

SAFEPATH®



Steps Ahead

A Guide to Loudspeaker Paging and
Telephone Systems Interface


COOPER Notification



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Step 1 - Select the Correct System

24 volt self amplified or 70 volt central amplified. Which is best? The answer is that either system is right for certain applications. Here are a few guidelines:

For small systems involving 6-8 speakers, 24VDC self amplified systems offer the advantages of low cost, easy installation using telephone (quad) wire, individual volume control and built-in redundancy (if one fails, the rest keep working). Self amplified speakers are speakers with their own amplifier attached. They use a 4-wire connection — a 2-wire connection for the 24VDC that powers the amplifier and another 2-wire for the audio.

70 volt distributed systems are generally preferable with larger systems because one central amplifier can power a great many speakers that cost much less than self amplified speakers. The price break occurs at about 6-8 speakers, where the cost of a central amplifier and lower cost speakers will begin to offset the cost of self amplified speakers and 24 volt power supplies. The wiring is simpler: A single pair of wires.

70 volt systems are the better choice when good sounding background music is a requirement. The speakers and amplifiers generally have much better frequency response than the self amplified systems, which are designed basically for good speech reproduction, but not for good music reproduction. Additionally, 70 volt amplifiers provide selective inputs and mixing capability for FM tuners, CD players, etc.

Wiring/Code Issues for Audio Systems

In the past, there has been much debate on the issue of wiring requirements for speaker systems, especially 70 volt audio. Table 11, chapter nine of the National Electric Code (NEC) 1999 version, establishes Class 3 circuit rating for 70V audio as well as for 24 volts DC signaling circuits. This means that 70 volt (central amp) or 24 volt (self-amplified) speaker systems may use *Class 3 wiring methods*, for example the common practice of loose cabling draped across ceiling tiles. Further, according to the **National Electric Code Handbook** (McGraw-Hill, 1999 edition) page 1183: "...Amplifier output circuits rated not over 70V, with open-circuit voltage (this means no speakers connected) not over 100V, may use *Class 3 wiring* as set forth in Code section 725-41(a) of Article 725". Unless local codes or local authorities specify otherwise (yes, always check if in doubt), this ruling basically says that you don't have to run *conduit* (a typical Class 1 wiring method) for speaker cabling.

Actually, UL (Underwriter's Laboratories) has greatly simplified the matter by requiring amplifier manufacturers to silkscreen their speaker output section terminals with the specific class of wiring method required, a much simpler approach that makes it easy for anyone to understand. For 70 volt speaker lines, Class 3 wiring is specified. For 100 Volt or greater speaker lines, Class 1 wiring is specified.

A word about 100 volt systems: 100 volt audio simply means that the amplifier develops full output power, in watts, with 100 volts of potential across its speaker output terminals. This is a higher transmission voltage than 70V or 25V, and there are certain advantages to this. Technically, the higher the transmission voltage, the more efficient the system becomes. Consider the relationship $P=VA$, where P=power in watts, V=voltage and A=current in amperes. This is a variation of Ohm's Law which says that for a given amount of power (in watts) the higher the **voltage** the lower the **amperage**. The choice of wire size and length of run is directly related to the amount of current (amperage) that the wire has to carry. In high voltage, low amperage systems, wire runs can be longer and smaller in size than the wire runs used in lower voltage systems. 100 volt systems are more efficient than 70 volt systems, which in turn are more efficient than 25 volt systems.

According to the NEC, 25 and 70 volt central amplified systems can be wired using class 3 methods, for example, the common practice of loose cabling draped across ceiling tiles or other methods using exposed cabling. By strict definition, 100 volt audio would have to be wired according to class 1 wiring methods, which usually means conduit in commercial/ industrial installations. However, if the builder/installer is already committed to conduit for the speaker wiring (almost a given for hospitals, factories, government buildings) 100 volt audio for the speaker wiring becomes the clear choice because of the power transmission efficiency and lower wiring cost.

100 volt audio is not new: It is widely used around the world, especially in Europe. High power stadium applications in this country have traditionally used even higher voltages, such as 140 volt and 200 volt, because of the length of runs and the power involved. The majority of applications in the US are 70 volt. 25 volt is also commonly used, mostly in schools. However, in order to make our discussion easier, the term 70 volt audio will be used throughout this book to describe all central amplifier type systems.

Amplified Paging Speakers and Horns

SA-Series Amplified Speakers and Horns

The SA-Series Amplified Speaker Horns provide clear, audible, output for voice paging, background music, and tone alerting. The two models offered are 5 watt and 15 watt weatherproof horns. Each model features a built-in amplifier and individual tamper resistant volume control. The horns are provided with a conduit interface adapter and a clear plastic shield. A universal mounting base is adjustable in both vertical and horizontal planes and has banding slots for beam and pillar mounting.



Model No.	Power Output	Input Impedance	Audio Input	Operating Voltage	Nominal Current	dBA @ 1 Meter	Frequency
SA-H5B	5 Watts	600 Ohms	-15 dBm to +10 dBm	24VDC	325mA	118	275 Hz to 10K Hz
SA-H15B	15 Watts	600 Ohms		24VDC	900mA	122	

Paging Speakers and Horns with 25V/70V/100V Transformer

Series ST-B4, ST-C8 and ST-C8V Speakers and Series ST-H15 and ST-H30 Horns

The ST Series Speakers and Horns provide clear, audible, output for voice paging, background music, and tone alerting. Five models are offered: an 8" with white textured plastic grille with or without volume control for flush ceiling mount; a 4" with ivory colored plastic housing for surface wall mount and two metal weatherproof horns. All are equipped with a line matching transformer, for matching the speaker or horn power requirements to the 25 V or 70 V constant voltage output of an amplifier. The horns can additionally be powered from a 100 V line. The speaker transformer has color coded power taps and the horns have a power selector switch. The horns are provided with a conduit interface adapter and clear plastic shield. A universal mounting base is adjustable in both horizontal and vertical planes and has banding slots for beam and pillar mounting.



A



B



C



D

Item	Model No.	dBA@ 1 Meter	Frequency Response	Max. Wattage Selection	Wattage Tap Selections
A	ST-B4	93	200 Hz to 10K Hz	4 Watts	1/8W, 1/4W, 1/2W, 1W, 2W, 4W
B	ST-C8 ST-C8V	95	80 Hz to 14K Hz		
C	ST-H15B	122	275 Hz to 10K Hz	15 Watts	1.0, 2.0, 3.8, 7.5, 15.0
D	ST-H30	125		30 Watts	2.0, 3.8, 7.5, 15.0, 30.0

NOTE: Sound output (dBA @ 1 meter) measured at 1 W for ST-B4, ST-C8 and ST-C8V. ST-H15 and ST-H30 are measured at full rated power.

Step 2 - System Design and Layout

It's easier than it may first appear, and once you master some basics, it will become routine. Armed with these basics and a good dose of common sense, you can design a system that will work well, **every time**.

Creating a uniform sound field

In order to be effectively heard, a paging system simply has to be **loud enough** to be heard above the noise level of the environment, and **intelligible**, which means the system should produce clear, audible sound without being muffled or distorted. "Sounds" simple, right? Now let's look a little closer.

An important point to remember is that effective coverage in a room depends more upon speaker placement and spacing than upon volume of the speaker themselves.

For example, a garden hose has a certain spray pattern. Increasing the water pressure will not give you much greater coverage for your garden but adding another nozzle certainly will. In a similar fashion, multiple paging speakers "spray" sound evenly to all areas and create a **uniform sound field**. Achieving sufficient loudness and intelligibility is not simply a matter of turning up the volume. Many poor paging systems are the result of trying to compensate for an insufficient amount of speakers with too much volume. At one end of the room people are asking "What did he say?"...while the people near the speaker are getting "knocked out of their socks".

SPL & dB — WHAAAA???

Here come two more intimidating terms. But, once you master their meaning and application, they will become two of the best tools you could possibly have. Your customers will also be impressed with your expertise, which will enhance your image as a knowledgeable installer. We should first discuss "sound pressure level" (SPL) which your ears interpret as "loudness" or "volume". SPL is expressed in decibels, abbreviated dB. dB's are tossed around a lot, without much understanding. When you talk dB's, you are always talking the **difference** between two sound levels. For example, "100 dB SPL" means a sound pressure level 100 dB above a zero point set at the lowest sound pressure level discernible by the average human ear.

You are also talking differences when you say one sound is 3 dB louder than another sound. A 3 dB difference can be heard by most people, but it certainly won't "knock your socks off". It takes something like a 10 dB difference in average SPL to be perceived as a doubling of loudness. As we shall see in the next section, doubling amplifier power gives only a 3 dB increase in a speaker's output. The same result, or better, can be obtained by using a more efficient speaker. For example, a ceiling speaker might specify 92 dB SPL @ 1 meter distance from the speaker with 1 watt of applied power. Yet, a different speaker may yield 95 dB SPL @ 1 meter @ 1 watt. That's 3 "free" dB, or about 30% more volume, because of the difference in speaker efficiency.

Power and distance

Okay, now that it's safe to talk about dB's and SPL, let's continue — A paging speaker's loudness (SPL) is affected by two unchanging laws of physics: The **power** (in watts) applied to the speaker and the **distance** between the listener and the speaker itself.

Power and the 3dB rule

As previously stated, **if you double the power to a speaker, you gain 3 dB. Cut the power in half and you lose 3 dB.** For example, if you have an appliance that produces 90 dB at a distance of 64 feet using the 3.8 watt tap, then doubling the power by using the 7.5 watt tap will give you 93 dB. A modest gain at best, and something to really consider since doubling the power can mean double the amplifier cost. A more efficient speaker or more effective placement could give you that extra 3 dB without having to double the amplifier power. HMM...seems like we've mentioned this before, but let's go on.

Distance and the 6 dB rule

Simply put, **doubling the distance from the speaker means you lose 6 dB SPL, cut the distance in half, and you gain 6 dB.** This means that **each time** you double or half the distance you lose or gain 6 dB. In the above example, an appliance delivers 90 dB @ 64 feet with 3.8 watts of applied power. **Double the distance** to 128 feet and the SPL drops 6 dB to 84 dB. Doubling once again to 256 feet means 78 dB, and so forth. Of course, the reverse is also true: **Cutting the distances in half** yields gains of 6 dB each time you do it.

The distance factor becomes especially important when laying out a system using horns. Ceiling speakers typically have to project sound only a few feet to the listener's ears, but a horn may have to project sound 30, 60, 100 feet or more. So it's important to understand how a horn's output is affected by distance and applied power. **A cost effective, well designed system balances amplifier power, speaker placement and speaker efficiency.**

How loud?

OK, here's the point of the entire last section: **The paging volume should be at least 6dB over the background (ambient) noise level.** This makes sense. The page level is competing with the background noise level and if the page isn't loud enough, no one can hear it!

How do we know what the background noise level is? Most offices, lobbies, department stores, banks and restaurants are fairly quiet (55-70 dB) and can be predictably dealt with using ceiling or wall speakers tapped or set at 1 watt or less. This is usually more than enough power to generate sufficient volume. Noisier environments are generally industrial areas or large expansive areas such as warehouses. The speakers usually chosen for these areas are horns because they are more efficient (louder) than a typical cone ceiling speaker.

The wise installer will want to know precise background noise levels in order to properly design the paging system to overcome these noise levels. In these situations, the first step is to measure the ambient, or background noise. **Don't guess — use a sound level meter!** You can purchase an inexpensive, yet effective sound level meter and it is money well spent if you want to design a paging system that works. By eliminating the guesswork, you will be "right on" with your levels and subsequent selection of equipment. For best results, take SPL readings during peak noise hours so the system can be designed for "worst case" conditions.

Here are some examples of the most commonly encountered commercial background noise levels:

Typical Noise Levels	
Location	dB
Machine Shop	90
Manufacturing (Noisy)	80
Printing Shop	80
Assembly Line	75
Supermarket	75
Transportation Waiting Room	75
Office (Noisy)	70
Shipping/Warehouse	70
Restaurant	70
Department Store	65
Bank (Public Area)	65
Office (Quiet)	55
Office/Doctors Waiting Room	55
Hotel Lobby	55
Doctors Exam Room	55

Once again, this gives us a starting point for our "6 dB over ambient" paging system goal.

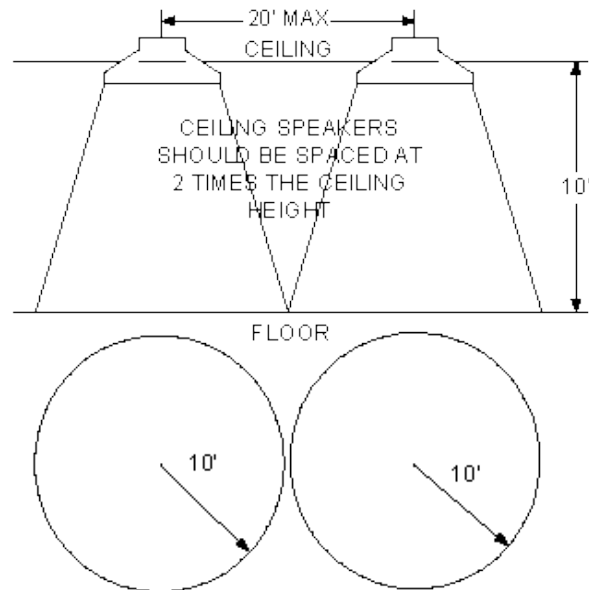
Ceiling Mount Speakers

Speaker spacing

For ceiling mount installation in most offices, stores, schools, etc., recessed ceiling mount speakers can be used. **Space the speakers at twice the ceiling height.** If the ceiling is 12 feet high, space the speakers 24 feet apart. This will provide uniform coverage.

Ceiling Speaker Spacing and Coverage

Ceiling Height	Spacing
20 ft	40 ft
12 ft	24 ft
10 ft	20 ft
8 ft	16 ft



How many speakers?

First, find the coverage given by one speaker in square feet. The coverage of one speaker is the spacing times itself. In other words, if the speakers are spaced 20 feet apart (because of 10 feet ceilings) then 20 feet X 20 feet = 400 sq feet. Next, divide the square footage of the room by the square foot coverage of one speaker. For example, if a room measures 60 feet X 100 feet (6000 sq feet) divide 6000 sq feet (the square footage of the room) by 400 sq feet (the square foot coverage of one speaker) and you will get 15 (the total number of speakers required for that room). Here's a handy chart for spacing and coverage:

Ceiling Speakers
The 2 times rule
(2 times ceiling height = speaker spacing)
Coverage = Spacing

Ceiling Speaker Spacing and Coverage		
Ceiling Height	Speaker Spacing (Feet)	Coverage per Speaker (Sq Feet)
8	16	256
9	18	324
10	20	400
11	22	484
12	24	576

Wheelock Speaker System Calculator

Much of the information contained in this book has been condensed into a simple and easy to use sliderule calculator available from your local Wheelock sales representative. This powerful tool calculates the required number of ceiling speakers or horns, power requirements, wire size, etc., for a given size area, ceiling height and background noise level. The calculator is designed for both self amplified (24VDC) and central amplified (25/70/100 volt) systems.



This calculator is also available and downloadable on Cooper Notification's website at www.coopernotification.com



How much power?

Always design the system for maximum "headroom"...which means plenty of reserve power to allow for future expansion or unusual volume requirements. For example, for office environments, try to design for at least **1 watt of power** for **each** eight inch (central amplified) speaker and/or **full power** for **each** self amplified speaker. What this means in terms of hardware is correct amplifier power supply size and proper wire size (more about this later).

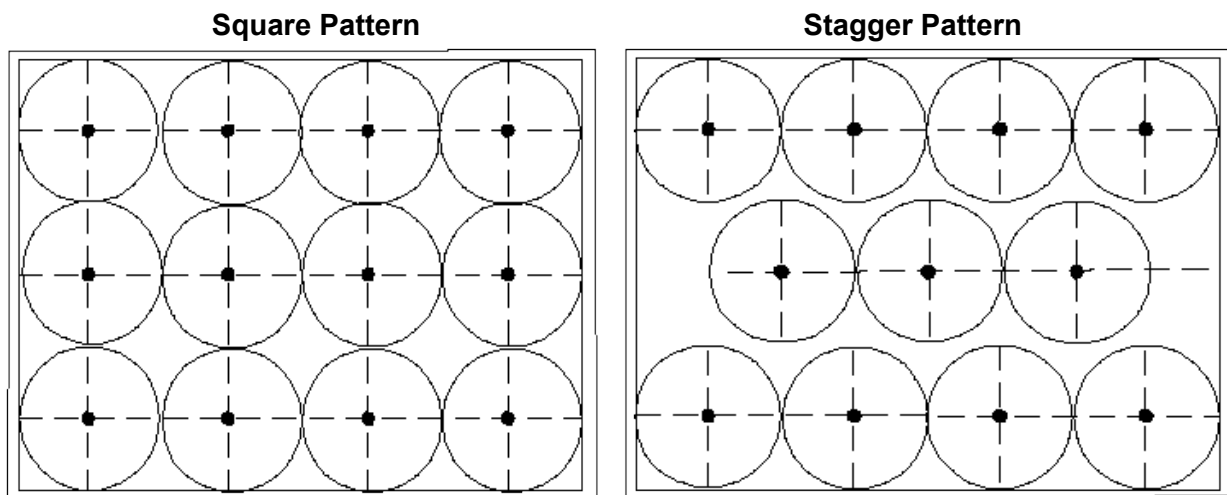
What does this kind of reserve power actually mean? 70 volt speakers and horns typically incorporate a number of different power settings or wattage "taps". These taps determine the amount of power that the speaker will draw from the amplifier. A Wheelock ST-C8 ceiling speaker with one watt applied will typically generate about 95 dB @ 1 meter, which is just about the distance to someone's ears if they were standing under the speaker, and 95 dB is overkill to say the least, in a 60 dB office environment! However, in order for the speaker, tapped at 1 watt, to actually **receive** that 1 watt, the amplifier must be at **full power**. That's right: Pedal to the metal, volume control to the max. Although most modern amplifiers can operate in this manner, it's more ideal to operate any amplifier with the volume controls at or near their midway position. This gives the user some flexibility and overall system control.

Consider this: With the amplifier at 50% power (approx 1/2 volume) the speaker, tapped at 1 watt, will actually pull 1/2 watt from the speaker line. With 1/2 watt of applied power the speaker will still deliver 92 dB! Remember power and the 3 dB rule? Cutting the power from 1 watt to 1/2 watt results in a 3 dB drop in volume. A speaker tapped at only 1/8 watt would still deliver better than 80 dB, assuming the amplifier is turned up to max power. At 1/2 volume this same speaker, tapped at 1/8 watt, would still deliver better than 75 dB. Thus, in a quiet office environment a single 100 watt central amplifier could power a large number of ceiling speakers tapped at 1/2, 1/4 or 1/8 watt with sufficient volume for 6 dB-over the ambient noise.

The choice of wattage tap in this situation can simply depend on the number of speakers required. In other words, more speakers tapped at 1/4 watt could be put on the line than speakers tapped at 1/2 watt. It's just that you have to crank up the amplifier a little more and sacrifice some headroom. In any case, as we will also see a bit later, ***the amplifier size is determined by the sum total of the wattage taps, not the number of speakers.***

What about the pattern of the layout?

The “square pattern” layout uses all 12 speakers and is used because of layout simplicity. The “stagger pattern”, because it results in a tighter edge-to-edge pattern, gives somewhat better coverage and actually uses less speakers. In this example, 11 speakers are used.



Wall Mount Speakers

If the ceiling is too high or not accessible, then wall mount speakers can be used.

Coverage

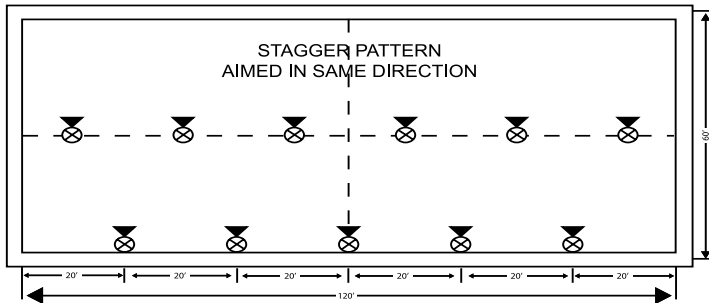
These speakers will project 30 feet into the room, so the square foot coverage is 20 feet x 30 feet = 600 sq feet. ***Power settings*** for either a wall mounted central amplified speaker or a wall mounted self amplified speaker should be similar to that of the ceiling mount speakers previously described. ***Design*** for 1 watt (70 volt system) or 105 mA (self amplified) per speaker; ***use initial settings*** of 1/2 watt or 1/2 power for best system flexibility and headroom.

How many speakers?

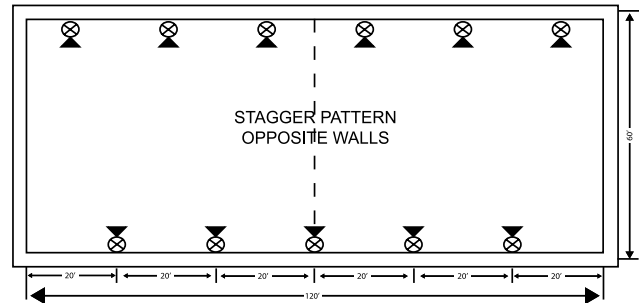
Once again, divide the square footage of the room by the square foot coverage of one speaker. If the room is wider than 30 feet, a second row of speakers can be used. The preferred method is shown below, where all speakers are aimed in the same direction. This requires the room to have pillars or posts to which the second row of speakers can be mounted. Where possible, a stagger pattern is preferred. The more common arrangement (due to lack of pillars or posts in most locations), is having the second row of speakers mounted on the opposing wall. (As shown) a stagger pattern ***must be used.***

Because of a phenomenon called phase cancellation, NEVER have speakers pointing directly at each other because the result will be poor sound reproduction.

Wall Speaker Layout Speakers Mounted on One Wall and Pillars



Wall Speaker Layout Speakers Mounted on Opposing Wall

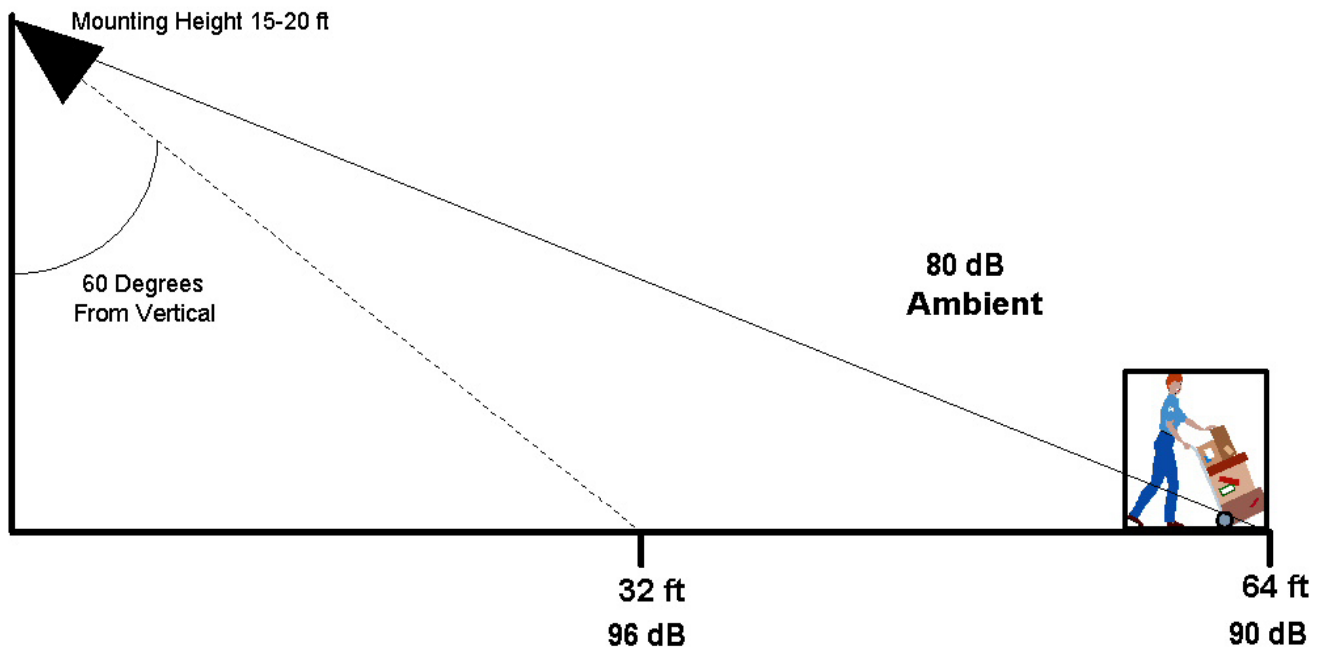


Horns

Horns are used in large, open areas or very high noise areas mainly because of their efficiency. They put out a lot of sound! Typical applications are factories, warehouses, loading docks, school yards, military applications, parking lots, etc.

Typical Horn Installation

Horn Performance
114 dB @ 3.8 Watts at 1 Meter (4 ft)



Spacing and forward projection

Experience has shown that the most effective side to side spacing of a typical horn is about 40 feet. This is determined by the flare rate and dispersion pattern, which are fixed and constant.

The front-to-rear spacing requires a little more thought, because we are actually dealing with the forward projection of the horn. This projection is determined by two variables:

- The SPL (sound pressure level) that the horn is capable of at a specified wattage
- The ambient noise that this SPL has to compete with in order for the audio to be heard

Remember, **a page has to be at least 6 dB above the ambient noise level** in order to be heard effectively. Generally, for horns such as Wheelock's SA-H5, SA-H15 (self-amplified) or ST-H15B, ST-H30 (70 volt) to be effective, front-to-rear spacing should be as follows:

- 128 feet for quiet to moderate locations (50-74 dB ambient)
- 64 feet for noisy locations (75-85 dB ambient)
- 32 feet for very noisy locations (86-96 dB ambient)

The following discussion should make this clear. Let's say you are bidding a job and this particular situation calls for paging in a noisy production area. You take out your trusty SPL meter and get readings of 85 dB throughout the area. Now, we know that for the page to be heard, we need at least 6 dB more than ambient, or 91 dB. You have already decided upon a 70 volt system, and you will be using Wheelock's ST-H15B horn. Wheelock provides the following performance data for the horn:

ST-H15B Performance			
Feet on Axis	Sound Pressure Level (dB @ 1K Hz)		
	Full Power (15W)	1/2 Power (7.5W)	1/4 Power (3.8W)
4	120	117	114
8	114	111	108
16	108	105	102
32	102	99	96
64	96	93	90
128	90	87	84

Remember, we need 91 dB for an effective page. From the table, we can see that at 64 feet the selection of wattage taps gives us the SPL range we need. At the 7.5 watt setting the horn will give 93 dB which is certainly adequate. Note that at 128 feet there is a range of 84 dB to 90 dB (not quite good enough) and that at 32 feet the range is 90 dB to 102 dB — probably too much, and spacing the horns at 32 feet instead of 64 feet means twice the quantity of horns and twice the money. So, the best choice for front-to-rear spacing is 64 feet.

The same principles apply to the self-amplified SA-H15 horn. Instead of wattage taps, however, there is simply a volume control. **Full volume means full power or 15 watts; half volume means half power or 7.5 watts.** The SPL and dB performance is very similar to the 70 volt ST-H15B.

How much area will this cover? Multiply the side-to-side spacing (40 feet) by the front-to-rear spacing (64 feet) — 40 feet x 64 feet = 2560 sq feet. Area of coverage is useful because you can get a quick estimate of the actual number of horns you need. Let's say you have a 100,000 square foot area to cover. You know from taking readings that you will be spacing the horns at 64 feet for a coverage of 2560 sq feet. You divide 100,000 by 2560 and get 39 — the number of horns that you need for the job.

The Nuts and Bolts of an Actual Installation

This application of paging horns in a noisy (75-85 dB) warehouse and production facility, as shown in the following illustration, puts it all together: In the 23,040 sq foot production area we have...

- Divided by 2560 sq feet per horn to get 9 horns
- Applied the stagger pattern which used only 8 horns
- Applied the 40 foot side-to-side spacing
- Applied the 64 foot front-to-rear spacing
- Remembered to face all horns in the same direction (Don't forget phase cancellation)

In warehouses, we commonly encounter tall storage racks creating aisles. These racks effectively block the “clear shot” we need for the horns. The solution is to treat each aisle as a long narrow room. Our example illustrates four aisles. The horns can be mounted on overhead girders, ducts or on the sides of the storage racks. The horns are arranged back-to-back, and we have again applied the 64 foot forward coverage.

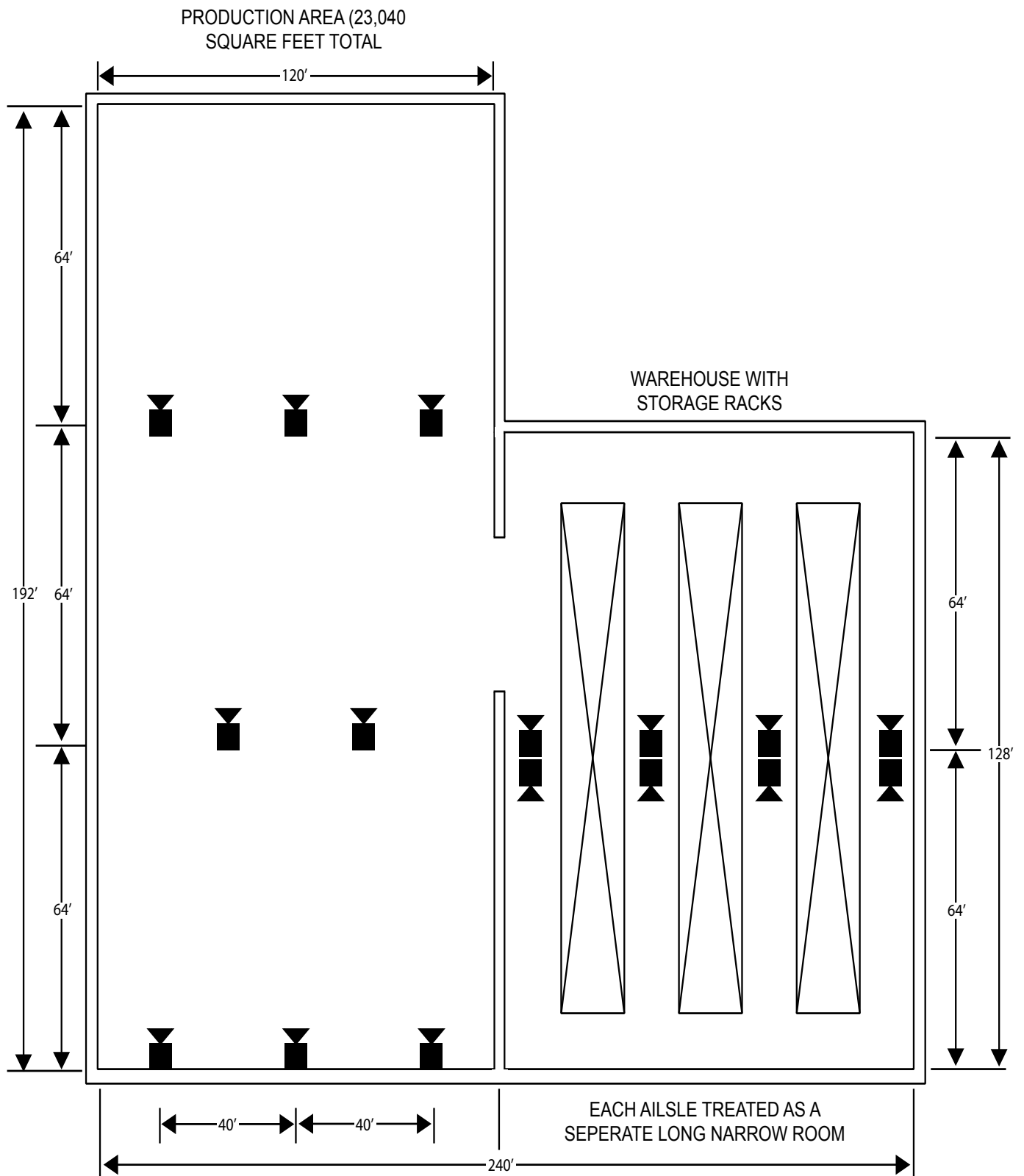
If the warehouse was quiet to moderate (50-74 dB), a “throw” of 128 feet per horn would generate sufficient SPL over ambient noise and...

- Only 4 horns would be needed
- Each with a forward projection of 128 feet

That means there could be one horn...

- Located at the beginning of each aisle
- Each horn would cover the full length of its aisles

Application of Horns in a Noisy Production and Warehouse Facility



Here is a handy chart that pulls together horn selection along with distance and power settings in typical commercial applications:

Horn Loudspeaker Selection Guide					
Noise Level	Typical Area	Wheelock Self Amplified Horn	Effective Forward Coverage	Wheelock Central Amplified 25/70/100 Volt Horn	Wattage Tap/Effective Forward Coverage
Quiet to Moderate 50-75dB	Shipping Warehouse	SA-H5	128 feet	ST-H15B	3.8 watts/128 feet
Noisy 75-85dB	Print Shop, Factory	SA-H5 SA-H15	64 feet 96 feet	ST-H15B	7.5 watts/64 feet 15.0 watts/96 feet
Very Noisy 86-96dB	Machine Shop, Factory	SA-H15	32 feet	ST-H15B ST-H30	15.0 watts/32 feet 30.0 watts/48 feet

Step 3 Select the Correct Amount Of Power

In this section we will see how to select the appropriate size power supply (self amplified 24 volt system) or amplifier (central amplified 70 volt system).

Self amplified

Self amplified (24VDC) systems are 4-wire systems. A pair of wires for the audio and a pair for the DC voltage necessary to power each speaker's amplifier. **A very important consideration then is the maximum total current draw, in milliamps of all speakers to be connected on the same power supply.** Thus a single Wheelock RPS-2406 power supply, which provides 600mA, may be sufficient to power multiple speakers. Actually this approach is somewhat conservative; it is seldom necessary to operate these speakers at full volume and power. At half volume self amplified speakers draw considerably less current and still deliver plenty of sound for most environments. Power supplies can be run in tandem...that is, **paralleled** with positive poles and negative poles connected together **to yield double the available current.** For example, a pair of 600mA RPS-2406 power supplies can be tied together to yield 1200mA (1.2 amps). For more power, Wheelock also provides the 4 amp RPS-2440 24VDC power supply, and the 8-output, 20.8 amp PSC-2420-B 24VDC power supply. The PSC-2420-B features a battery charging circuit with automatic switchover to backup batteries. Check the specifications of the power supply to be used in order to stay within its operating range. Using self-amplified speakers and other 24 VDC products with a power supply with battery backup will allow a completely battery backed telephone paging system.

Central Amplifier

For central amplifier 70 volt systems, the sum of the selected speaker wattage taps will determine the size of the amplifier — in other words, add up the wattage taps. Forty speakers tapped at 1 watt represent a total wattage demand of 40 watts. Then, size the amplifier so that the sum of the wattage taps does not exceed 85% of the amplifier's rated power. This will ensure headroom and reserve power.

Power Supplies

RPS-2406: Fully Regulated and Filtered, 24 VDC, 600 mA. Current limited, short circuit and overload protected with auto shutdown and reset. Wall mounting with 6 ft. AC power cord.

RPS-2440-A: 24 VDC, dual output. Either two 2 A, or one 4A. Fully regulated and filtered. Each output with independent power on LED, current limiting overload and short circuit protection, auto shutdown and reset. AC circuit breaker for input protection.



Item	Model Number	Output Voltage	Output Current	Regulations	Ripple Voltage
A	RPS-2406	24 VDC	600 mA	± 5%	10mVRMS
B	RPS-2440	24 VDC	4 A	± 5%	10mVRMS

Correct Wire Size for Central Amplified System Speaker Lines and Amplified Speaker System 24 VDC Power Lines

In any electrical installation, sound or otherwise, proper wire size is important if you want maximum efficiency from the system, not to mention safety and reliability.

Wire conducts the audio and electrical signals in your system. Like arteries and veins in the human body, good unobstructed flow is vital. Wire that is sized too small acts like a resistor in the circuit and can restrict the flow. If the wire is too small (or the run too long) for the speaker load, a lot of amplifier power will never reach the speaker. This electrical energy simply becomes heat in the wires, and will result in volume loss.

So, **bigger is better**. The less restriction in the wire, the better the path for your audio and electrical signals. It's like the difference between sending your signal down a dirt road or the interstate. However, if you have more wire size than you need you're wasting money. So, it's important to know what size wire to use for a given power load and how far you can run this particular size wire with this power load.

Cable lengths for 70 volt speaker lines

Table #1 should prove useful for 100 volt, 70 volt, 25 volt or low impedance (8 ohm) speaker lines. As an example, let's say your installation calls for a 60 watt load and you have to run the cable about 900 feet. Looking at the chart, the correct wire size is #14. Or, let's say it's an older installation and you want to use the existing wire — 600 feet of #22. Again, looking at the chart, you must limit the connected load to 15 watts, which could be 15 speakers tapped at 1 watt, 30 speakers tapped at 1/2 watt or a single horn tapped at 15 watts. These figures are meant to be guidelines. It is not that the system would not work at all if you used smaller wire or longer runs than specified, it is just that the volume loss would be greater, and the efficiency of the system reduced.

Table #1
2 WIRE COPPER CABLE LENGTHS FOR SPEAKER LINES AT 0.5 dB
LOSS IN SPL (12.5% POWER LOSS IN WATTS)

AWG Size	Max Power AWG	Low Impedance Speaker Line 8 Ohms	70 Volt Speaker Line												AWG Size
			Nominal Power in the Load Length in Feet												
			10W	15W	20W	40W	60W	100W	125W	200W	250W	400W	500W		
10	Per NEC	240	15,000	9,900	7,500	3,750	2,500	1,500	1,180	730	590	370	290	10	
12	Per NEC	150	9,100	6,200	4,680	2,340	1,560	940	730	460	370	230	180	12	
14	1,060 W	95	5,600	3,800	2,880	1,440	960	600	450	280	220	140	110	14	
16	420 W	60	3,600	2,400	1,870	930	620	370	290	180	140	90	—	16	
18	210 W	40	2,300	1,500	1,150	570	380	230	180	110	—	—	—	18	
20	70 W	25	1,400	960	730	360	240	—	—	—	—	—	—	20	
22	35 W	15	900	600	460	—	—	—	—	—	—	—	—	22	

NOTE: 1. For 25 V line divide all 70.7 lengths by 8. 2. For 100 V line multiply all 70.7 lengths by 2.0. 3. To allow for future expansion and distribution cable line loss, it is recommended that the total system wattage should not exceed 85% of the amplifier's rated output. 4. The total system wattage requirement is the summation of the wattage tap selections of all system speakers and horns.

Cable Lengths for 24 VDC Power Lines

Wiring for self amplified systems, or systems using low voltage DC to power self contained amplified speakers, can present a different problem, and that is voltage drop. With 70 volt speaker systems, the audio signal is distributed at a higher voltage and then stepped down at each speaker via a transformer much the same way utility companies bring power to your home — high voltage transmission that is stepped down at each location. This is a very efficient method that works because of the nature of AC voltages (audio is an AC voltage) and transformers (voltages can be stepped up or down). DC voltage cannot be stepped up or down with transformers, so the voltage that is available from the source (the power supply) is the same voltage that the device receives. If the device that must be powered by this voltage is some distance away, careful attention must be paid to current draw, length of run and wire size.

In self amplified speakers, the small amplifiers behind each speaker are powered with 24 VDC, and these amplifiers have a definite current draw, which means that a specific length of run and wire size (which in turn create a certain resistance) will have an impact on the amount of current, measured in amperes, or milliamps, that the amplifiers will actually receive. By imposing a larger current draw than the wiring can handle, the system will “see” a drop in voltage and current flow. Most devices specify a minimum operating voltage and current requirement.

All of these considerations are basically gyrations of Ohm’s Law. And, unless the wire is sized correctly for the current draw and length of run, strange things may happen when you fire up the system. Volume will be lower than expected, sound may drop in and out, or, in extreme cases, it may not work at all!

Table #2, at a glance, gives wire size, length of runs and current draw for a 10% drop in voltage for 24 VDC systems. A voltage drop of 10% represents 21.6 VDC, well within the operational range of Wheelock’s 24 VDC powered products. As an example, let’s say your installation calls for ten 8” self amplified ceiling speakers. The distance between the power supply and the last speaker on the line is about 170 feet. For simplicity and even greater “headroom”, let’s assume an “end of the line” situation — that is, view the situation as if all 10 speaker amplifiers were sitting out there at the end of a 170 foot run of wire.

If, at full power, a typical self amplified speaker draws about 105 mA, the full connected load will draw 105 mA x 10 speakers = 1050 milliamps, (1.05 amps). Looking at the chart, 1100 milliamps can be drawn through 170 feet of #18 gauge wire. The correct wire size, therefore, is #18 AWG.

Table #2
2 WIRE COPPER CABLE LENGTHS FOR 24 VDC POWER LINES
AT A 10% DROP IN VOLTAGE

AWG Size	CURRENT DRAW (MILLIAMPS)															AWG Size
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	
10	12000	6000	4000	3000	2400	2000	1720	1500	1335	1200	1090	1000	925	860	800	10
12	7500	3750	2500	1880	1500	1250	1070	940	835	750	680	625	570	535	500	12
14	4800	2400	1600	1200	960	800	690	600	535	480	435	400	370	345	320	14
16	3000	1500	1000	750	600	500	430	375	335	300	275	250	230	215	200	16
18	1880	940	630	470	380	310	270	235	210	190	170	155	145	135	125	18
20	1200	600	400	300	240	200	170	150	135	120	110	100	90	85	80	20
22	375	375	250	185	150	125	110	95	85	75	70	65	60	55	50	22
24	470	235	160	120	95	80	70	60	55	50	45	40	35	35	30	24

LENGTH IN FEET

- NOTES:
1. Doubling the current draw reduces cable length 1/2. Halving the current draw doubles cable length.
 2. Doubling the voltage (ie. 48 VDC) doubles cable length. Halving the voltage (ie. 12 VDC) reduces cable length 1/2.
 3. 1000 milliamps — 1.0 amp.

What about the audio pair?

As mentioned previously, self-amplified speakers use a 4-wire hook-up: A pair for the 24 VDC power and a pair for the paging audio. What about the audio pair? Shouldn't we worry about correct wire size for the audio wiring as well? Pre-amplified paging audio is a very low power, low impedance (usually 600 ohms or less) electrical signal. For this reason, small gauge wire of #22-24 AWG works well, even for very long cable runs. To illustrate this further, consider that telephone companies typically transmit low level voice audio over distances of two miles or more on #24 AWG wire.

Low power, low impedance pre-amp audio can generally be transmitted over considerable distances using small (#22-24) wire gauge.

Shielded vs unshielded wire

An entire book could be written on this subject, so let's boil it down to a few simple guidelines. **Speaker lines** from 70 volt central amplifiers can generally be **unshielded cable** with little or no chance of noise pick-up. An exception would be elevator shafts where an audio signal's worst nightmare comes true. These are electrically high noise environments and shielded wire or conduit should be used. **Audio lines** (wires carrying any low power pre-amplifier signal) should always use **shielded cable** to avoid noise pickup. This included microphone wiring, amp-to-amp connection between 70 volt amplifiers, and amplifier connections to FM tuners, tape decks, CD players, etc.

Self amplified speakers are often installed in telephone paging systems with acceptable results using unshielded telephone wire. Generally, this can be done with little or no noise pickup provided that the wiring doesn't pass close to electric motors, transformers, or fluorescent lighting ballasts. If in doubt, use shielded cable for the audio pair. It's cheap insurance.

Step 4 - Other Considerations

Telephone System Interface

Now that we know the basics of designing a paging system, in terms of speaker placement, efficiency and amplifier power, let's explore how to connect all of this hardware to a telephone system.

Up to this point, we have been discussing a paging system as a "stand alone" system — as if we had all of these components in place and we were going to use a single microphone to speak through it. This is often the case in small retail stores or perhaps a bowling alley, but in large complexes such as manufacturing plants, hospitals, office buildings, airports, etc., it becomes very desirable to access the paging system via the inhouse telephone system thereby enabling many users in many locations access to the paging system right from the nearest telephone. By taking advantage of all the extensions within the phone system, it's like having a PA system with 20, 50 or 100 microphones connected to it; all at different points in the building.

Telephone systems

Most commercial telephone systems in use today are basically variations of several types, namely electronic key systems (**EKSU's**), **PBX** systems, hybrid systems that are sort of a mixture of the two, and **Centrex**. First, let's look at **EKSU's** and **PBX** systems, because in the field, they are similar from an interface standpoint. **Centrex** systems are a little different, so we'll look at them separately.

Although they differ considerably in switching function, most **EKSU's** and **PBX** systems have a built-in page output right on the main unit which is accessed by pressing a dedicated key (EKSU) or a set of numbers on the touch-tone™ pad (PBX). In either case, the system has now connected you to a low power (usually 600 ohm) audio module in the main unit. That's right, an audio output that you can now bring right over to the 600 ohm output on your paging amplifier or self-amplified speaker(s).

Centrex systems work very much like PBX systems with one important difference: Instead of being located on premise, the switching gear is located at the telephone company's central office (CO). The extension lines come back from CO like telephone lines coming into your home — with 90-130 volt ringing voltage. **Centrex lines cannot be directly connected to amplifier inputs.** An telephone paging interface must be used to connect a ring voltage line to a paging system. The telephone paging interface answers a regular ringing voltage line (such as Centrex, station level PBX or single line residential type phone service) and then opens an audio path for connection to additional equipment such as a Wheelock paging system (MZC-144).

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Using Unused CO Ports

Some EKSU's and PBX's have no built-in paging access. In such cases, an unused CO line port or trunk port can be used. However, **talk battery ("A" battery)** must be provided in these applications.

What is it?

Talk battery or "A" battery is the DC voltage supplied by the telephone company (CO) central office to:

- A) Operate the carbon transmitter in the telephone handsets to allow audio (talking).
- B) Enable initiation of calls.
- C) Allow communication through the CO trunk ports of a telephone system (PBX, key, hybrid) installed in a customer's premise.

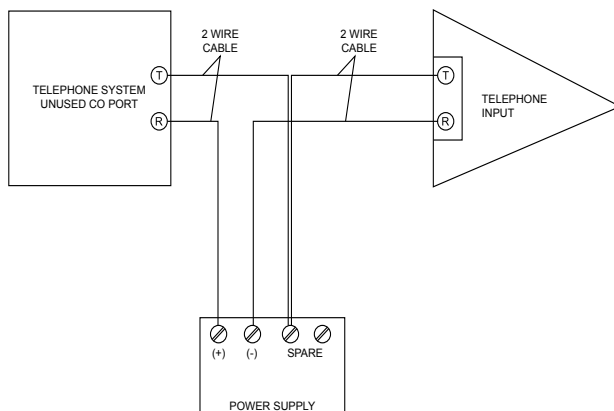
Talk battery (usually 48 VDC) is constantly present on the TIP (green) and RING (red) wires of each telephone company line. Note that **talk battery is not to be confused with ring voltage**, which is an AC voltage of about 105 volts and is superimposed right on top of the 48 VDC talk battery, over the same pair of wires, for the purpose of ringing a telephone.

How does it affect telephone paging applications?

When paging is connected to a telephone system's unused CO trunk port, talk battery is not available at that port. The operative word is "unused". That means the CO port is not connected to a public telephone (CO) line. If the telephone line is not connected to the port, then the talk battery the line would otherwise provide is simply not present. Nevertheless, the telephones within the system need to access that port for paging, so the port still needs talk battery for audio (paging). Therefore, talk battery must be supplied by the paging equipment.

Single Zone CO Port Paging Applications

Talk battery can be provided with a filtered and regulated 24 VDC power supply as illustrated by the following diagram



Note: This diagram shows the output of the telephone system feeding the input of a typical Wheelock amplifier for distribution on a 70 volt system. That same output could also directly feed self-amplified speakers or Wheelock talk back speakers in a similar manner.

Accessories

Now that we have built a paging system and interfaced it with a telephone system let's take a look at some different accessories that can be utilized.

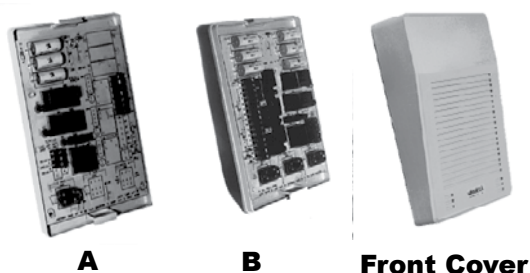
Common Audible

If the telephone system has no night ring feature, you can activate a tone generator by using a **common audible**, such as a Wheelock CA-312-1 or CA-622-1. These devices connect to all of the CO lines **ahead of** the EKSU or PBX main-frame and then put out a common ring signal whenever a call comes in on any of the lines. This common output can be either a dry contact or network ringing voltage, either of which can be used to activate a tone generator — or other types of signals for that matter.

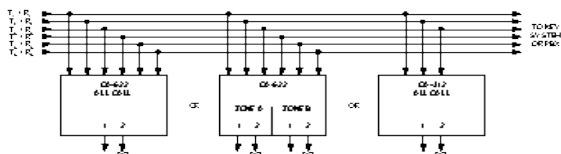
PRM-150 Pre-Amplifier

Besides correcting for proper impedance matching and compensating for long wire runs, the PRM-150 functions as a master volume control for a group of 600 Ohm, Self Amplified speakers. The PRM-150 requires 24 VDC.

Common Audible Interfaces



Wheelock's Series CA-622-1 Common Audible Control Unit can monitor up to six telephone lines to provide "All Call" signaling or "Zone" signaling. Two separate zones can be signaled and two or more control units can be ganged to monitor additional input lines. The economical CA-312-1 model monitors three tip and ring lines. These interface products are designed for Electronic Key Systems and PBX or 1A2 systems (with touch tone station sets) that do not offer a common audible ring circuit or dry contact closure for night bell connection or zoned ringing.



OUTPUT OPTIONS:

- 1 = Ringing Voltage
- 2 = Contact Closure: (use Wheelock's DCI-24-24 or EPS-2401 to drive 24 VDC alerts)

Both models provide a choice of two outputs for connection of alert signals: standard ringing voltage output or contact closure. A wide selection of audible and visual alert signals is available to operate directly off the ringing voltage output. Alternatively, Wheelock's dry contact interface or economy power supply can be connected to the optional contact closure output to drive 24 VDC alert signals.

ORDERING INFORMATION

Item	Input	Output	Application	Model No.
A	50-130 V, 20-30 Hz	Ringing Voltage or Contact Closure	Monitor up to 3 tip & ring lines (one zone)	CA-312-1
B			Monitor up to 6 tip & ring lines (two zones)	CA-622-1

NOTES: 1. Both models UL 1459 Listed, FCC Registered.

Paging Pre-Amplifier

Series PRM-150 Pre-Amplifier

Wheelock's PRM-150 Line Pre-Amplifier boosts the low audio signal from 600 ohm CO and audio page ports to a level capable of driving up to 150 600 Ohm self amplified speakers. The pre-amplifier will also compensate for audio signal loss (low volume) on long cable runs. The PRM-150 also functions as a one-way paging CO port interface. When used with a Wheelock RPS-2406 power supply talk battery is supplied to the CO port. It contains a volume control and is designed for convenient wall mounting.



Item	Model Number	Input Current @24 VDC	Input Impedance	Output Impedance	Input Level	Max Audio Output Level
A	PRM-150	35mA	600 Ohms	4 Ohms	-15 dBm to +10 dB	0.8 VRMS

Conclusion

Hopefully all of this has been of some help. There's no reason to be timid when faced with a job involving a paging or sound system. If you have never done much paging and/or telephone interface before, your process may be slow at first, but after you have handled some of the more routine phases of installation, troubleshooting and maintenance, you will be surprised at the confidence you develop. **Confidence and experience;** these are the most important basic keys to becoming a real paging "pro"!

Questions?/Assistance?

Contact Cooper Notification's Technical Support Engineering at
1-800-631-2148 or 732-222-6880
8 am - 5 pm Eastern Time

We are waiting to assist you with your paging/commercial sound needs!

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