Technical Overview

The Key Components of a Sound System

However complex or simple a sound system is, it always contains the same basic groups of equipment.

Source	Pre-Amplification	Amplifier	Loudspeakers

Source	Pre-Amplification	Amplifier	Loudspeakers

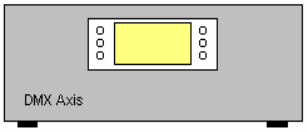
Source

A source is anything that plays source material. Most sources are similar in the sense that they provide a similar output signal, referred to as “line level”. Examples of these “line level” sources are:

DMX DR 500

Radio

DVD Player



DMX Axis DMM

Tape Deck

VCR

TV

MP3 Player

Mini Disc Player

Competitive Services

All of the above sources work within a sound system the same way a conventional CD player would. Other **Sources** like turntables and microphones have to be treated differently. This is why on small mixer amplifiers there are separate inputs for microphones.

Source	**Pre-Amplification**	Amplifier	Loudspeakers

Pre-Amplification

Pre-amplification consists of anything that is done to the various sources in order to get them ready for amplification. In our business the role of pre-amplification is largely restricted to mixing and equalization.

Mixers

There are two primary type of mixers, one of which the commercial music sales person will almost never deal with, but must know about to avoid customer confusion. Mixers essentially take all sources and arrange them for amplification. The type of mixer in the business music arena takes all the sources that a customer would like to play and gives them each an independent volume control.

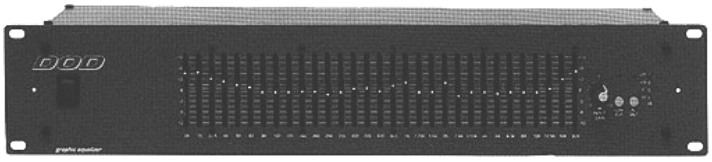
The other type of mixer is a Console Mixer which is used in live music performance and recording. This type of mixer takes each instrument or voice and adjusts the volume, bass, treble etc. accordingly. Unless you are designing a system for live music you will never need to deal with this, but it is important to know, because if you mention “mixer” to anyone associated with music performance, this is what probably will come to mind.

Most people have an elementary mixer on their home stereo amplifier. You can connect a CD player, a VCR and a tape deck to a receiver. You then select which one you want to play. These systems only play one source at a time.

In most business applications, mixers essentially serve the same purpose. However, there may be the occasion that two sources are needed to play at the same time. The primary example of this is paging. The paging microphone needs to be on at the same time as the music source. The microphone will send a signal to the mixer that will mute or reduce the volume of the music, so that the voice can be heard clearly.

In most of the applications for business music the mixer will be integrated with the amplifier.

Equalizers



Most people know what equalizers are, but they have a hard time explaining them. Equalizers adjust different frequencies of the signal to adjust the sound heard. To understand equalizers well enough to explain them to a customer, it is important to understand the term **"frequency"**

Frequencies

In sound system terminology the word frequency refers to "tone". Low frequencies are bass tones, largely produced by bass drums and bass guitars and high frequencies are high tones, usually produced by hi-hat cymbals and the like. Humans cannot hear the highest tones, hence the use of high frequency whistles to train dogs. Dogs can hear higher frequencies than humans. Similarly, the lowest frequencies can only be felt, not heard. This explains the sensation of "feeling" the music at a nightclub.

Frequencies are measured in hertz (hz) and kilohertz (khz). One kilohertz is equal to one thousand hertz. Loudspeakers will boast of being able to reproduce frequencies from 50 hz to 18khz. CD quality sound, as defined by Sony Phillips, includes reproduction of frequencies from 20hz to 20khz.

The area that is key for a sales person to understand is the low frequencies or bass. Most loudspeakers can easily reproduce the higher frequencies. They might not produce the same naturalness or clarity, but the high frequencies will be there. This is not so with low frequencies.

If a loudspeaker produces frequencies in the 70 – 80 hz range, it can be deemed full range. Full range means that it will give a warm full sound across all spectrums. What it will not do is produce the thumping bass associated with a teenager's car. The bass will be rich and warm, but not overly powerful.

To achieve more powerful bass, a loudspeaker that produces 50 hz and above should be used. This can be done by using a loudspeaker that produces all of these frequencies, or by adding a sub-woofer.

A **sub-woofer** is a loudspeaker that produces just low frequencies.

Typically, to produce low frequencies naturally, two things are needed. These are more power (wattage) and larger speakers. In business applications, larger loudspeakers are undesirable for two main reasons, aesthetics and dispersion. Typically, the larger the speaker the narrower the beam of sound produced. As many business applications are with relatively low ceilings, a loudspeaker that throws sound a relatively short distance but in a wide arc, is more desirable. This means small speakers are desirable in most business applications.

To get around this problem, sub-woofers can be used. Bass frequencies travel long distances, so typically only one or two subwoofers are required in an installation, and they can be located where the impact on the aesthetics is minimal. By using a device that produces the low frequencies exclusively, the designer is free to use smaller devices, giving the customer both the look and the sound coverage that they desire.

If frequencies lower than 50hz are required, you should engage your engineer's help. The most common application for these types of systems is nightclubs and movie theatres, both of which are beyond the scope of this course.

Back to Equalization

The simplest form of equalization is the "bass" and "treble" controls that are on most sound systems. By adjusting these controls the user can increase the low frequency (bass) or the mid/highs (treble).

Most people are familiar with more complex equalizers. They have seen seven band equalizers in cars or on boom boxes. These can be thought of as more defined bass and treble controls. The far left adjustment affects "low bass", the second "mid bass", the third "low mid" etc. In complex installations equalizers are used that have thirty-one different adjustments, one for every third of an octave.

Problems with Equalizers

The problem with equalizers is that in the wrong hands they can do more harm than good. Most equalizers that we see have "smiley faces" or "unhappy faces". More often than not, this is an inappropriate use of an equalizer. Therefore if an equalizer is to be employed, it should be placed in a locked rack or a security cover should be used.

There are two main functions of an equalizer:

- Compensating for inferior loudspeakers
- Compensating for room anomalies

Compensating for Inferior Equipment

If a loudspeaker does not accurately reproduce certain frequencies an equalizer can be used to compensate for this lack of performance. It should be noted that this might overly exert both the amplifier and loudspeaker. It should also be noted that if a system is designed with cheaper loudspeakers, with an adjustment in bass used to make the sound better, a staff member could re-adjust the bass, nullifying the designer's intention.

Compensating for Room Anomalies

This is the sound professionals primary use for an equalizer. Each room has its own sonic qualities or acoustics. The acoustics of the room are affected by: the type of carpet or drapes; the shape and size of the room itself; the materials used in construction; and the type of furniture. An equalizer can be used to compensate for many acoustic qualities of a room that may negatively affect the sound quality. Adjusting the equalizer will typically be performed by a sound engineer and will only occur in installations where premium sound is paramount.

Source	Pre-Amplification	**Amplifier**	Loudspeakers

Amplifiers do just what their name implies. They take the signals that are sent from the source, mixer and equalizer, and make them bigger. Whatever is sent to the amplifier is made bigger. This is an important concept, because it is often necessary to explain to a customer that certain things that they want to do, like having the TV's playing over the speakers in the bar, while music plays in the restaurant, will require two amplifiers.

There are two main type of amplifiers used in business music applications:

70-volt mixer/amplifier. The 70-volt amplifier is usually combined with a mixer. This amplifier is typically a mono amplifier. This type of amplifier is used in most business music applications. They range in power from ten watts to 250 watts.

Modular vs. Non-Modular

Generally, 70-volt amplifiers come in two types:

- **Modular**
- **Non-Modular**

Modular 70 volt amplifiers are designed to be very flexible. The back of the amplifier accepts plug-in modules that perform various functions such as paging, proprietary equalizer curves, microphone inputs, phone page inputs, etc. They allow for the amplifier to be customized.

The modular amp sold by DMX MUSIC is manufactured by TOA.

Non-Modular 70 volt amplifiers do not have modular capabilities. They come with various pre-set inputs and features. They come in a wide variety of power ratings from 10 watts to 250 watts.

High powered amplifiers. These amplifiers typically do not have any mixing functions included, and therefore require an additional mixer. They are used in systems requiring more power than a typical mixer amplifier offers, and therefore will be covered in more detail in the intermediate manual. These amplifiers can sometimes often operate in 70 volt mode.

You will also encounter consumer grade stereo receivers while in the field. They can usually be identified by their general characteristics:

- Black plastic face plate
- Oversized volume knob
- Bass and treble controls
- Selector switches for CD, Tape, Tuner and Aux.
- Made by a well known Consumer Electronics Company (Sony, Pioneer, Panasonic, JVC, etc.)

Amplifier Considerations

Stereo versus Mono

When designing a sound system that has the main function of delivering even sound to a large area (**a distributed system**), using a mono signal is more efficient.

Most people are conditioned to think that stereo is synonymous with hi-fidelity sound. This is not so. There is such a thing as low fidelity stereo sound and high fidelity mono sound. To most non-experts, fidelity refers to the quality of the sound produced. Does it have good naturalness, good clarity or nice bass?

Stereo is delivering music in two discrete channels. A stereo amplifier is essentially made up of two mono amplifiers. The bass drum may come from the left channel, the lead guitar from the right. In a controlled listening environment, like a car or a living room, this gives a spacious feel to the music, making it feel more, as Bose would say, “lifelike”.

In a commercial distributed system this has drawbacks, particularly if the loudspeakers are mounted flush in the ceiling. If you are under a loudspeaker, you do not want to hear the bass drum at the expense of the lead guitar. You would like to hear both.

If you want to hear the effect of this, or need to illustrate it to a customer, use “Rubber Soul” by the Beatles. Play it in mono then stereo. While playing it in stereo mode, detach one of the speakers. You will be left with either John Lennon or Paul McCartney, never both.

Power and Watts is a term that you will hear used in conjunction with amplifiers. Watts are simply the term used to rate how powerful an amplifier is. Amplifiers are available in various wattages (10, 15, 30, 60 and 120 are common amounts). The number of watts reflects the amount of sound power available. To decide how much power you need for a particular system, see "Tapping" later in this module.

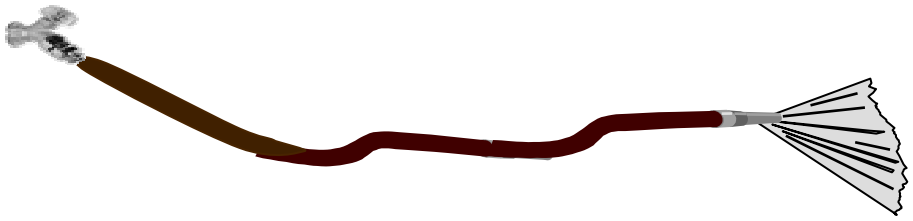
Think of a Watt as a unit of sound. A 30-Watt amplifier has 30 units of sound available to use. This means the speaker system should be designed to need no more than 30 watts. Ideally, you should try not to try to use every single unit of power available. Allowing some unused units of power, is called leaving **“headroom”**. Ideally you should leave at least 20% of an amplifiers power unused to provide “headroom”.

70 Volt and 8 Ohm

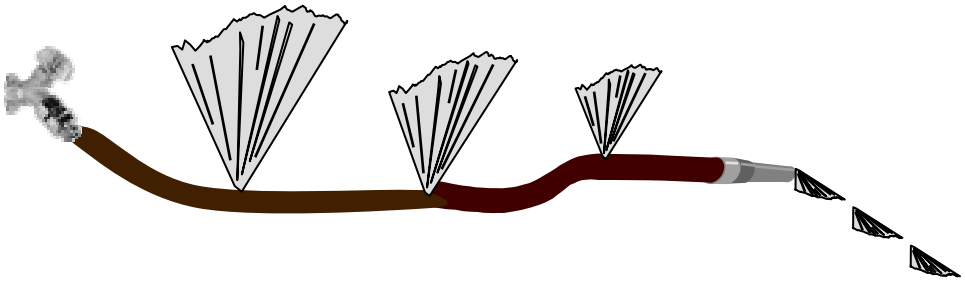
Systems are often referred to as **70 volt or 8 ohm**. Ohms and volts are both terms used when talking about electricity. At this stage it is not necessary to fully understand the “whys and wherefores” of these terms, but it very important to understand the following.

70-Volt systems are designed to string large numbers of speakers together in an uncomplicated manner. 8-ohm systems are typically designed for fewer speakers. The system in a restaurant is typically 70 Volt. The system in your living room is 8 ohm.

Think of an 8-ohm system as a garden hose with a nozzle at the end. In order to water your grass you could hold the nozzle and spray it on your lawn. This is fine if you want to water one little area. You've got plenty of water coming out of the end of the hose and you can direct it where you like.

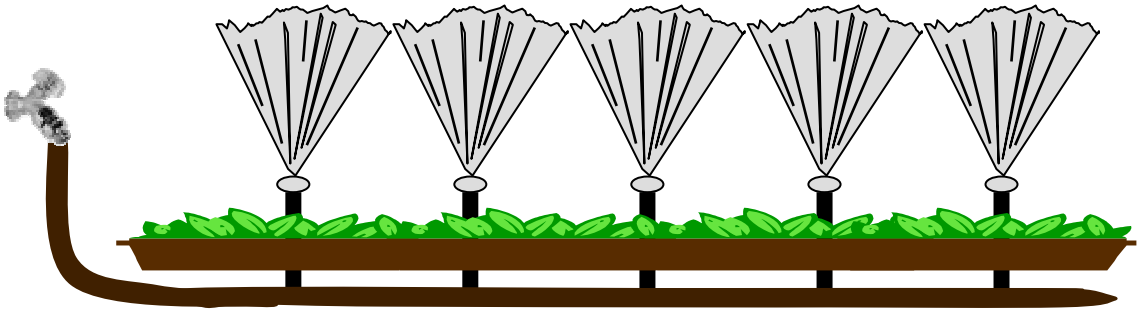


Home systems are 8 ohms since the number of speakers is small and distances involved are short.



But what if you wanted to water your whole lawn at once? You could use the same setup and simply poke holes in the hose to cover more area. The problem there is that you'd have a lot of water coming out of the hole nearest the faucet and only a trickle coming out of the end of the hose. It would make for uneven watering of your lawn. If you are operating from a well, you could run it dry and damage the pump. If you run too many loudspeakers from a non-70 volt amplifier, you could easily damage or “blow” that amplifier.

Or, you could install an underground sprinkler system with sprinkler heads strategically located around your lawn. The water pressure is controlled and the sprinkler heads are designed to distribute the water evenly for a good soaking.



70-volt systems work the same way. The amplifier has a "step-up" transformer that creates a certain "pressure" in the speaker line, and the speaker has a "step down" transformer that converts a certain amount of power from the line. The result is an even distribution of power throughout the whole system.

Most commercial sound systems are 70-volt systems. The sound in a 70-volt system is distributed evenly to the speakers and is the most efficient method to deliver sound to a large number of speakers.

Commercial vs. Residential Systems

Commercial	Residential
Multiple Speakers	2 or 4 speakers
Mono	Stereo
Even Coverage	Focused Listening Points

Source	Pre-Amplification	Amplifier	Loudspeakers

Loudspeakers are the part of the sound system that everybody sees. In the commercial world we focus on two main types, surface mount and flush mount.

Surface Mount loudspeakers are usually bracketed to a wall or a beam.

Flush Mount loudspeakers are usually installed into a drop-tile ceiling, or occasionally into a sheet rock ceiling.

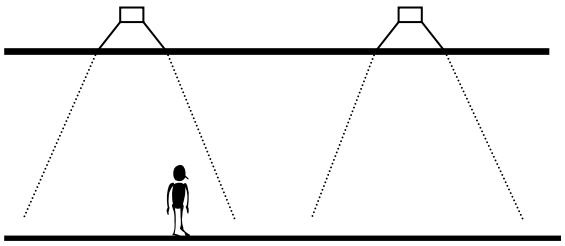
There is a huge variation in the quality and price range of loudspeakers that DMX MUSIC can offer. Your ability to diagnose what level of quality and price the customer needs, and your ability to sell that choice will dramatically impact your ability to sell sound systems.

Loudspeaker Considerations

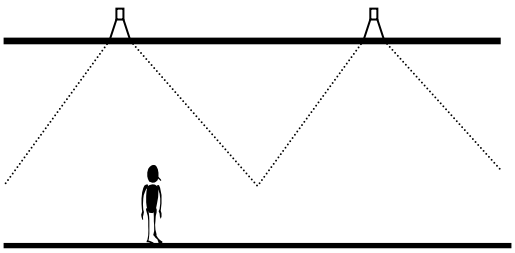
There are a couple of rules of thumb that help with loudspeakers.

- The smaller the loudspeaker is, the wider the dispersion. Small speakers behave like floodlights.
- The larger the speaker the narrower the dispersion. Larger speakers behave like spotlights.
- Typically the larger the loudspeaker, the easier it is for the loudspeaker to reproduce low frequencies.
- Small loudspeakers that are forced to reproduce low frequencies are typically equalized internally or externally to achieve the effect. It requires more power (wattage) to achieve these low frequencies in small loudspeakers, and therefore they are not very efficient.

Large Speaker / Narrow Dispersion



Small Speaker / Wide Dispersion



Transformers

Most loudspeakers that you will sell will include a **transformer.** It is important to understand what transformers do. They function to either step up or step down the level of signal.

A step-up transformer enables us to create a 70-volt line in the first place. It is essentially the handle on the faucet that allows us to increase the water pressure to our sprinkler hose. It is included in any 70-volt amplifier that you would specify. It represents much of the reason that 70-volt amplifiers are heavier than their equivalent consumer model.

A step-down transformer is necessary for each loudspeaker in a 70-volt. It is necessary because most loudspeakers are designed to accept a lower voltage, so we must reduce the 70-volts that is bringing the sound to our speakers back down.

On many of the premium loudspeakers that DMX MUSIC offers, you cannot see the transformer, as it is located inside the loudspeaker housing.

It should be noted that the use of transformers, while making the delivery of sound much more efficient and cost effective, can degrade the fidelity somewhat. The quality of transformers used in premium 70-volt loudspeakers like JBL and Bose minimizes or eliminates the impact of this degredation.

Tapping

We referred to watts as units of sound. We also noted that when you used all the units available there was no more power left. Tapping allows you to control how many units, or what portion of a unit, can go to an individual speaker. By tapping the speaker you also control how loud the loudspeaker can play.

Tapping on 8-inch flush-mount loudspeakers occurs by choosing a color wire to attach the positive current. Typically the taps available are ¼, ½, 1, 2 and 4. On premium loudspeakers and surface-mount loudspeakers the tapping screw or knob is typically under the grille or on the back.

To decide how much power you need for a system, you simply add the total number of Watts for each speaker, plus add 20% for "headroom". Headroom is not so critical in low fidelity systems. Make sure that your amplifier has more power than you need and you'll be all set. It should be remembered that future expansion might occur, so extra wattage is always desirable if it is affordable to the customer.

Example:

You have determined that you need to use 50 loudspeakers in a job. They will all receive the same signal. 25 need ½ watt, 5 require 1 watt, 10 require 2 watts and 10 require 4 watts.

You will need:

25	**x**	**½**	**=**	**12 ½**
5	**x**	**1**	**=**	**5**
10	**x**	**2**	**=**	**20**
10	**x**	**4**	**=**	**40**

12 ½ + 5 + 20 + 40 = 77 ½ watts

77 ½ + 20% = 93 watts

Therefore you will need to use an amplifier that has at least 93 watts available.

Volume Controls

The concept of tapping relates to the use of external volume controls or attenuators. These attenuators allow the user to turn the volume of the output down relative to the rest of the system. Attenuators are typically offered at four wattage levels, 10 watts, 35 watts, and 100 watts. These measurements denote how much power can run through them.

In the previous example, if the different taps on each loudspeaker denotes a room, the following attenuators can be used.

25 x ½ = 12 ½	**requires a 35 watt volume control**
5 x 1 = 5	**requires a 10 watt volume control**
10 x 2 = 20	**requires a 35 watt volume control**
10 x 4 = 40	**requires a 100 watt volume control**

Attenuators allow the customer to adjust the volume needed in a specific area without having to return to the main system when it is located in another area. They have the related benefit of allowing the owner to lock the main system away, leaving the staff with control only of the volume, with a pre-set maximum.

How loud will the system play? – Some Basic Laws

Here is some basic physics knowledge that helps in your understanding of designing sound systems.

The first thing that a representative should know and be able to relate to a customer is the concept of "how loud do you need?"

Loudness, or **Sound Pressure Level (SPL)** is measured in terms of decibels (db). Decibels are not measured in a linear fashion, but rather logarithmically.

Explained simply, 100 decibels is not twice as loud as 50, as you might logically think. Actually, an increase of approximately 10 decibels represents a doubling of SPL. Therefore 75db is twice as loud as 65db, which is twice as loud as 55db. Therefore 75db is four times as loud as 55db.

When people refer to music as **"background"**, they usually mean that it is unobtrusive to the environment. **Typically background music is played at between 55 and 70db,** depending on the ambient noise.

When people refer to music as **"foreground"**, they usually mean that it is a definite part of the environment. **Typically business foreground music is played at between 70 and 85db,** depending on the ambient noise.

Typical sound pressure levels of various sources

(at indicated distances to ear, where appropriate)

	.45 ACP Colt Pistol (25 feet)	**140**
	50 HP Siren (100 feet)	**130**
	Threshold of Pain	
Typical Recording Studio	Rock Music (10 feet)	**120**
Control Room Monitors for:	Film Scoring (20 feet)	**110**
	Loud Classical Music	**100**
	Heavy Traffic Street (5 feet)	**90**
	Loud Business Foreground Music	
	Cabin of Jet Aircraft (Cruise Configuration)	**80**
	Average Conversation (3 feet)	**70**
	Average Background Music	**60**
	Average Suburban Home (night)	**50**
	Quiet Auditorium	**40**
	Quite Recording Studio	**30**
	Quiet Whisper (5 feet)	**20**
	Extremely Quiet Recording Studio	
	Rustling Leaves	**10**
	Anechoic Chamber	
	Threshold of Hearing	**0**

Ambient Noise is an important starting point in sound design. Ambient noise represents the natural SPL of the space before any sound equipment is installed. In an office the ambient noise may be 58db, in a retail space 65db, in a crowded restaurant 80db.

To create background music, the music needs to be played at the same level as the ambient noise. If it is louder, in a restaurant for example, the chances are that people will just talk more loudly to overcome it, thus raising the ambient noise.

If paging is required, the system needs to be capable of playing at 10db louder than the ambient noise.

Power and SPL

When looking to tap loudspeakers, it is important to know that if you double the power to the loudspeaker, the maximum SPL that can be produced increases by three decibels (3db). Conversely, if you reduce the power by half, the maximum SPL that can be produced decreases by 3db.

Example: A loudspeaker can produce 87 decibels with 8 watts of power

1 watt can produce 78db

2 watts can produce 81db

4 watts can produce 84db

16 watts can produce 90db

32 watts can produce 93db

Distance and Power

When looking to tap loudspeakers, it is important to remember that when you double the distance from the speaker, the maximum SPL that can be produced diminishes by six decibels (6db). Conversely, if you reduce the distance by half, the maximum SPL that can be produced increases by 6db.

Example: A loudspeaker produces 78 db of SPL at 4 meters (13 feet)

At 1 meter it produces 90db

At 2 meters it produces 84db

At 4 meters it produces 78db

At 8 meters it produces 72db

At 16 meters it produces 66db

These two laws relating distance, power and SPL are the basis for our formulae that calculate how many speakers you use and what you tap them at. You will not need to employ these laws every time you design a system, but they are important reference points when you are in doubt, or when a customer is asking for a detailed explanation of your proposal.