up the total power, adding about 15% if it is for speech only or 20% if music and speech is required. This will give the minimum total power needed to run the system as required. Select the nearest amplifier rating above this figure. For large systems, booster or slave amplifiers may be needed to attain the total required output power.

As an example a speech-only system is requested for an office block requiring 73 speakers, all tapped at 2W, the canteen requires 4 speakers, each set at 4W, the plant room will have one speaker set at 6W. The total power is 168W. Adding 15% brings this figure to 193W.

A typical manufacturer might supply amplifier with outputs of 10W, 30W, 60W, 120W and 240W.

Clearly, 240W would not only suffice, but would leave room for possible expansion and/or modification at some later date. Should the range manufacturers range of amplifiers only go up to 120W, then a 120W amplifier and a 120W booster/slave amplifier would be needed. Note that a 120W amplifier plus 60W booster, totalling 180W, would not suffice, this total being too low.

Should the design be part of an emergency evacuation system, reference must be made to BS7443 which stipulates the minimum requirements for the intelligibility of such systems. BS6259 details the standards for sound systems in general.

For the most part, loudspeaker wiring will be carried out using twin sheathed 1mm2 (10a) twin cable, although for the smaller installations, with shorter cable runs, 0.75mm2 (6a) twin will suffice. The speakers will be wired in parallel, using any configuration that is convenient to the installer.

Installations demanding very long cable runs with possibly higher powers on them may well require even larger diameter cable.

Care must be taken to ensure that all installations meet Local Authority fire, wiring and planning regulations.

Microphones will almost certainly be of the balanced type, requiring twin core plus screen cable. Try to avoid unbalanced microphones and single core screened cable in all but the shortest of cable runs (< 5m).

All the information given thus far has been for sound reproduction, to be heard by those with normal, or near normal hearing capabilities. Often, a system will be requested for the hard of hearing. A special approach is needed utilising on induction loop system.

EAGLE Induction Loops

In order that the hard of hearing may benefit from sound distribution, it is necessary that they have a hearing aid fitted with a 'T' (Telecoil) switch. This would normally allow ease of use of a telephone. Most modern aids will have this facility inbuilt, no switch being required. Basically, the loop system operates as the primary of a large transformer, creating an electromagnetic field around the site to be covered. Each individual aid would then effectively become a secondary within this field, receiving the signal and transforming it into sound for the user.

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Some calculations are needed so as to meet the requirements of BS7594, which governs these installations. The calculations are a little involved and include length and width of the area, together with the required field strength, in order to determine the loop current. The calculation also varies somewhat with the differing shapes of sites. Then, the cable diameter will be determined, taking into account the total loop size, loop resistance and current rating. It is felt that these calculations are beyond the scope of this text. However, most manufacturers and suppliers offer a design service for loop installations.

Uses for induction loops include churches, banks, service counters, schools, theatres, meeting rooms, waiting rooms, etc. They may be installed as a stand-alone unit, e.g. in a bank, or as a 'slave' to an existing PA system, e.g. in a theatre.

The loop itself will usually consist of a single turn conductor around the listening area. Care must be taken not to run the loop parallel to existing wiring, conduit or piping, since these will all be regarded by the system as suitable 'secondaries', each absorbing considerable amounts of the radiated signal.

The calculations will also take into account the fact that it is generally undesirable to site the loop too near to 'ear' height as this may well produce overloading to a listener physically close to the loop. Usually, the loop will be sited around 1 metre above or below the listening plane. This could be in a false ceiling or perhaps around a skirting board.

Follow the manufacturer's setting up procedure closely, paying attention to detail, since any digression may result in a system which fails to meet the users expectations. In the absence of a field strength meter or loop test receiver, simply organise the aid of a hard-of-hearing member of the public. They will soon advise if levels are incorrect!

Induction loops shall reach EN60118-4 (formally BS6083 Part 4 1981), BS7594 and the requirements of the RNID.

EAGLE In Conclusion

Whilst it is stressed that the foregoing pages are only to be considered as a basic introduction to a complex subject which normally requires much study at a college or university, it is hoped that an insight has been gained into the design, planning and installation requirements of sound systems. The emphasis has been largely on distributed sound, since many other texts are already available covering 'concert' and stage sound systems.

Further advice should always be sought if any doubt exists. Most manufacturers and/or suppliers will give free advice on the correct installation of their equipment, a system planning service often being available on request.