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POWER AMPLIFIER REQUIREMENTS FOR MOTION PICTURE THEATRES

BY

JOHN F. ALLEN

HIGH PERFORMANCE STEREO™

HIGH PERFORMANCE STEREO™
NEWTON, MA 02459 USA • TEL: 1-617-244-1757

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In last November's BOXOFFICE, my article on speakers and amplifiers quoted a formula for determining power amplifier requirements in theatres equipped for stereo. Suggested by Dolby Laboratories' loan Allen, this formula says to divide the number of seats in the house by 4 and add 25. Thus a 400 seat theatre would need 125 watts of power for each screen channel, 1000 seats; 275 watts and so on. He goes on to suggest the next higher powered amplifier available, usually 50 percent more. Allen recommends this only as a guideline, not a final determination. For instance, his formula does not take into account the efficiency of the speakers used. How then does one really determine the needed power?

Allen's formula is actually very good if one uses the most efficient and most expensive speakers, which, in my opinion, one should. Loudspeakers are not perfect. Only a small percentage of the electrical energy fed to them is converted into acoustical energy. The rest is turned into heat. A standard way to measure a speaker is to supply it with one watt of electrical energy and measure the sound pressure level (SPL) at a distance of 4 feet.

The Klipsch TMCM, the Altec A4 and the JBL 4676-2 speaker systems all have outputs at 4 feet of 107 decibels (dB) SPL when one watt is applied to them. This translates into an efficiency of about 20 percent, which, for loudspeakers, is very efficient.

Say our 400 seat house is 80 feet long, 45 feet wide and 20 feet high. If there were no walls or ceiling, a 20 percent efficient speaker would deliver a level of 87 dB SPL in the middle of the theatre with a one watt amplifier. Since we are indoors and reverberant energy is also in the room, the level measured will actually be higher. One watt, in other words, will be sufficient for most dialog if it is played at about an 80 dB level (comfortable).

Here is where it gets interesting (I hope). Why would such a theatre need more than a 1 or 2 watt amplifier instead of the 150 or 200 watt units which are recommended? There are several reasons, but the main one is the dynamic range of the entire soundtrack which is

much greater than that of dialog. The larger amplifiers will have enough power for this total dynamic range without ever becoming over-driven. The last thing one wants to do is overdrive an amplifier.

When an amplifier "runs out of gas", the tops and bottoms of the electrical waveforms are "clipped" off, much like taking a nice round hill and flattening the top. This can be heard as lots of clicking during loud passages. A clipping amplifier no longer moves the speaker in and out smoothly. When the clipped signals are fed to a speaker, they try to hold the moving diaphragm in its extreme positions. During this time heat builds up in the voice coil and distorts its shape. After a while, the coil may burn up, short out or bend far enough out of shape to hit the magnet structure. From there, it's all down hill. Briefly exceeding the continuous power capacity of the speaker is far safer. Hence the higher power is required not so one can turn up the sound to volcanic levels, but so one has all the dynamic range needed for those brief peak demands without over driving the amplifier and destroying the speakers.

A 200 watt amplifier and a 20 percent efficient speaker will deliver levels of about 110 dB SPL in the middle of our 80 foot long theatre. Is this enough? Yes it is, particularly for 35 mm soundtracks. Producing higher levels would exceed the reasonable dynamic range one can get from optical soundtracks. In other words, the background noise would be too loud. This is because as one turns up the loud sections, one also turns up the quiet sections where the background noise is. Eventually this noise gets louder than the noise level !in the room itself and becomes audible.

A peak level of 110 dB SPL is thus a good design criteria. Since theatres are indoors, I think it's safe to use 109 dB as the peak sound pressure level each main speaker should deliver in the center of a theatre. A 120 foot long 1000 seat theatre using 20 percent efficient speakers would need about 360 watts per channel. Allen's suggested 275 watts is in the ballpark and the next higher powered unit would be just right.

Alas, it is not that simple. Most theatres use loudspeakers which are about 5 percent efficient. What does this mean? It means they need 4 times the power from the amplifier to do the job. If our 400 seat theatre were equipped with 5 percent efficient speakers, it would require three 800 watt amplifiers. The 120 foot long 1000 seater would need a whopping 1420 watts per screen channel, not to mention some additional measures to keep the speakers cool. These systems typically have a 50 watt capacity and no -one has a 1420 watt amplifier (at least as far as I know).

So what do you, the theatre owner, do when using Allen's formula? If your speakers are

the 20 percent efficient Altec A4's, the JBL 4676-2's or the Klipsch TMCM's, use the formula as stated. If your speakers are the 5 percent efficient Altec A7's or JBL 4674's, multiply the formula's result by 4. And if your speakers are the 10 percent efficient Klipsch LaScala's, then you only multiply by 2. Obviously high efficiency is the route to go.

Surround speakers (seemingly the bane of this industry's existence) should also be relatively efficient. Consider a typical acoustic suspension consumer loudspeaker that many are attempting to use for surrounds. It has an efficiency of about .05 to .1 percent. An array of 10 of these very inefficient systems will require 20 to 40 times more power than a similar array using 2 percent efficient speakers.

Clearly (pun intended) the amplifiers currently in use in many theatres are not large enough. Many small speakers are being used in theatres larger than they were designed for. The result is that amplifiers are distorting, speakers are distorting and burning up. The sound is horrible. Increasingly sophisticated audiences are getting sick of it and are staying home. And who can blame them? Is this any way to compete with domestic stereos, color television and personal computers?

John F. Allen is the founder and president of High Performance Stereo in Newton, Mass. He is also the inventor of the HPS-4000® cinema sound system and in 1984 was the first to bring digital sound to the cinema. John Allen can be reached by E-mail at JohnFAllen@aol.com.