FASST

Field Associate Sound System Training

Loudspeakers

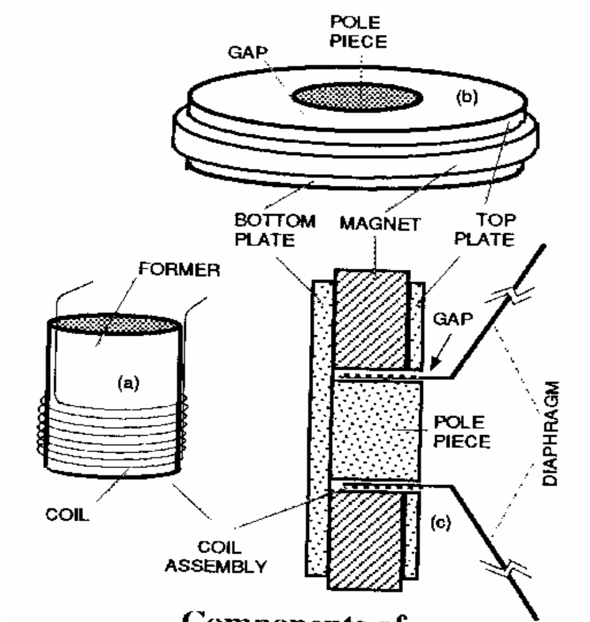
“But I’ve always called it a speaker…..”

A loudspeaker is the summation of one or more transducers (or drivers) that convert electrical energy to acoustical energy. However, these devices are more commonly referred to using a contracted form of the word: speaker. When discussing sound systems, this nomenclature can lead to confusion since technically a speaker is defined as one who speaks. A good example can be seen in the statement, “The speaker is too close to the microphone.”

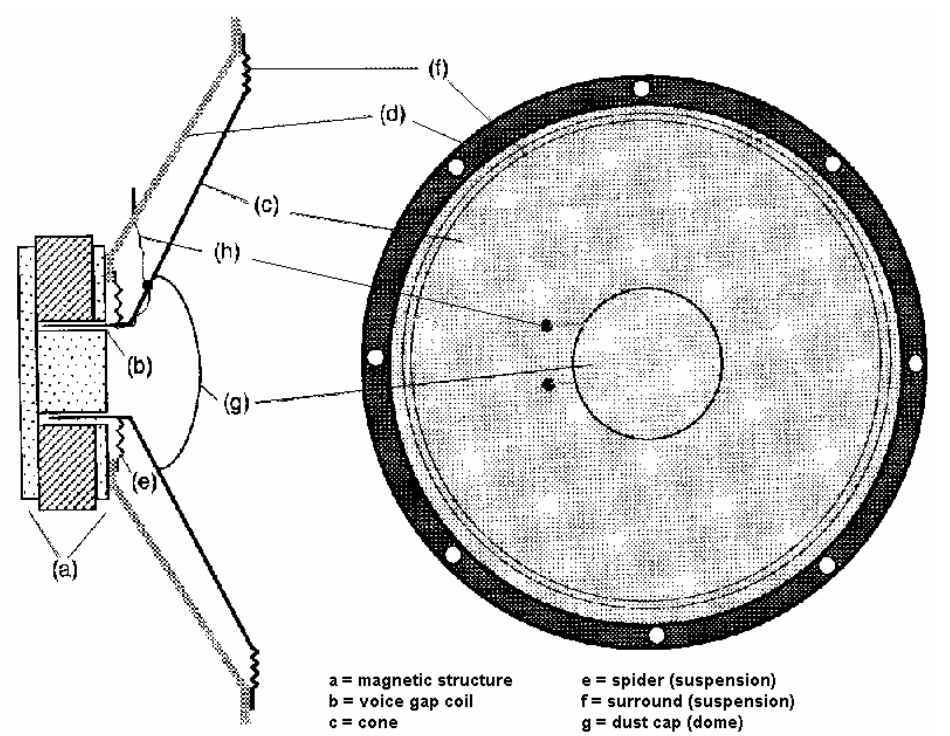
Electromagnetic Design

Although there are a number of transducer designs, the most common utilizes an electromagnetic field. The core philosophy of this design lies in the fact that electrical energy, or current, traveling through a coil will generate a magnetic field. This magnetic field can be used to create kinetic energy when interacting with another magnet that is in a fixed position. Remember how two magnets interact? Opposite polarities attract and likes repel. Essentially by alternating the polarity of the magnetic field generated through the coil, we are able to push and pull the cone forward and backward creating sound.

The figures below and to the right show the components of an electromagnetic motor and its function in a cone-type transducer.



Components of a linear electromagnetic motor (In a typical driver)



a = magnetic structure
b = voice gap coil
c = cone
d = frame (basket)
e = spider (suspension)
f = surround (suspension)
g = dust cap (dome)
h = flexible wires

Cross-section of a cone-type driver

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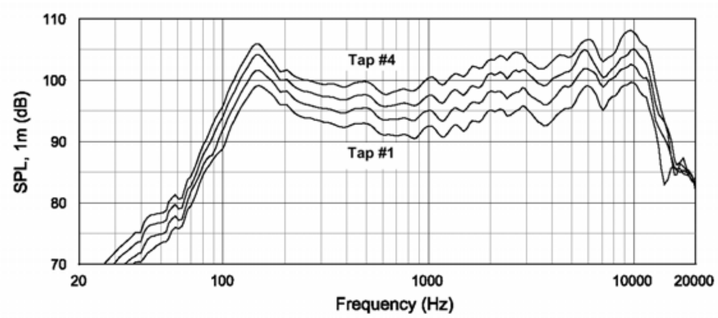
Frequencies and Frequency Response



Loudspeakers are often measured by the frequencies they can reproduce. Suspiciously, the range in which they are measured just happens to correlate with the human ear, albeit a very sensitive one. This range is typically from the very low 20 Hz (Hertz) to the very high 20,000 or 20k Hz. Actually, most people are unable to hear the extreme highs and low of this range. A good test of your own hearing is to connect a frequency variable tone generator to a sound system that is capable of reproducing the full audio spectrum and listen.

Some manufacturers will supply their measurements, but be careful when comparing these charts as not all measurements are done identically.

We mentioned in our definition of a loudspeaker that it is the summation of one or more drivers. The reason for having multiple drivers in a loudspeaker is because some driver designs more clearly and efficiently reproduce specific frequencies than others. The fairly common terms of *tweeter* and *woofer* are used to describe drivers that are designed to reproduce high and relatively low frequencies, respectively. The majority of commercial loudspeakers employ these two types in their dual driver 2-way system. 3-way enclosures utilize a third driver to cover the middle range of frequencies. This group of mid-range drivers is classified by the less known term *squawker*.

Additionally, you might have heard the term subwoofer. As you may guess, a subwoofer handles the extremely low frequencies that are below (or sub) the woofer range. These drivers are typically mounted in their own larger enclosure because the wavelengths of the frequencies that they create are relatively long and difficult to control.

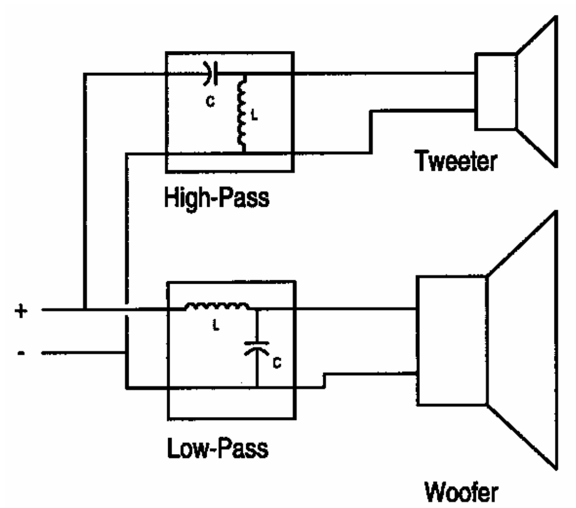
Driver Type	Frequency Range	Audio Impact
Subwoofer	20 Hz – 60 Hz	Rumble, often felt more than heard
Woofer	60 Hz – 250 Hz	Fullness, richness, and thump
Squawker	250Hz – 4000 Hz	Honk, crunch, and edge
Tweeter	4000 Hz – 20000 Hz	Sibilance, definition, and air

Passive Crossovers

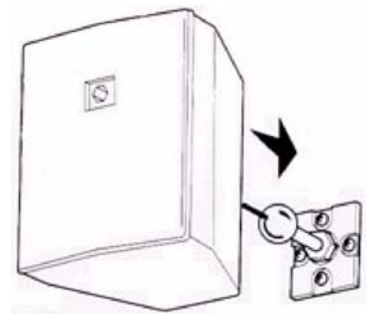
Hopefully it is clear that there is some overlap in the frequencies that each of these types of drivers can create. In a 2-way system for example, the woofer must act as the woofer and squawker. However, just because these drivers can reproduce a range of frequencies doesn't mean we want them to. If we sent a full range signal to each of the drivers in an enclosure, we would have an acoustic mess.

Inside every multi-driver enclosure that has a single input is a passive crossover that allows the appropriate frequencies to reach the intended driver. This electronic circuit is called a crossover. It is passive because it does not need 120 volts of AC power to operate. The passive crossover helps to improve the clarity and efficiency of the loudspeaker by sending the frequencies to the drivers that are designed to handle them.

The drawing below is a schematic of a typical 2-way loudspeaker. The passive crossover is comprised of the low and high pass filters.



Mounting: Surface vs. Flush

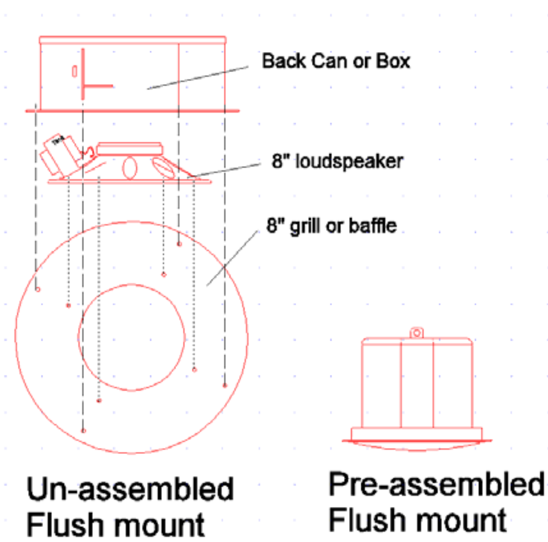


Loudspeakers are designed to be mounted on a surface or mounted behind a ceiling or wall. This latter type is considered a flush mount.

A surface mount loudspeaker is nothing other than an enclosure that has a bracket enabling it to be mounted to a ceiling, wall or some other supporting structure. These brackets are often ‘U’ or ‘C’ shaped, however there are some ball & socket designs that offer greater directional flexibility.

Flush mount speakers have historically required on site assembly, but recently there have been more pre-assembled models on the market. They typically cost more, but save on labor since they are quicker to install.

An unassembled flush mount assembly always consists of the driver, grill and some sort of weight distributing bracket or support arms. Additionally, in most installations the assembly will include a back box. This back box serves multiple purposes including protection of the loudspeaker, increased sound pressure levels and low end response by reflecting acoustic waves, provides a termination point for spaces that require conduit, and provides a clean point for the grill and speaker to be mounted to. Back boxes come in all shapes and sizes. Larger cans tend to have a superior bass response than the smaller cans, but some locations have limited space above the ceiling that requires a shorter can. Some are designed to be installed from above the ceiling, while others can be cut in from below. These blind mount cans can be very useful when working with existing hard lid ceilings. Two things to remember: Size does matter, but a small can is better than no can at all. And always, always, always use a tile bridge or support rails to support the loudspeaker assembly. A ceiling tile will sag over time and moisture can cause a loudspeaker to fall if the weight is not properly distributed.

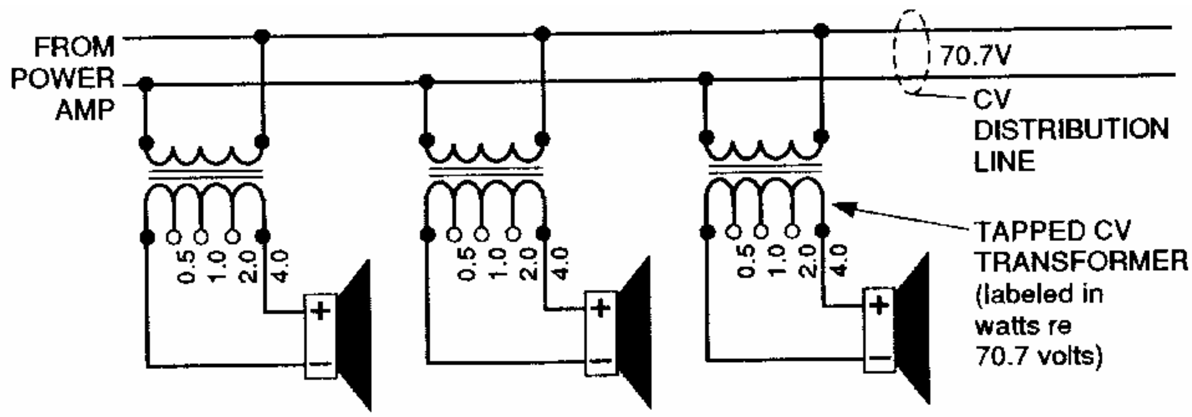


Pre-assembled loudspeakers are usually mounted from underneath. They incorporate wings that open up after the can has been pushed through the opening in the ceiling. In a drywall or drop tile installation, make sure that the support ring is used to distribute the weight of the can over the entire circumference of the hole and not just the 3 points where the wings are touching the ceiling.

Impedance

All loudspeakers that I know of are born as low impedance devices. In the professional world, that normally means the loudspeaker is rated between 4 and 8 Ohms. Furthermore, they like to be powered by a low impedance amplifier.

In commercial systems, we like to add transformers to our loudspeakers so that we can connect several devices together on a single amplifier and still be able to wire them in parallel. Electrically speaking, these transformers essentially change the device from low to relatively high impedance.



Constant Voltage Distributed Loudspeaker System

Most transformers allow the user to select one of four different tap values. Each step up doubles the power passed to the driver which nets a 3dB SPL gain. There are a couple different ways of selecting the tap value. Most unassembled drivers have a pig tail of 5 different colored wires. One wire, usually black, is the common and each of the others corresponds to a specific tap value. The installer will connect one of these four wires to the hot side of the feed coming from the amp. The other three must be cut and electrical taped so that no conductors are allowed to touch each other or anything else. Otherwise they could short out and burn up the amplifier. The second type of tap selector is a rotary switch that the installer simply turns to the appropriate setting. These switches are very convenient to use but some have a bypass setting that allow the loudspeaker to be used in low impedance systems. It is important to have the taps set in the correct position in order to avoid damaging the amplifier or loudspeaker.

The benefit of having multiple taps allows the installer to make minor level adjustments at each speaker relative to the others. A good example is a cash wrap or cash register area in a retail store.   Typically the customer wants to have any loudspeakers in this area tapped down so that they can hear their customers, while still maintaining a prominent level throughout the rest of the store.

Almost all of our distributed systems use 70.7 volt transformers, but there does exist 25 and 100 volt transformers as well. It is not unheard of for a manufacturer to slip in a 25 volt transformer with a 70 volt shipment, so beware. This should be noticeable when taking impedance readings prior to connecting the cable to the amplifier. If it is missed, you will have one driver that is significantly louder than any of the others. Many times the transformers that manufacturers use can be used with one of the other voltages as well. These are typically dual labeled and shouldn't create problems.

Sensitivity

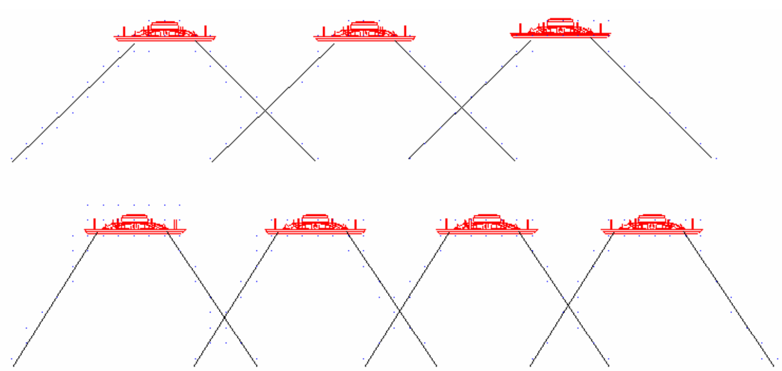
We want to briefly address the issue of speaker sensitivity. The main point is that not all loudspeakers have the same output level when supplied with identical power. Some manufacturer's are willing to document this little tidbit and others aren't. These measurements are typically done with 1 watt of power at 1 meter. The higher the sensitivity level, the louder it will be. As a rule of thumb, be careful when mixing loudspeakers in a sound system. You can wind up with very different sound pressure levels.

Maximum SPL

This information is good to know if your customer wants to add loudspeakers in a high ambient noise environment, like a bar or manufacturing facility. You need to make sure that the loudspeaker is designed to overcome those levels given the distance from the listener at which they will be mounted. Not all loudspeakers are designed for a high noise environment. If you have doubts, consult an engineer. I can't imagine anything being more embarrassing than installing a sound system that was unable to be heard!

Dispersion angles

It can be good to know the angles at which a loudspeaker is emanating sound. A flush mount ceiling device with a 60 degree dispersion angle will require many more loudspeakers than one with a 90 degree dispersion.



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Sample Specifications:

Frequency Range (-10 dB)[1]:	40 Hz –19 kHz
Frequency Response (± 3 dB)[1]:	45 Hz – 18 kHz
100 Hr Power Capacity [2]:	300 Watts Continuous Program Power 150 Watts Continuous Pink Noise
Maximum SPL @ 1m[3]:	Short-Term: 120 dB; Long-Term: 114 dB
Nominal Sensitivity[4]:	91 dB, 1W @ 1 m (3.3 ft)
Nominal Coverage Angle[5]:	110° H x 85° V, rotatable
Directivity Factor (Q):	7.2, averaged 500 Hz to 16 kHz
Directivity Index (DI):	8.6 dB, averaged 500 Hz to 16 kHz
Nominal Impedance:	8 ohms
Minimum Impedance:	6.3 ohms @ 230 Hz
Crossover Type:	3rd order High Pass, 2nd order Low Pass with impedance compensation, 2.5 kHz crossover frequency
Transformer Taps:	70V: 110W, 55W, 28W & 14W 100V: 110W, 55W, & 28W Thru Position: 8Ω nominal