NSM Icon Speaker System Guide

Everything you need to know about speakers and amplifiers to install a great sound system.

What is a speaker?

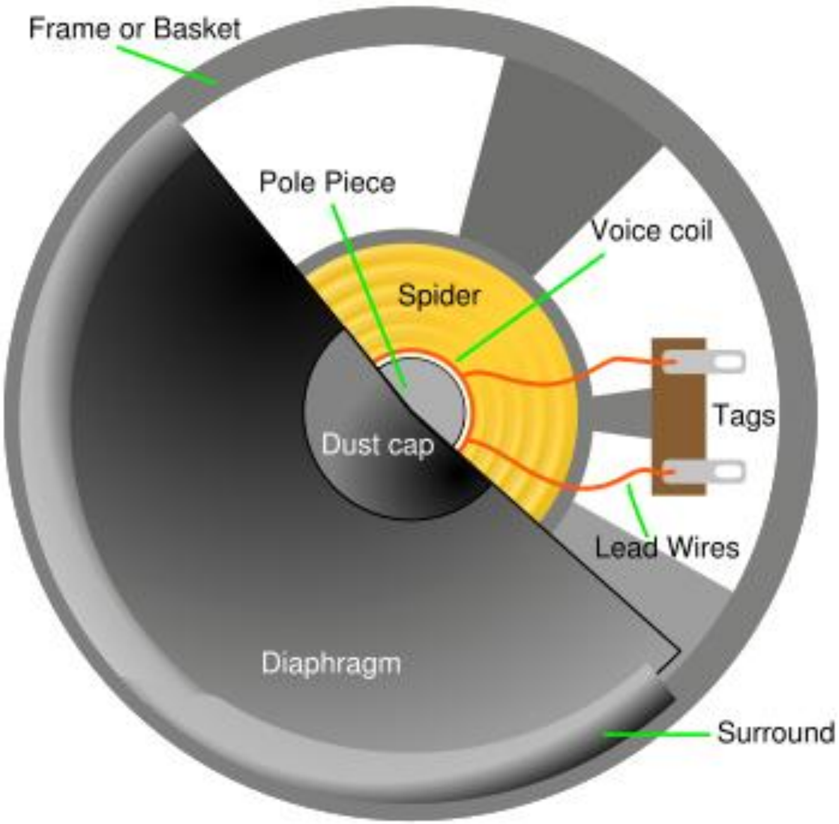
A speaker is an electromechanical transducer which converts an electrical signal into sound. It does so by vibrating air. Our ears pick up that vibration and our brain makes us believe we're hearing something.

The term loudspeaker is used to refer to both the device itself, and a complete system consisting of one or more drivers in an enclosure.

Because a loudspeaker is the most variable element in a sound system, it is responsible for marked audible differences between systems.

Polk Audio Atrium Series SDI 65 Speakers

How is a driver built?



Cut-away view of a driver.

At the heart of a driver is an electromagnet which consists of a pole piece, permanent magnet and voice coil.

A diaphragm (cone) connects to the spider. The spider is attached to the voice coil.

The cone is also attached to the frame with a flexible material called the surround.

The dust cap keeps dirt out of the voice coil.

When an audio signal is fed to the lead wires, it causes the electromagnet to pull up and down, causing the cone to vibrate, thus creating sound.

Driver Functions

Generally, the size of a driver will define it's function in a loudspeaker system.

For instance, in a larger speaker, a 12" driver is usually used as a woofer.

You will see smaller drivers used as a woofers, but don't expect a great amount of bass because a small driver simply cannot vibrate the air as strongly as a larger one.

In a larger cabinet, a 4" or 6" driver is utilized as a mid-range speaker.

A 2" driver is most often a tweeter.

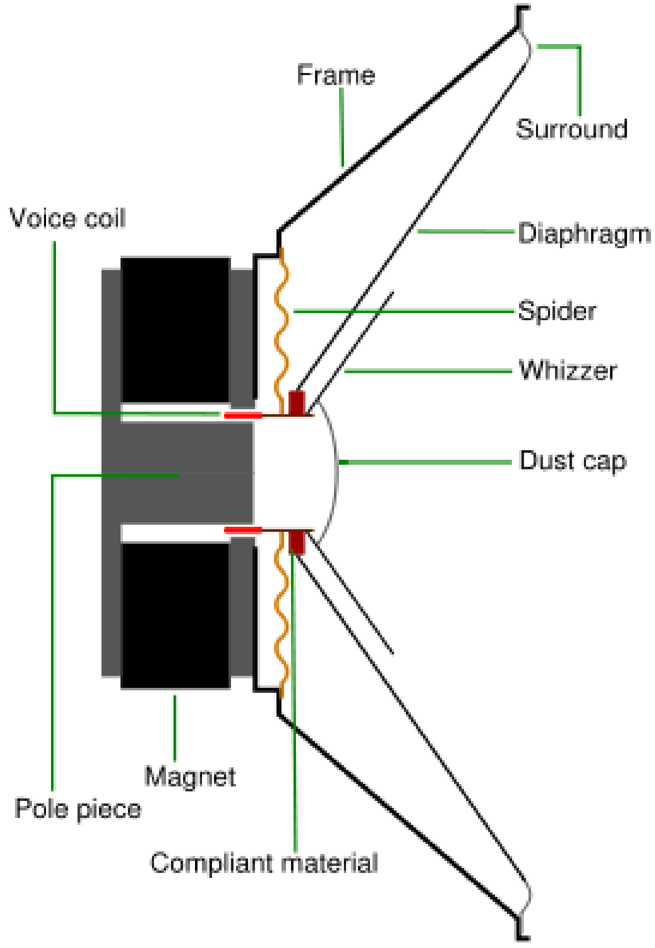
Some loudspeaker systems utilize a horn as a tweeter.

Driver Functions – Full Range

A **Full-range** speaker is a driver that attempts to reproduce as much of the audible frequency range possible, with high-fidelity.

Typically a full-range speaker consists of a single *voice coil*, used to actuate the *diaphragm*. The diaphragm usually includes optimizations to enhance high-frequency sounds.

For example a small low-mass horn or *whizzer* cone is mounted where the voice coil and diaphragm meet thereby increasing the efficiency (and hence frequency range) at high frequencies.



Loudspeaker Ratings

Model	AAL8	AAL10
System Type	8" 2-Way	10" 3-Way
Woofer	8" Fiber Foam Surround 1"Voice Coil	10" Fiber Foam Surround 1-1/2"Voice Coil
Midrange	N/A	5" Mid-bass
Tweeter	2"x6" Horn- Loaded Quartz	2"x6" Horn- Loaded Quartz
Freq. Response	75Hz-22kHz	55Hz-22kHz
Sensitivity	91dB	92dB
Nominal Impedance	8 Ohm	8 Ohm
Power Handling	50Watts RMS/ 100Watts Total	75Watts RMS/ 150Watts Total
Height	17-3/4"	23-1/4"
Width	10-1/2"	14-1/4"
Depth	8-7/8"	10-3/8"

Speakers have five important ratings.

They are:

- **Impedance**
- **Max Power Handling**
- **Nominal Power Rating**
- **Efficiency or Sensitivity**
- **Frequency Response**

Speaker Ratings - Impedance

Impedance describes a measure of opposition to a sinusoidal alternating current. In other words, AC resistance. This is the “Ohms” rating of a speaker.

It used to be that most speakers were of the 8Ω variety. Now, more often than not, 4 and 6Ω speakers are what’s out there… Even though their specs say they’re “8Ω compatible” or “8Ω Nominal”, *they’re not 8Ωs* and must be treated as such.

Impedance of a speaker doesn’t matter as it pertains to performance… But you need to know what it is so that the Total Impedance can be calculated and the speakers be connected to the jukebox without overloading its amplifier.

Accurately measuring impedance requires a special meter. Your multi-meter measures DC resistance, which is not the same as AC impedance. However, a multi-meter can be used to give you a rough idea of a speakers impedance. Typically, an 8Ω speaker will read 7.2 to 7.6Ω. 4Ω speakers generally read 3.2 to 3.4 Ω.

Max Power – Nominal Power

The **Max Power** rating of a speaker does not tell you how loud it will get. This spec is the power level at which the speaker, if continuously operated, will be damaged.

Be careful when comparing different speakers' Max Power rating as some manufacturers show their spec as per pair, and some show this spec as per speaker.

Nominal Power is how many Watts are needed to make the speaker work best. It is usually ½ of the speakers Max Power.

Some manufacturers specify a recommended power range, such 20 to 100 Watts, meaning the speakers are designed to give best performance when that amount of power is applied.

It is always best to use speakers whose nominal power rating is equal to the amount of power you'll be able to deliver with your amplifier.

DPI Speakers

Woofer	8" Polymer, Rolled Edge
Tweeter	2" x5" Super Horn
Nominal Impedance	8 Ohm
Efficiency (1 wt. 1 mtr.)	87 dB
Frequency Response	45-30,000 Hz
Nominal Power	4-90W, RMS
Maximum Input	180 Watts
Dimensions	16" H, 10" W, 9-1/4" D
Weight	30 lbs./pair

Loudspeaker Ratings - Sensitivity

A loudspeakers **sensitivity rating** is reflected in Decibels or dB. Some manufacturers call this Efficiency.

What are dBs?

Decibels are a unit of measure reflecting how loud a sound appears to be. A sound pressure level (SPL) of 0 dB represents the threshold of hearing in the most sensitive frequency range of a young, healthy ear, while the thresholds of tickling or painful sensations in the ear occur at about 120 to 130 dB.

Loudspeaker Ratings - Sensitivity

This is the rating that will tell you how loud a particular speaker can get.

Sensitivity is reflected in decibels using one Watt of power and measured from one meter (about 3 ft.) away from the speaker.

•Normal loudspeakers have a sensitivity of 85 to 95 dB

•Nightclub speakers have a sensitivity of 95 to 102 dB

•Concert or stadium speakers have a sensitivity of 103 to 110 dB

• **The human ear hears a 10dB increase in sensitivity as twice as loud.**

•**A 96dB sensitivity speaker will sound twice as loud as an 86dB speaker at the same volume setting.**

Normal Loudspeaker - Polk Audio RTi Series Speaker

Nightclub Loudspeaker - Peavey PR Series Speaker

Loudspeaker Ratings - Sensitivity

A speaker that is 3 dB more sensitive requires half as much power to achieve the same volume level.

When driven at 100W, an 89dB speaker will produce a volume level that an 86dB speaker would need 200W to match.

A speaker rated at 89 dB will be louder than a speaker rated at 86 dB when both are driven with the same amount of power.

When buying speakers, pay very close attention to the sensitivity rating. A difference of 3 dB can make a huge difference in how loud your sound system will be.

89 dB - Polk Audio Atrium 45 Speakers

86dB - Yamaha NS-AW390 Speakers

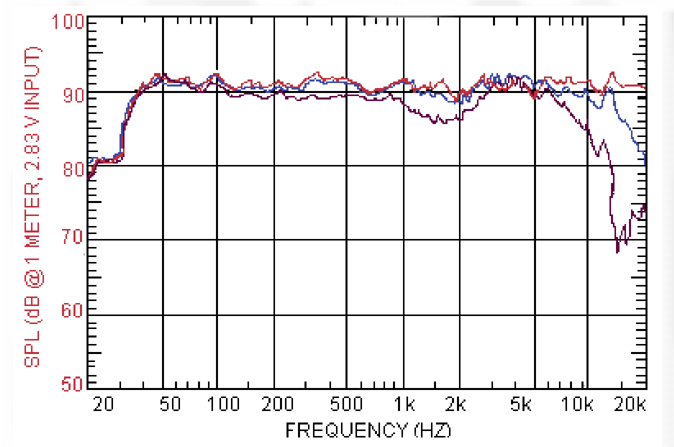
Speaker Ratings – Frequency Response

Frequency Response is the measure of a speakers ability to audibly reproduce audio frequencies. This is the spec that tells you how good it may sound. The wider the frequency response, the better the speaker will sound.

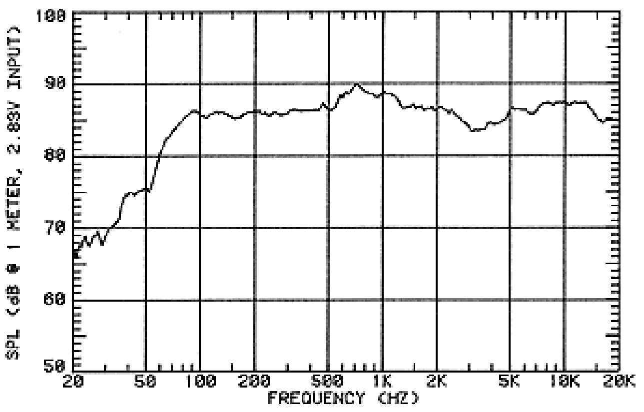
A human ear can hear from 20 Hertz to about 22,000 Hertz. A good speaker design is to have it reproduce what we can hear.

As frequencies reach the outer ends of a speakers spec, the volume for that frequency greatly diminishes. Note on the charts, at 60Hz Speaker A is producing 92 dB while Speaker B is producing only 76 dB. In other words, the bass is more than twice as loud in Speaker A.

A speaker with a frequency response of 35Hz to 22KHz will sound much better than a speaker rated 90Hz to 15KHz.

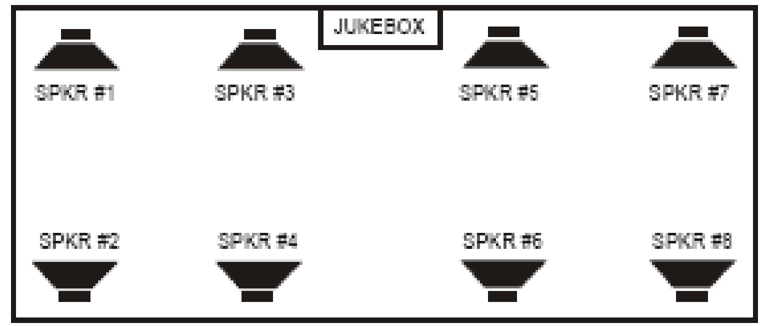


Graph of SPL at a given frequency for a speaker rated 35Hz to 22KHz (Speaker A)

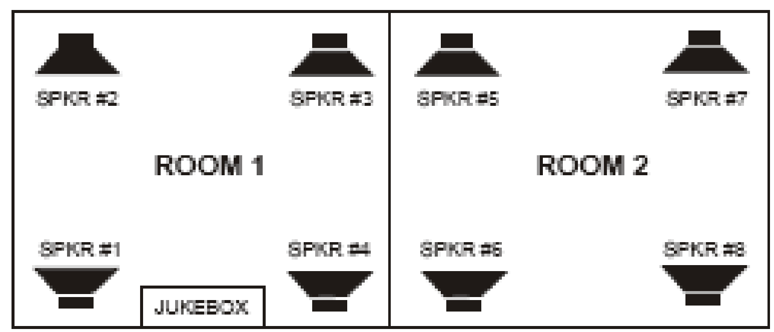


Graph of SPL at a given frequency for a speaker rated 50Hz to 15KHz (Speaker B)

Speaker Placement



An article on "correct" speaker placement is impossible to write. That’s because every situation and, to a certain extent, every speaker requires a different approach to optimization. Further, ones personal preference may suggest departure from the norm. Fortunately, there are some helpful guidelines that we can use to aid us in our quest for perfect sound.



First, experimentation is the key to optimum results. Trial and error will tell you a great deal about how a particular speaker reacts in your environment and help you to better balance strengths and weaknesses of each position you try.

Speaker Placement

A room affects the sound of a speaker by the reflections it causes.

Some frequencies will be reinforced, others suppressed, thus altering the character of the sound. If we were to listen to our speakers outdoors or inside an anechoic (an·ə¦kō·ik) chamber, much of the coloration we'd hear would disappear.

This is a major reason loudspeaker designers test their creations in such an environment, not wanting their design decisions to be influenced by the colorations of any given room.

The real world, however, requires that our speakers co-occupy our locations, therefore we must deal with the room as a significant contributing factor.

Speaker Placement

In any listening environment, what we hear is a result of the mixture of both the direct and reflected sounds.

Direct sound travels straight to our ears from the speaker drivers.

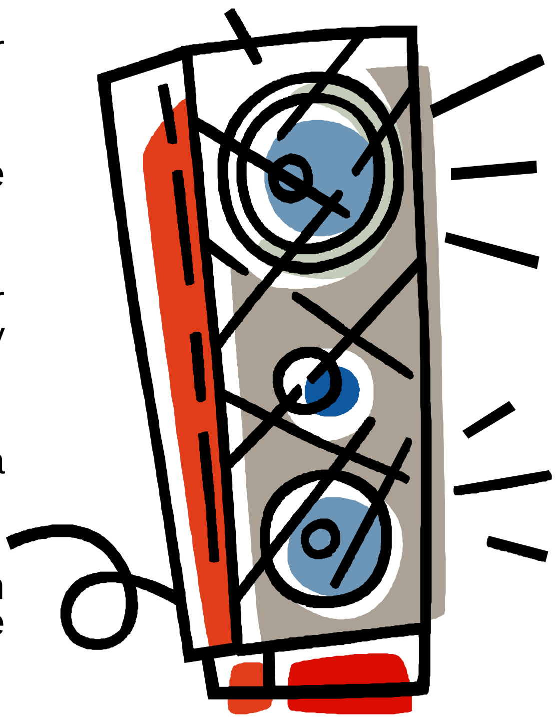
Reflected sounds are many, bouncing off most any hard surface and reaching our ears after the direct sound.

Direct sounds from the speakers are primarily responsible for the image, while reflected sounds contribute most to the tonality of the speaker (richness, leanness etc).

Any boundary surface (back wall, side wall, floor) can cause a reflection, and all need to be considered during placement.

With some speakers, bass will sound louder if they are placed in a corner. However, be careful as their other frequencies may be dampened.

The trick is to place the speaker in a location that will take advantage of the desirable reflections while diminishing the unwanted reflections.



Size and Number of Speakers to Use

Speakers create sound by vibrating the air. To create adequate sound, you need to ***vibrate all the air***.

The number of speakers you'll need in an installation depends on the square footage of the location. The size of the speakers you need to use depends on the amount of space you need to fill with sound.

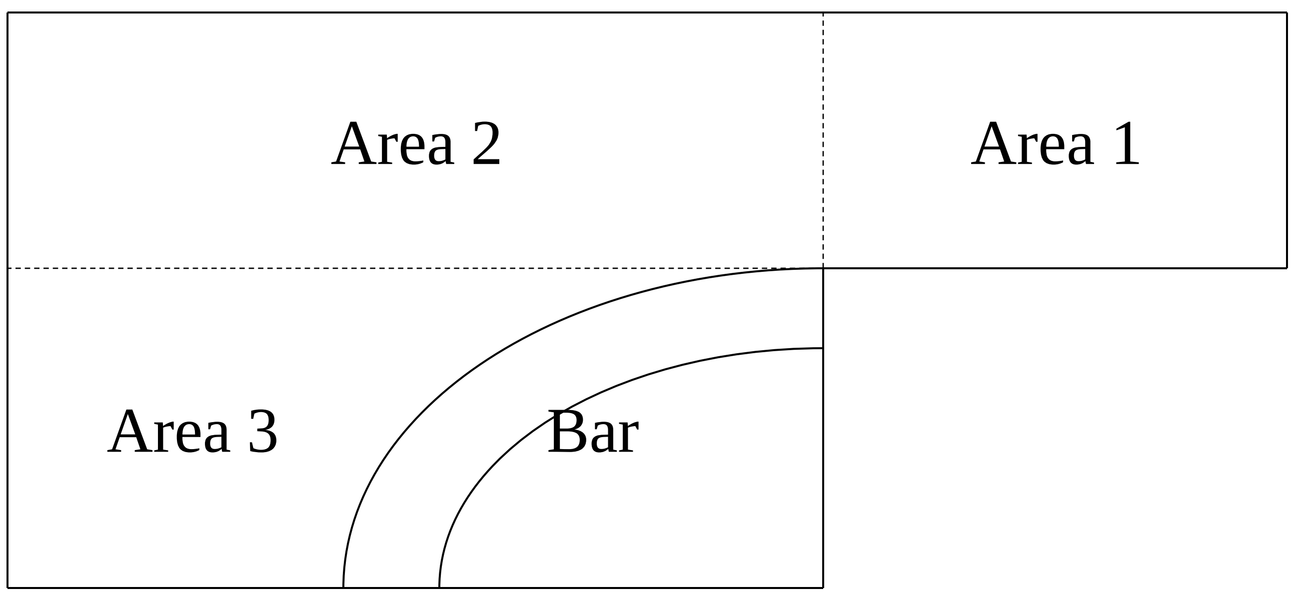
For instance, some locations have 12 to 18 foot ceilings. The air above the speakers needs to be vibrated too. If the speakers are too small, air in that space will not be vibrated. That will cause a marked *decrease* in volume, most likely to the point of the overall volume not being sufficient. In other words, *the jukebox won't be loud enough.*

The bigger the space, the bigger the speakers need to be!

Size and Number of Speakers to Use

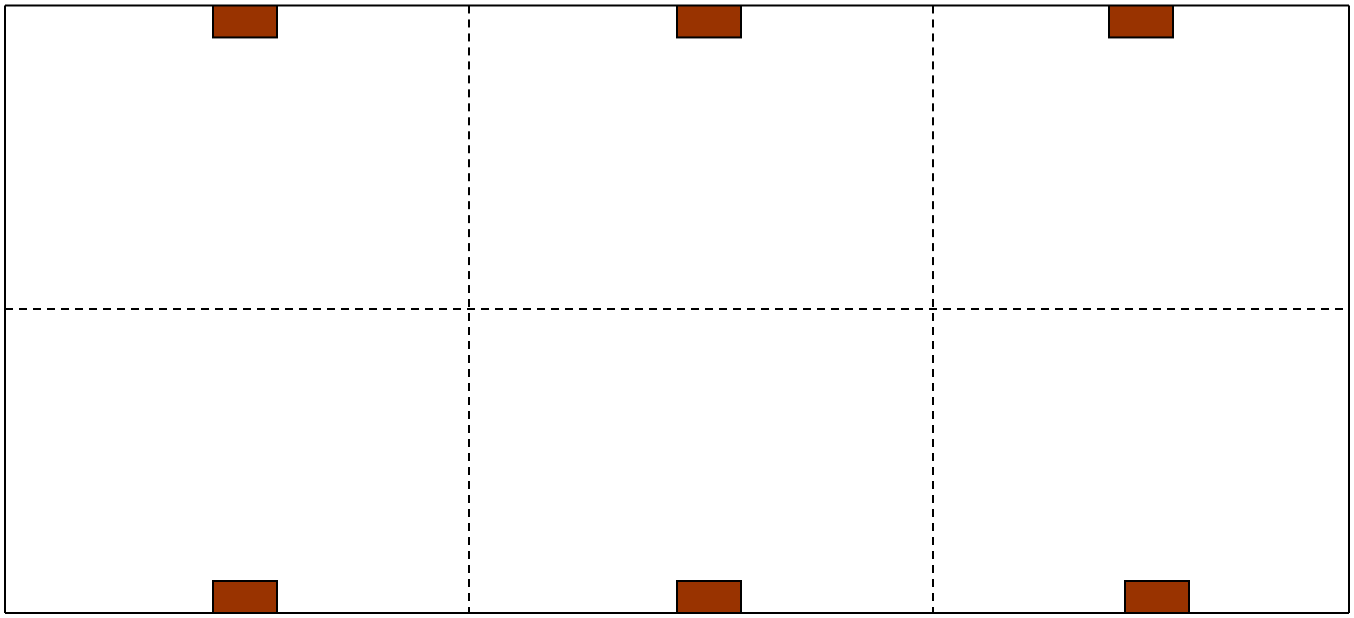
Generally, a venue has several “Listening Areas.” The type of and how many speakers each area needs is dictated by it’s size, shape, the loudness desired as well as customer concerns.

In order for everyone in the location to hear the music, you need to break it into individual listening areas and then install enough speakers to ***vibrate all the air*** in each of those areas.



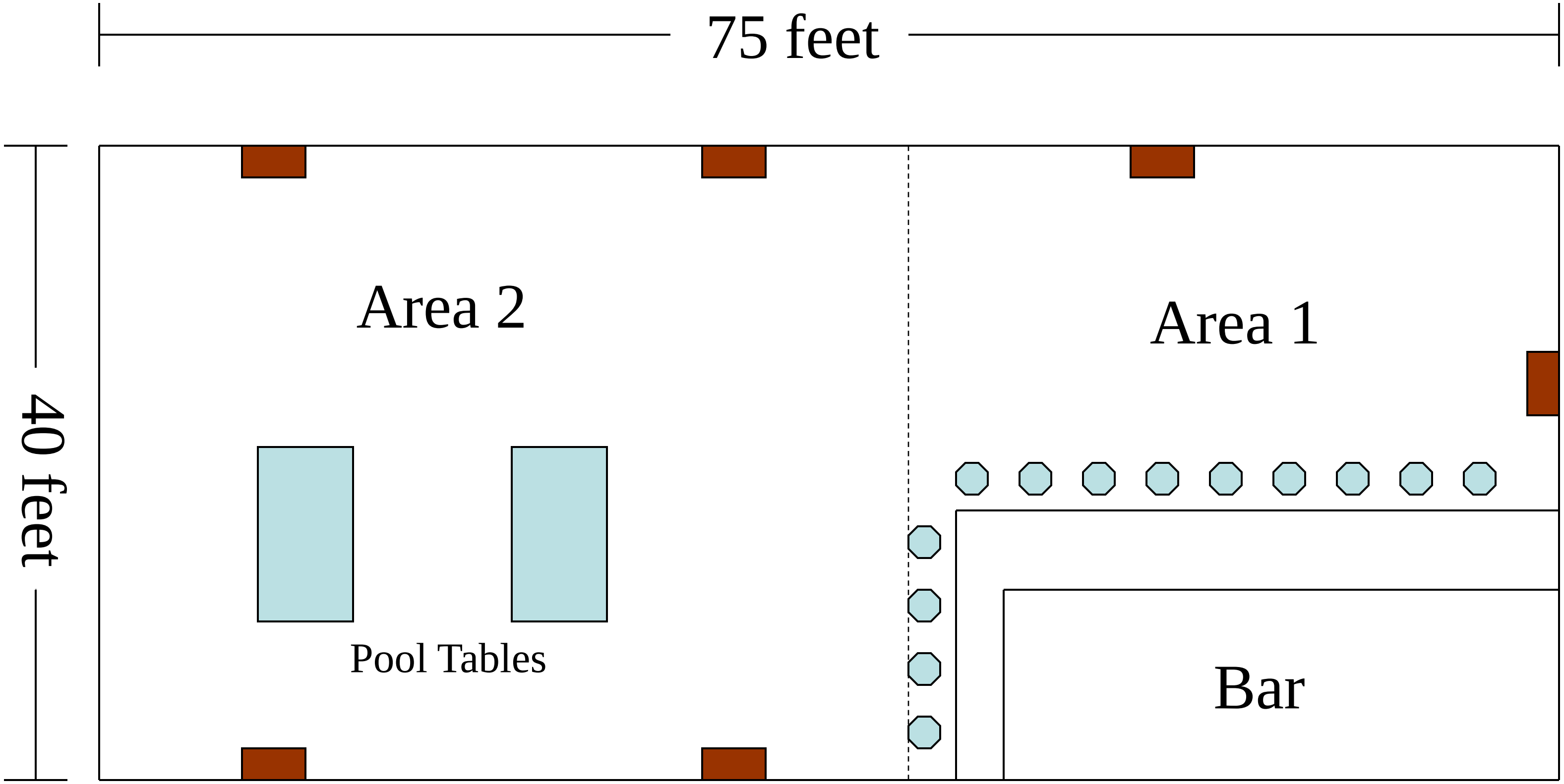
Size and Number of Speakers to Use

To figure the number of speakers needed and to determine speaker placement divide each listening area into 20 foot sections and place a speaker in the middle of each section. It’s a good idea to point (angle) the speaker toward the center of the area. If possible, mount the speaker so that it’s in the corner of where the wall meets the ceiling, bass response may be enhanced.



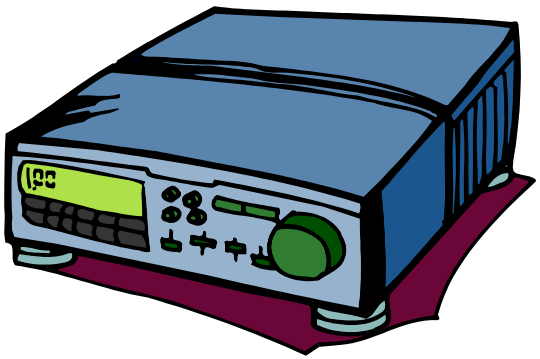
Size and Number of Speakers to Use

As a rule of thumb there should be at least 1 speaker for every 20 feet of wall space. Size of the speaker to use is determined by the amount of air that needs to be vibrated. The larger the space, the larger the speaker needs to be.



Amplifier Power

You now know how many and what size speakers to use, but still don't know what the speakers nominal power rating needs to be and how to connect them. To figure that out you need to know how much power there is to work with and what the amplifiers load rating is.



Amplifiers are rated in Watts at a specific impedance load, such as 300 Watts RMS @ 4Ωs per ch X 2. That means it is a 2 channel amp with each channel rated 300 Watts giving a total of 600 Watts.

To keep things simple, we are going to use Watts RMS, per channel.

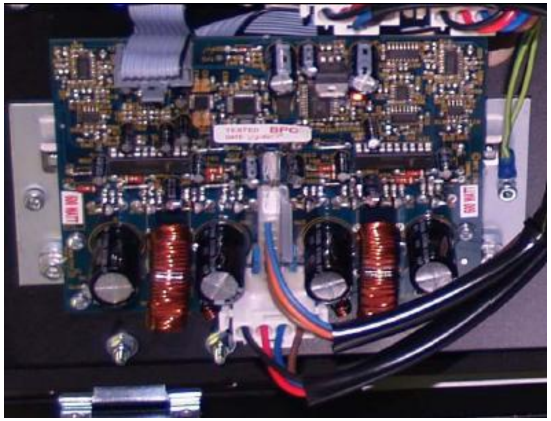
Amplifier Power

In order for an amplifier to put out its full power, the speaker’s impedance load needs to match the amplifiers rating.

For instance, a channel rated 300 Watts @ 4Ωs needs to “see” a 4Ω load to put out 300 Watts. If the load connected is 8Ωs, it will put out about 70% of rated power. If the load is 16Ωs, output will be about 25% of its rated power.

A load lower than the channels rating, say 3Ωs, will cause it to try to put out more power than its capable of. In other words, it will be overloaded.

An overloaded amp, even just one channel, will “cut out” at higher volumes, will get hotter than blazes and eventually fail. ***Overloading is the most common cause of all audio related service calls and amplifier failures!***



NSM Power Amp, 300Wrms @ 4Ωs per ch X2

Connecting Speakers

When hooking up a home system, you'll normally be connecting one speaker to each channel, so impedance is rarely an issue. Not so with a jukebox because it's not unusual to have multiple speakers connected to one channel.

In order to meet the amplifiers impedance requirements, when connecting multiple speakers to an individual channel, they will be connected in one of three ways; **Parallel, Series or Series/Parallel.**

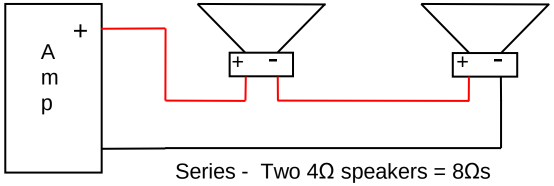
The connection scheme you'll need to use depends on the number of speakers to be connected, their impedance rating and the impedance rating of the amplifier.

Confused? Actually, determining which connection method to use is pretty simple. Let's define and analyze each one.

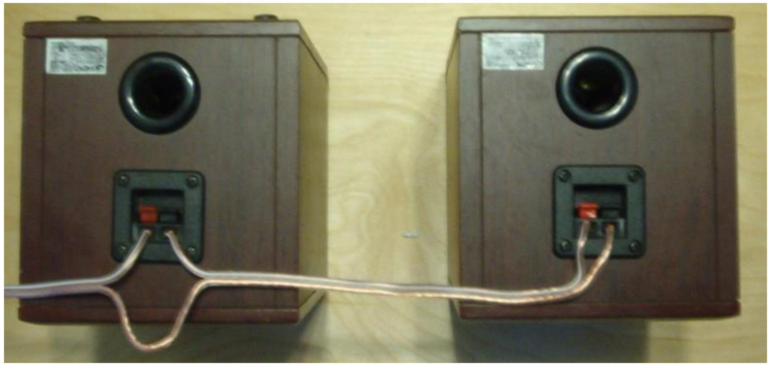
Connecting Speakers

Series

Speakers are connected from amp pos to first speaker pos. First speaker neg is connected to second speaker pos, second speaker neg is connected to third speaker pos, etc. The last speaker neg is connected to the amp neg. To calculate the load, **add together the impedance of each speaker**. In this case the total impedance is 8Ωs.

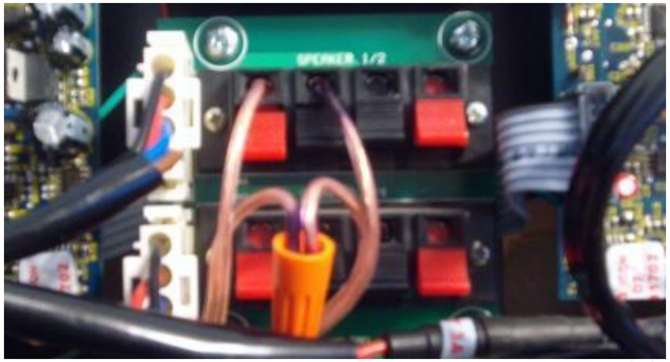


Series - Two 4Ω speakers = 8Ωs
4 + 4 = 8



One line to jukebox

OR

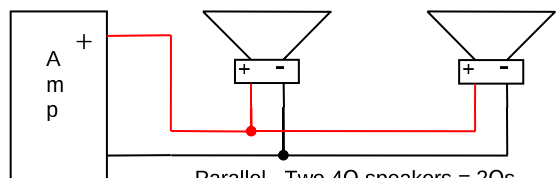


Line from each speaker to jukebox

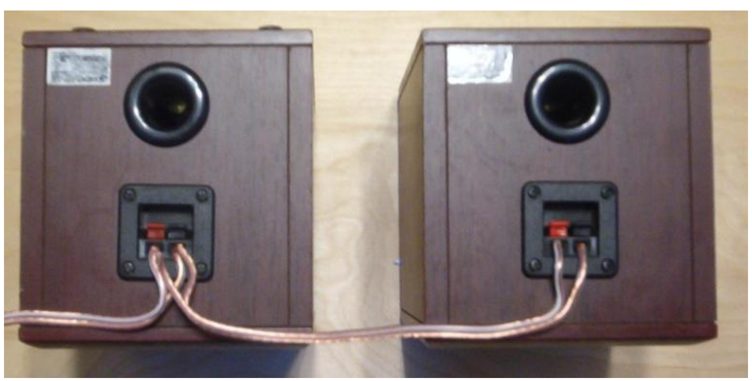
Connecting Speakers

Parallel

Speakers are connected to the amp and each other pos to pos, neg to neg. To calculate the impedance, assuming equal loads, **divide the number of speakers into the impedance value of one speaker**. In this case, the total impedance is 2Ωs.

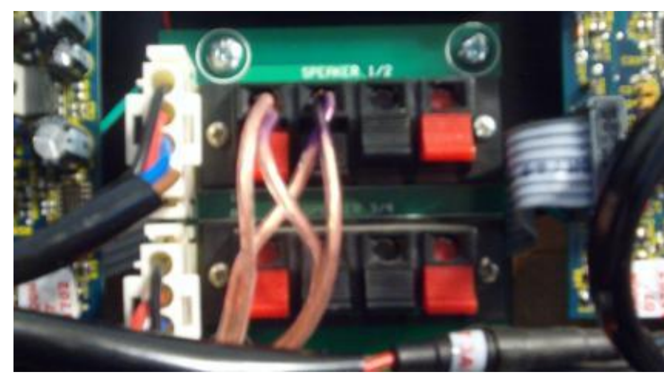


Parallel - Two 4Ω speakers = 2Ωs
4 ÷ 2 = 2



One line to jukebox

OR

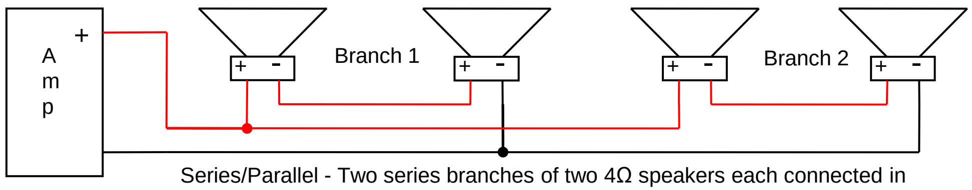


Line from each speaker to jukebox

Connecting Speakers

Series/Parallel

Speakers are connected in series branches then each branch is connected to each other and the amp in parallel. To calculate the load, **assuming equal branches, calculate the series impedance of one branch then divide by the number of parallel branches**. In this case, the total impedance is 4Ωs.



Series/Parallel - Two series branches of two 4Ω speakers each connected in parallel = 4Ωs
Each branch is 8Ωs
8Ωs divided by 2 branches
8 ÷ 2 = 4

This arrangement is two series runs connected to the amp in parallel.

Connecting Speakers

Ok, now which connection scheme do I use?

Simple. Use the one that will allow you to connect the desired number of speakers without going below the amplifiers impedance rating.

If the channel has a 4Ω rating, use a scheme that will get you closest to 4Ωs without going under.

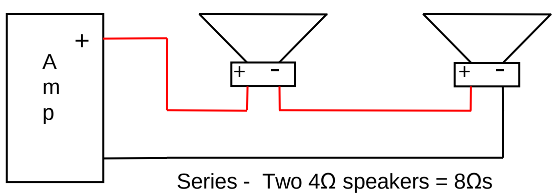
Avoid using a scheme that will have the impedance too high. Creating a 32Ω system will certainly be easy on the amp, but you may not deliver enough power to properly drive your speakers.

Connecting Speakers

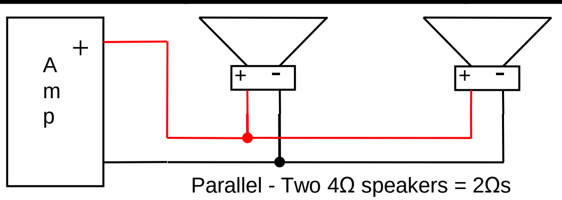
Power Distribution

Regardless of connection scheme and assuming like speakers are used, each speaker will draw an equal amount of power. Below is the per channel power chart for an NSM Icon Jukebox amplifier. An Icon comes standard with 4 channels, so you have the ability of connecting 4 separate systems.

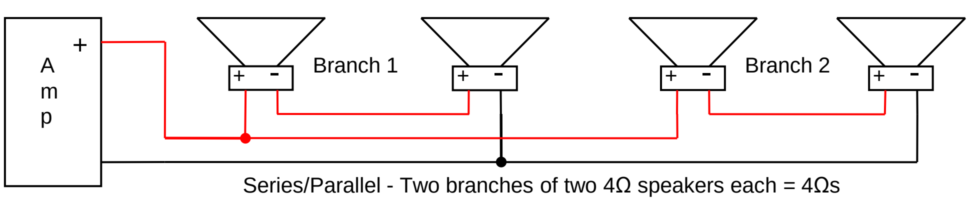
Speaker System Impedance	2Ω	4Ω	8Ω	16Ω	32Ω
Output Power per Channel	Overload	300 Wrms	220 Wrms	105 Wrms	45 Wrms



Series - Two 4Ω speakers = 8Ωs
4 + 4 = 8
Power = 110 Wrms per speaker
220 ÷ 2 = 110



Parallel - Two 4Ω speakers = 2Ωs
4 ÷ 2 = 2
Power = Overload – Less than 4Ωs

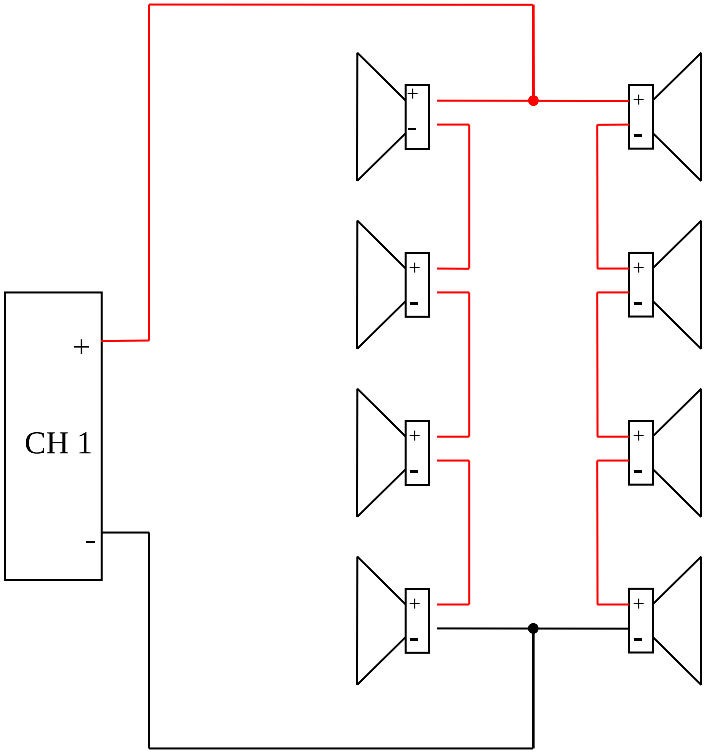


Series/Parallel - Two branches of two 4Ω speakers each = 4Ωs
Each branch = 8Ωs
8 ÷ 2 = 4
Power = 75 Wrms per speaker
300 ÷ 4 = 75

Connecting Speakers

Need more speakers? Try this one.

Sure it's 27.5 Watts per speaker, but if you're using the right speakers, (such as Polk Atrium 55's) it's more than enough power.



This installation consists of two series branches of four 4Ω speakers yielding a total impedance of 8Ωs.

For those who like to see the math, here it is;

Imp = (4+4+4+4) ÷ 2

Imp = 16 ÷ 2

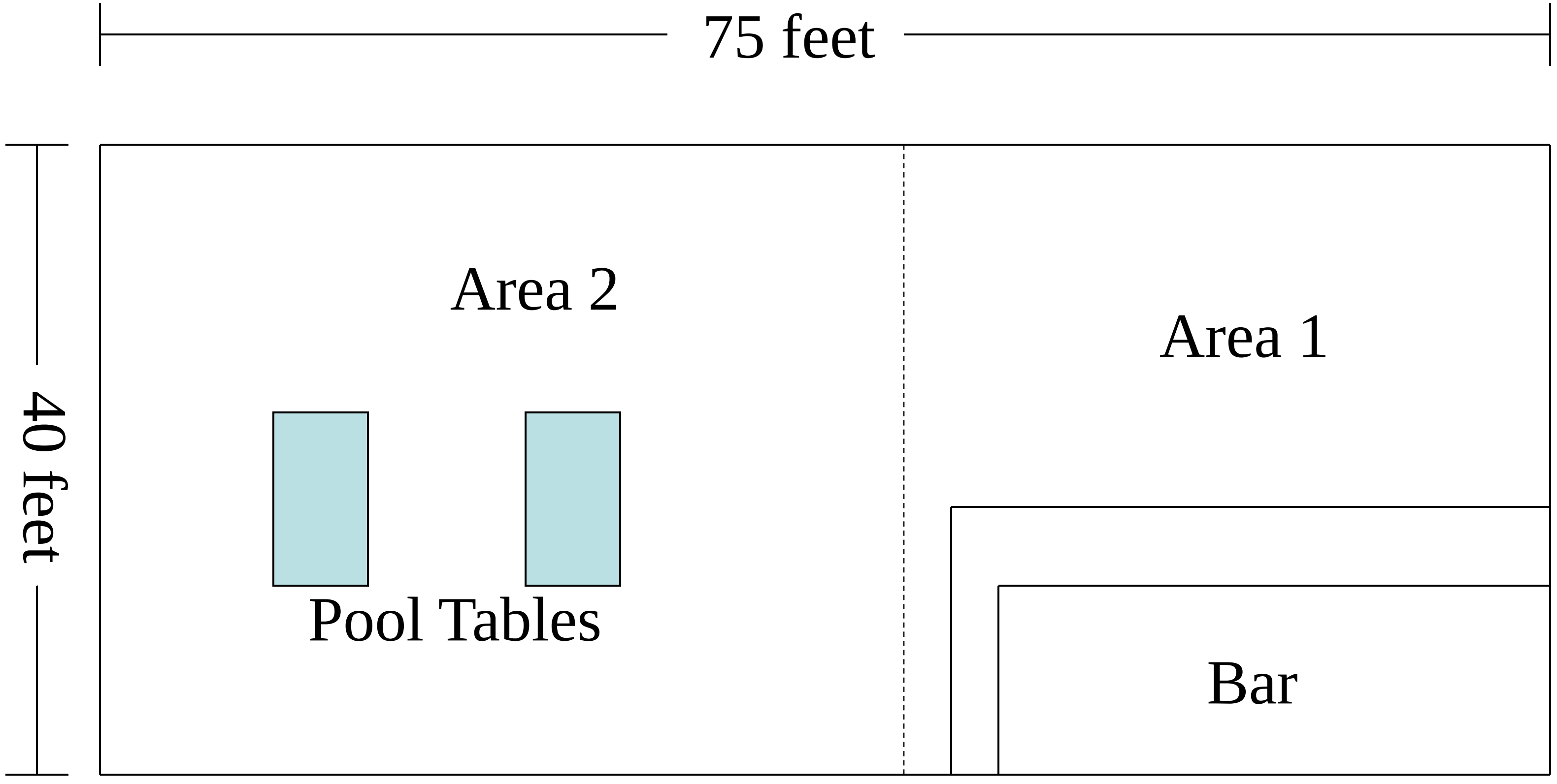
Imp = 8

A total impedance of 8Ωs, according to the NSM power chart, creates a 220 Watt draw from the amp. Divide the total power by the number of speakers to get 27.5 Watts per speaker.

220 ÷ 8 = 27.5

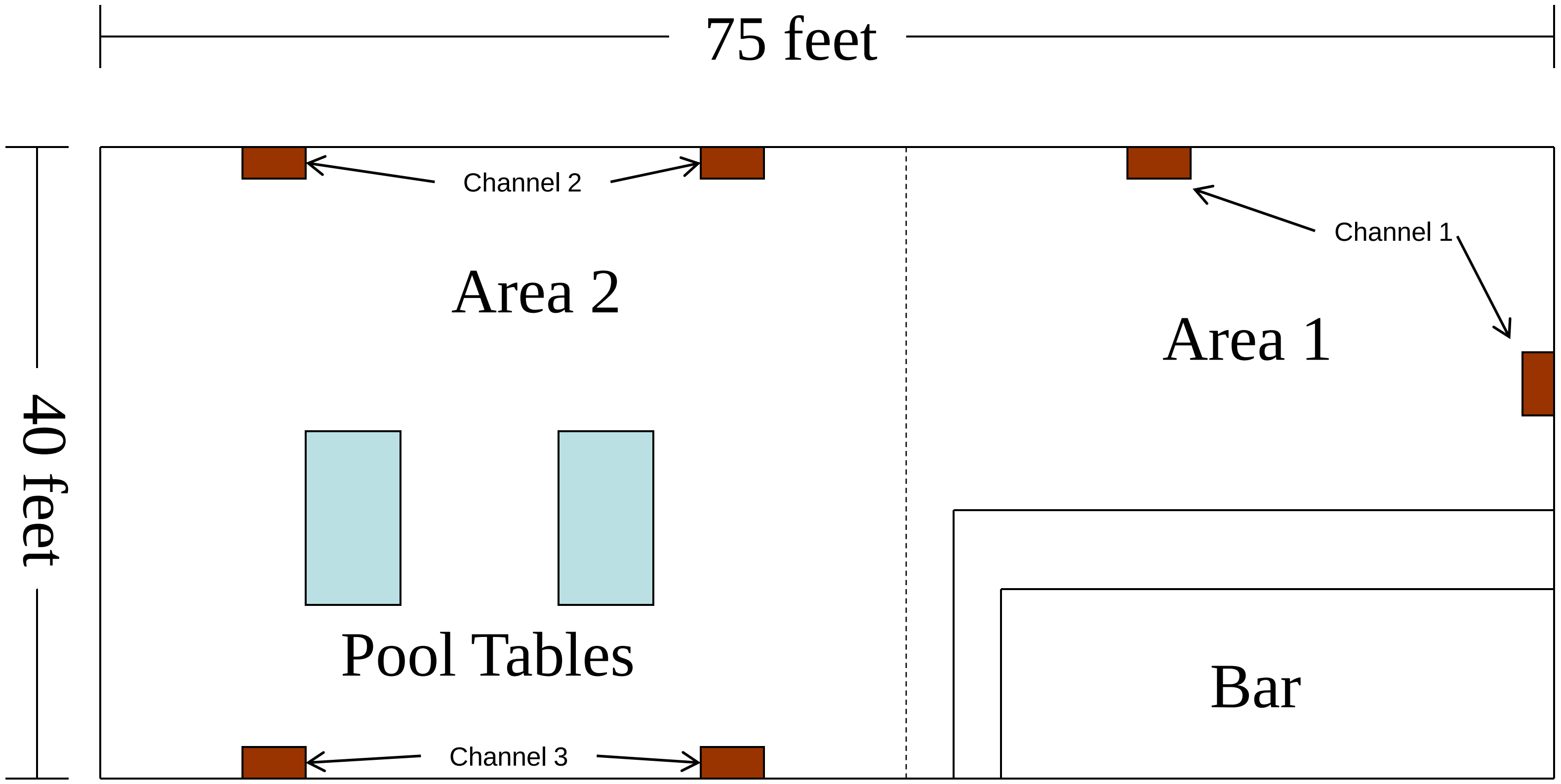
Choosing Speakers

Which speakers should be used? The answer depends on 3 things:
1. The size and cubic feet of the area.
2. How much power you have to work with.
3. Volume level (SPL) desired.



Choosing Speakers

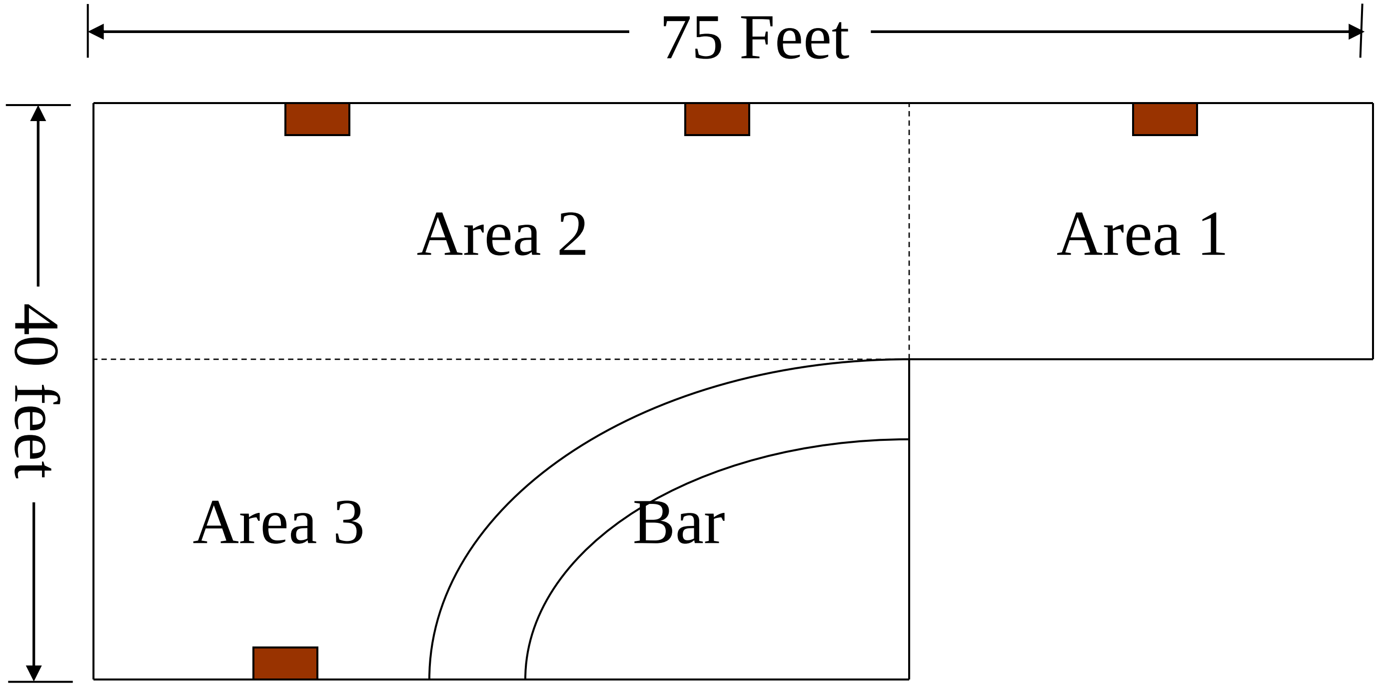
This example has two listening areas. Assuming you're using a standard Icon and the venue has typical height ceilings, you'll probably wish to go with 4Ω, 10" speakers, 89 to 92 dB efficiency, that have a max power rating of 200 to 250 Watts. Area 1 speakers should be connected in series to channel 1. Two speakers of Area 2 should be connected in series to channel 2, the last two connected in series to channel 3.



Choosing Speakers

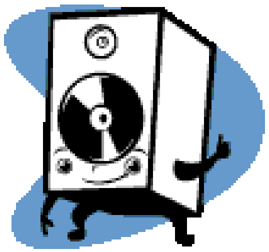
Now lets look at a location with 18' ceilings. In this case, we need to use much bigger speakers to vibrate all the air. Again, we're using a standard Icon which has 4 channels of 300 Watts @ 4Ω

In this example, 12 or 15 inch, 300 to 350 Watt 8Ω speakers are mounted about 10 feet from the floor. One will be connected to each channel.



Choosing Speakers

How did we figure out what speakers to use in the two examples? It's actually pretty simple. Based on the lessons learned here, we know three things:



1. How much amplifier power is available.
2. How many speakers are needed to cover all the listening areas.
3. Which size speakers are needed to vibrate all the air.

So all we had to do was divide the number of speakers needed per channel into the power available to determine the Nominal Power rating of the speakers. Then chose the efficiency level to create the desired SPL. Pretty Simple!

Speaker Wire

Now that you know which speakers, along with how many are needed for a particular installation, it's time to discuss what you're going to use to hook them up… WIRE!

The type of wire used is just as important as the speakers themselves. You must use wire that can handle the power being delivered to the speakers. Speakers draw current the same way that any electrical appliance does. A 4Ω system running at 300Watts will draw more than 8 Amps. That amount of current cannot flow through 22ga zip cord. 14ga speaker wire MUST be used.

If the wire does not properly deliver amplifier power, your speakers will not work well. Worse, if the power meets resistance in the wire, it will cause the amplifier to work harder than it needs to, will cause it to overheat and will cause the amplifier to eventually fail. In other words, the type of wire you use, if incorrect, will cause an amplifier to overload the same way as if you had an impedance overload. … **Using thin wire will only cause you massive headaches!**