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How Much Power Do I Need In A Portable Amp System?

June, 2012

The typical answer to that question is: "as much as you can get!" But, in these days of ultra-high power, small size amplifiers, it's not that simple. If you have too much power, it's easy to damage transducers, especially if you have opted for a compact system with a relatively small speaker. Further complicating the issue with a smaller speaker system, more power is needed to get high volume due to the lower efficiency (and limited radiating area) of small woofers. In the design of our own systems, we have had to confront this issue. We've always tried to offer the smallest systems possible and along the way have learned a lot about the tradeoffs between compact size, amp power and loudness. As a result, we've come up with guidelines which we generated during the redesign of our new Series 4 product line. In this paper, I'd like to share some of what we learned, including the tradeoffs involved.

Background

Before we start, I want to review some background information. In an earlier paper ("The Purpose of Power"—available on our website), I wrote that speaker radiating area is the determining factor in how loudly an amp system can play. The amp's power output level plays a role in how loud the system plays but its role is mostly to reduce distortion by providing enough headroom to keep the amplified signals from being clipped. So, "the purpose of power" is to minimize distortion, not to determine loudness. In other words, if you want a loud system, get a big speaker. But for many performers, particularly those who are trying to amplify acoustic instruments, that's the wrong answer. They want to know: "How do I get the most out of a compact system?" "What are the limitations of a compact system?" "How do I know how much power is enough?" "How much is too much power and at what power level to I start to put my speaker at risk?"

To respond to these questions, we need to make some important assumptions (I'll try to give you enough information so that you can see how different assumptions change the results and allow you to adapt the findings to different situations as appropriate.) The issues we are dealing with are:

1. How loud does the amplified sound need to be?
2. How many acoustic watts does it take to produce the desired loudness in a given room size?
3. What speaker configuration will be used?
4. What are the efficiency and power handling of the assumed speaker configurations?
5. What peak to average power ratio is enough to reproduce the signal without clipping?

Assumptions

This table summarizes the typical average sound pressure level for various activities.

Event	Typical average sound pressure level	Typical peak sound pressure level
Motion picture	85 dB	105 dB
Classical concert, mid house	60-65 dB	85 dB
Chamber music	45-50 dB	70 dB
Stage musical, mid house	70-75 dB	90 dB
Rock concert, front seats	95 dB	120 dB
Audience noise, sports events	80 dB	110 dB
Subway noise	70 dB	95 dB

Table 1: Average SPL for Various Situations

We're going to assume an "acoustic" music setting, not a rock setting, with an average SPL of 90 dB. As you can see from the table, that is kind of loud—80 to 85 dB may be more accurate—but, let's err on the conservative side.

The next question is what acoustic power level (in acoustic watts) is required to achieve that SPL in a given room size? The figure below shows the level of acoustic watts required to produce a given average (not peak) SPL as a function of room size.

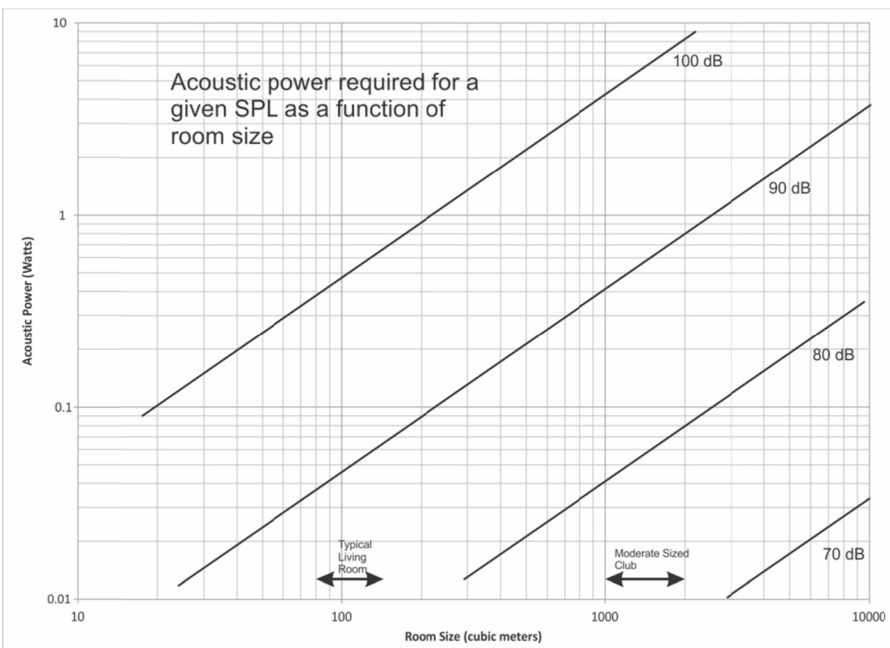

Figure 1: Acoustic Power Required for Various SPLs

This chart summarizes a complicated analysis that takes into account factors such as reflective and absorptive properties of the room, reverberant sound fields and other parameters of typical spaces. Note the size range for a typical living room and club are shown in the figure. So, for example, the chart tells us that if we want to have an average level of 90 dB in a moderate sized club (1000 cubic meters), a level of approximately 0.4 acoustic watts is required.

A loudspeaker converts electrical watts (the output of an amplifier) into acoustic watts with an efficiency of around 1%. So, in this example, about 40 Watts (average power) from an amp is required to produce 90 dB SPL. As you can see, the efficiency of the loudspeaker is a critical factor in determining the amp power requirement so we need to make assumptions about speaker efficiency.

The size and number of speakers determines the efficiency of the speaker system. Beyond that, the efficiency of a specific loudspeaker is determined by a number of things such as cone material, magnet properties, surround material, etc. But I won't go into the specifics of individual speakers. Rather, I will assume a range of efficiency for a given speaker size to cover the variations in different versions of a given size driver. The table lists the range of values for each speaker configuration that we will use in our analysis.

Speaker Configuration	SPL Range	Power Rating	Max Power
1x10	90 to 93 dB	200W	400W
1x12	93 to 96 dB	300W	600W
2x10	96 to 99 dB	400W	800W
2x12	99 to 102 dB	600W	1200W
1x15	99 to 102 dB	500W	1000W
4x10	102 to 105 dB	800W	1600W

Table 2: Efficiency and Power Rating for Various Speaker Configurations

A few things to note: The efficiency of the speaker configuration is given in terms of SPL which is shorthand for the output level in dB measured at 1 meter distance with a 1 Watt input. SPL is related to efficiency using the following equation.

$$\text{SPL (dB/m)} = 112 + 10\log_{10}(n_0) \quad \text{where } n_0 \text{ is the efficiency of the driver configuration}$$

The SPL range for each driver size is typical for that size but there are drivers with lower and higher efficiency. If you are analyzing a driver that is outside of the range, you can use the same technique to calculate your own result. Note that each additional driver added to a given configuration adds 6 dB to the SPL (more about that is covered in "The Purpose of Power").

There is also a power rating listed for each configuration. This is the thermal power limit which is the power which (when sustained over a period time) will cause the voice coil of the speaker to overhead and fail. The ratings assumed are on the conservative side, you will likely see many speakers rated higher than what is shown in the table, but those ratings are often overstated for marketing purposes. Again, if you want to evaluate a higher rated driver, you can use the method I've outlined.

A "Max Power" rating is also provided. This is an attempt to state the maximum amplifier power rating that should be used with the given driver configuration. Industry consensus is that for music signals, it is safe to use an amp that has an rms power rating of twice the thermal power rating of the speaker. We use the Max Power rating to set the upper limit on the amp power that should be used with a given configuration. Again, this number is somewhat conservative, the amp power rating can be up to 2.5 times the thermal rating of the speaker and still be safe, especially in the case of acoustic music amplification. In your own analysis, you can also change that number if you like.

The last assumption we need to make is the value of the ratio of maximum amplifier power (the power rating of the amp) to the average power that is required to produce the desired volume level. A ratio of 8 to 1 is used often in the audio industry when testing amplifiers and speakers (several testing standards specify an 8 to 1 ratio), so that's what we'll use.

Results

So now we have all the assumptions to answer the question: "how much power do I need in a portable amp system?" Let's look at it step by step for the example we have chosen:.

1. *What size room or stage will be used?* 1000 cubic meters.
2. *What average SPL is needed in the room?* 90 dB.
3. *What level of acoustic watts is required?* Use figure 1 to find the level of acoustic watts needed. For 90 dB in a 1000 cubic meter room, we need 0.4 Watts.
4. *What speaker configuration?* Assume speaker configuration (table 2) and find the efficiency. For this example, use a 1x10 system with an SPL of 90 dB. Use the efficiency equation to find the efficiency (0.63%).
5. *What is the required average amp power?* Divide the required acoustic power by the speaker configuration efficiency (0.4/.0063 = 63.5 Watts). This is the average power needed to reach the desired volume level in the room.
6. *What is the power rating of the amp?* Multiply the average power by the "amp rating to average power ratio" to get the amp rating for the analyzed configuration. In this case: 8 x 63.5 = 508 Watts.

Bottom line, our analysis says that we need a 500 Watt amp in order to power a 1x10 speaker system to achieve 90 dB SPL in a 1000 cubic meter room. A check of table 2 tells us that this power exceeds the maximum power for the 1x10 speaker configuration (400 Watts), so the 400 Watt rating becomes the determining value. In other words, we will be limited to a 400 Watt amp for the 1x10 system and as a result, won't be able to achieve our 90 dB SPL goal without causing a problem. The 1x10 system won't have enough output capability to work in that large a room. Adding a second speaker or using PA support will be required. If the analysis is repeated for a 2x10 system (adding a second, identical speaker), the result is an amp requirement of 130 Watts which is well below the thermal limit if the 2x10 system. In short, the 90 dB level requires a 2x10 system.

What about using an amp rated at 1000 Watts for the 1x10 and 2x10 systems that we analyzed? In the case of the 1x10 system, 1000 Watts would be totally unnecessary, would probably be dangerous for the speaker and would not result in higher volume in the room. In fact, pushing the speaker with the extra power to try to achieve the higher volume would likely result in failure of the system. In the case of the 2x10 system, the extra power isn't needed to get the required volume level.

The analysis of all of the assumed driver configurations results in the chart below.

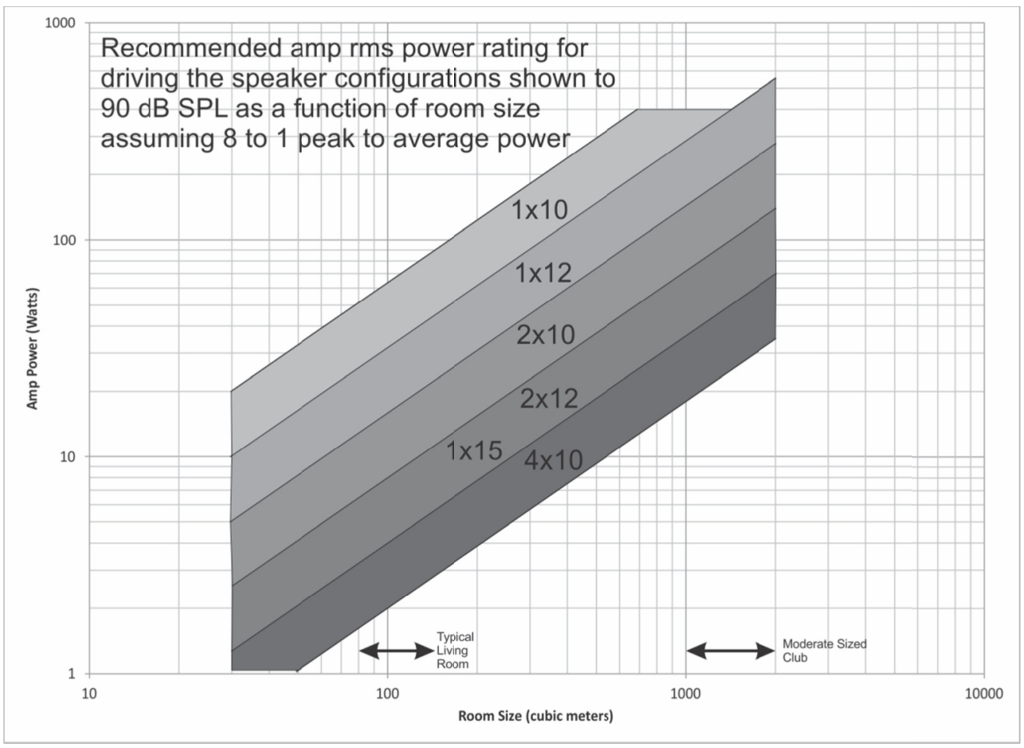

Figure 2: Recommended Amp Power for Various Speaker Configurations

As you can see, required amp power actually goes down as the size of the speaker system goes up. With a 4x10 system in a moderate sized club, only 20 Watts is necessary! That explains how a rock bassist or guitarist can play loud with a low power tube amp.

Should a player with a 4x10 system use his or her existing 500 Watt amp? Sure, but not with the hope of getting more volume..

Does this mean that everyone should ditch their high power amps and go get a cheap low power amp? No, it just means that all players should be wise in their purchase of an amp. Buying power just for power's sake doesn't make sense.