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PUBLIC ADDRESS SYSTEM DESIGN

PRACTICAL GUIDELINES

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PUBLIC ADDRESS SYSTEM DESIGN – PRACTICAL GUIDELINES

In simple non-technical language, this section outlines the practical points to be considered when designing a sound system for general public address requirements. These guidelines are not intended to ‘baffle with science’ and where possible, they avoid the necessity for complex calculations and the like. We at SOUNDCOM hope you will find them useful and informative.

GENERAL

Most P.A. systems are made up of four essential elements;

Sound sourcing; microphone(s) hard-wired/wireless, music player(s) (C.D., Tape etc.), sound generator(s) (Pre-announce Chime, Alarm tone), PABX paging etc.

Mixing; to bring all required sources to a similar voltage level in relation to each other, so that they may be prioritised and/or mixed for delivery to the

Power Amplification System; serving the

System Speakers.

Component choices to satisfy each element above are available, and some of these choices will depend on the

PRIMARY USE of the SYSTEM

1. Is the system to be used primarily for:
   a. ‘Speech with music (background)’
   b. ‘Music (foreground) with occasional speech’.

Many people hold the opinion that public address components, i.e. those using 100/70V line output amplifiers and speakers, do not adequately satisfy the requirement of b. This is simply not true however; this type of system should not be used for a DISCO or a venue where fully professional quality sound is essential. A public address amplifier featuring true sound quality characteristics will exceed most expectations, when coupled with full-range frequency response speakers intended for ‘foreground’ applications. It is also a lot safer to use (components do not blow up so easily) when operator knowledge is non-existent or limited.

2. a. How many sound sources are required, and of what types, i.e. microphone(s), C.D. etc.?
   b. What is the total wattage of the speaker load?

In many instances, the mixing and power amplification elements can be combined into one, i.e. a mixer/power amplifier. For more power, booster amplifier(s) can be added by connecting this to the ‘line’ or ‘rec’ out of the mixer/power amplifier.

Where the mixing section exceeds the above, use can be made of a pre-amp mixer to provide priorities, equalisation and muting control as necessary. Power amplification can be accommodated by a booster or mixer/power amplifier types, depending on cost, total system load etc.

DETERMINATION of 100V LINE SPEAKER WATTAGE SETTINGS (see also graphs page)

Before discussing this area of the system design, it is useful to know what ‘100V line working’ is.

Essentially, this type of system allows for any number of speakers to be connected to a power amplifier, provided that

the addition of the wattage settings of all speakers connected to that amplifier do not exceed its’ wattage capability.
To achieve this, each speaker driver is connected to the secondary winding of an audio transformer, the primary winding of the transformer being connected to the amplifier delivery line. Generally, the primary winding has a selection of wattage tapping connections that determine the speaker output level when receiving 100V audio level signal from the amplifier.

A common error is to set a speaker at a higher than required wattage tapping, or to leave the tapping as supplied on delivery, and then reduce the output of the amplifier by its’ volume or master controls, to achieve the correct audio delivery level. **THIS IS WRONG** and has no advantages!

To ensure that the most economic and efficient combination of amplifier/speakers is achieved,

1. A speaker should be set to the most appropriate tapping for its’ coverage area, when receiving an audio signal level of 100V.
2. The amplifier should be adjusted such that it delivers around 100V signal level when the sound source requiring the highest audio penetration is active. This is normally microphone announcements, and will be achieved when amplifier VU indication averages 80-100%.

By following these two recommendations,

- The system is optimised, i.e. balanced for different areas, resulting in
- Initial minimum speaker system loading
- Lower system power amplifier wattage requirement
- Spare amplifier wattage capacity for system expansion
- Achievable audio level delivery for additional speakers at a later stage, **without affecting the rest of the system**.

REMEMBER, a speaker will only deliver its’ wattage setting output when it receives an audio level signal of 100V and it will be very difficult, if not impossible, to correct the system at a later stage should the above not have been done when originally installed.

A simple example is provided as follows.

There are 10 x ceiling speakers in a system, highest tapping is 6W (1,67K ohms), and that is where they are set. **The system loading = 60W**.

The environment requires a 1W setting @ 100V audio signal delivery for each speaker so, to prevent the system being too loud, the amplifier volume control is turned down to achieve 1W speaker output.

**Audio signal voltage delivery is 41V.** This represents less than ¼ power output!

If a 60W amplifier has been provided to drive the system, it is fully loaded, i.e. should not be expanded!

If a 120W amplifier has been supplied:

- Any addition of speakers cannot deliver their required output at their correct setting, because the audio voltage to the speakers is too low
- If the amplifier output is turned up to satisfy a., the original speakers will be too loud.
- 60W system expansion is available.

Installed correctly, the speakers are set at 1W each, total system load = 10W and general system delivery is 100V.

If a 60W amplifier is supplied, there is

- 50W spare-system capacity for expansion
- Any additional speakers will deliver their required output at their correct setting.

Note there is almost as much spare amplifier output capacity in this example when compared with the above using a 120W amplifier, which costs more.

**HOW DO WE CALCULATE THE CORRECT SPEAKER WATTAGE SETTING?**

There are formulae that can be used however; you will need a scientific calculator. The easy alternative is supplied on the following pages by using the graphs. The unit employed is the ‘dB’ or decibel however, by using the graphs, and adding/subtracting the numerical readings, you will be 99% right.

Proceed as follows.
1. Establish the environment, or ambient, noise level from FIG. ‘A’ at the area of speaker output reception. Example; ‘Department store’ or similar = 70dB.
2. Add 10dB, to ensure adequate audio penetration. Sub-total = 80dB
3. Establish the distance in metres between the speaker and the centre point of audio reception. Example 5m. From FIG ‘B’, find out its’ dB value, in this case = 14dB.
4. Add this to 2. above, = 94dB

This is the power output, or sound pressure level (SPL), necessary at the speaker to be heard adequately at 5m, i.e. 94dB

a. Establish the speaker efficiency specification @ 1W/1m. Example; full-range speaker in the AHUJA brochure, model PS-400T = 86dB 
b. Subtract this value from 4. above,= 8dB 
c. Using FIG ‘C’, the speaker input wattage required = 6W, set to 8W tapping.

For these values to be done by calculation, the formulae are provided below

**dB value of wattage:** 
\[ dB = 10 \log \frac{W}{1} \]  
Note: If less than 1W, the answer is negative, i.e. subtract from 1W/1m speaker specification!

**dB value of distance:** 
\[ -dB = 20 \log \frac{1}{\text{distance (m)}} \]  
Note: This is negative and must be added to 2. above as it is level attenuation to be catered for.

**dB value of area ambient noise:** Unfortunately, a ‘SPL’ meter must be used for an accurate value.

**TIPS**

1. **When ceiling speakers are used:** People do not normally crawl on the floor, so the distance between speaker height and floor can be reduced by 1.5m when standing/walking, i.e. shoppers etc., and 1m when seated, i.e. office environment etc. In a typical office @ 2.5 – 3m ceiling height, a speaker grid of 5 – 6m is adequate for most applications. In supermarkets etc., the speaker height can be anything from 3 – 6m or more, depending on the structure, so the grid can be widened pro rata (less speakers, more wattage/speaker). An option to be seriously considered is the use of ‘wide dispersion’ speakers. The use of this speaker type will reduce the appropriate grid dimensions at any given height to ~50% that of a normal dispersion speaker, i.e. 75% less speakers used, reducing installation time and costs.

2. **When speakers are used outdoors:** Should the speaker be required to ‘throw’ sound less than 50m, the calculation of 1 - 4 above is adequate. If more than 50m, add 20dB to the answer of 4., to cater for wind, air rising (hot, day)/ falling (cool, evening/night).

3. **Speaker tappings:** Some are quoted in wattage values, e.g. 100V/6 – 3 – 1,5 – 0.75W, and some in impedance values, e.g. 1,67K – 3,3K – 6,7K – 13,4K however, note that these represent the same wattages as stated @ 100V working but are ½ these wattages @ 70V and ¼ @ 50V.

4. **Outdoor speaker coverage:** From ‘FIG B’, it can be seen that the further the sound is required to travel, the further it will travel, like it or not!! Why, because doubling the distance from any starting point attenuates the sound level by a further 6dB, i.e. from 5m (-14dB) to 10m (-20dB) = -6dB, from 50m (-34dB) to 100m (-40dB) = -6dB, from 500m (-54dB) to 1km (-60dB) = -6dB. Keep this in mind when using horn speakers for stadiums/ schools etc. Residents in the surrounding area may complain! Also note that, for every doubling of speakers, side by side, some distance apart, and facing in the same direction, a gain of 3dB is achieved for no extra power input, in the area past the point where the dispersion of these speakers merge or cross.

5. Keep in mind that a delay of 1/20 sec. between the arrival of the sound from one speaker to that of another at the same point will begin the destruction of speech intelligence to the recipient there. This equates to approximately 16m difference under typical conditions. Example; standing on the playing field, you look at two speakers facing you. If one speaker is 30m away, the other must be less than 46m away to maintain announcement intelligence.
From 4. and 5. above, it can be seen that it is just as important to control, as it is to deliver, sound to an area. Shorter distance ‘throw’ is easier to control! Also note that the specified ‘frequency response’ of a speaker indicates its’ frequency ‘range’, minus10dB (in most cases) at its’ outer limits. It does not indicate what it sounds like, and the best way to confirm this aspect is – listen to it and compare with others! You will be amazed at how different speakers with the same response specification can sound.

As with anything else, you only get what you pay for, and so does the client.

6. Note that to a listener, a difference of +/−3dB around an average in received sound pressure level is hardly noticeable due to the non-linear sensitivity of the human ear. The result is that the foregoing calculations are not very critical in most cases, being more intended to establish the best wattage setting to achieve the correct result.

MICROPHONE(S) AND OTHER INPUTS

Microphones; Generally, the different types are well known by contractors however, there are a few considerations that may not be so obvious.

- Always use a good quality braided microphone cable between amplifier and microphone location.
- Limits of cable distance between microphone and amplifier are:
  - UNBALANCED, 20-30m indoors, considerably further outdoors.
  - BALANCED; 70-100m indoors, >100m indoors, amplify the source signal to, e.g. 1Volt, balanced.
- The main problems encountered indoors are electrical electronic devices such as fluorescent lighting, computers, machinery etc. radiating sufficient interference when in close proximity to microphone cable.
- It is simple to convert a microphone from balanced to unbalanced for short cable run and/or the amplifier input is unbalanced, i.e. connect the ‘COLD’ and ‘SCREEN’ together. This is pin ‘1’/‘3’ (XLR), ‘RING’/‘SLEEVE’ (PHONO) or pin ‘2’/‘3’ (DIN). It is not so easy to convert a microphone from unbalanced to balanced. One method is to insert a 600/600 ohms transformer in the line at the microphone however, the transformer must be shielded, i.e. metal enclosure connected to microphone ‘SCREEN’.
- Unidirectional cardioid dynamic microphones accentuate bass frequencies, especially when close miking is employed. This will be improved by maintaining spacing between mouth/microphone at 50-100mm and directing speech slightly off the microphone centre axis.
- Where feed-back is a problem, reversing the speaker system polarity at the amplifier can provide an improvement.

Wireless microphones

- When using w/less microphones, especially indoors, avoid employing ‘lapel’ types unless system speakers are well away from the user. Feed-back easily occurs and audio level is inconsistent due to head movements. If hands-free use is necessary, suggest a unidirectional head or neck set.
- Always use alkaline or re-chargeable batteries to power microphone transmitters.
- A Full—Diversity receiver provides the best protection from RF signal ‘drop-out’.
- Due to increased interference from cell phones, P.C.s and the like, the use of VHF, i.e. 30-300MHz band, is going out of fashion. UHF, i.e. 300MHz-3GHz, is preferred, more often than not in the 650-950MHz region. It has better penetration through walls etc. however, it is definitely straight line-of-sight, i.e. the signal does not bend with land contour. Good for short distances.
- Should remote antennae be necessary, especially at UHF frequencies, use a low-loss coax cable connection to ‘booster’ amplified antennae and install antennae at least 4m apart if full diversity is employed.
- Always maintain the correct antenna polarisation for best reception, i.e. vertical or horizontal as per suppliers’ instructions. Mostly, vertical polarisation is employed.
Music sources
Cassette tapes are fast becoming obsolete, C.D./D.V.D. is repetitive no matter how many discs you have unless there is an agreement with a local music store or similar. This is OK if the environment is a transient one such as shopping malls, airports etc., but will irritate in a static environment such as offices. Variety is preferable, so consider local station radio, ‘DMX’ and the like, but remember that in all these approaches licences / fees may be applicable, and should be investigated.

CHOOSING and ADJUSTING AN AMPLIFIER
Having established how many inputs are required, and determined the speaker load from the foregoing, the choice is simple however, the following may affect this.

1. Is system expansion a requirement at a later stage and therefore is there a need to add a % of spare wattage capacity to the amplifier output? Always add at least ±20%.
2. Is the quality of music distribution a low or high priority? If high, choose an amplifier with good frequency response, 50Hz-15KHz minimum, bearing in mind that when quoted, this should include a dB reference, e.g. +/-3dB, indicating that the outer frequency limits are down/up to half/double power when compared to the average overall response within the range. Complement this choice with full-range frequency response speakers, at least equal to that of the amplifier. If low, and speech is the higher priority, try to choose speakers with limited bass response, i.e. 100Hz and above, as this helps to reduce low frequency overtones that can degrade announcement clarity, particularly when using male voice.

ADJUSTMENTS
Initially, all input sensitivity controls should be at zero and tone controls at ‘flat’. The important aspect here is that the main adjustment control settings, ex tone control(s) should be, hopefully, around the middle of the scale when finalised.

a. Adjust ‘master’ output level to ±70% of full. This allows for up/down trimming later.

b. Whilst transmitting, adjust the sensitivity control of the input required for highest audio level penetration, normally the microphone if supplied, until an average of 80-100% output level indication is achieved on the amplifier. If the speaker wattage settings have been done correctly, this will be confirmed at the speakers. Minimal ‘master’ volume ‘trimming’ may be necessary.

c. Adjust all other inputs for correct output system level.

d. Once set, ‘tone’ control(s) may be adjusted for best overall system clarity/tone.

e. Remember that the set input sensitivity levels are related to each other, not to the speaker system. The ‘master’ output control adjusts the amplifier output up or down whilst maintaining this relationship. Clients particularly do not grasp this, leading to subsequent system mal-adjustment and the system/contractor taking the blame.

Should you require further information, advice or design of public address system applications, our technical department will be pleased to assist.

THE END