WILL THE REAL MAXIMUM SPL PLEASE STAND UP?
Measured Maximum SPL vs Calculated Maximum SPL and how not to be fooled

Introduction

When purchasing powered loudspeakers, most customers compare three key specifications: price, power and maximum SPL. Unfortunately, this can be like comparing apples and oranges. For the Maximum SPL number in particular, each manufacturer often has its own way of reporting the specification. There are various methods a manufacturer can employ and each tends to choose the one that makes a particular product look the best. Unfortunately for the customer, this makes comparing two products on paper very difficult.

In this document, Mackie will do the following to shed some light on this issue:

- Compare and contrast two common ways of reporting the maximum SPL of a powered loudspeaker.
- Conduct a case study comparing the Mackie HD series loudspeakers with similar models from a key competitor to illustrate these differences.
- Provide common practices for the customer to follow, allowing them to see through the hype and help them choose the best loudspeaker for their specific needs.

The two most common ways of reporting maximum SPL for a loudspeaker are a Calculated Maximum SPL and a Measured Maximum SPL. These names are given here to simplify comparison; other manufacturers may use different terminology.

Calculated Maximum SPL

The Calculated Maximum SPL is a purely theoretical specification. The manufacturer uses the known power of their amplifier and the known sensitivity of the transducer to mathematically calculate the maximum SPL they can produce in a particular loudspeaker.

For example, a compression driver's peak sensitivity may be 110 dB at 1W at 1 meter. When powered by a 100W amplifier, which is equivalent to 20 dB of gain, the calculated Maximum SPL is then 110 + 20 = 130 dB SPL. This number is often increased by 3 dB since sine waves have a 3 dB crest factor; in our example, this gives a Calculated Maximum SPL number of 130 + 3 = 133 dB SPL!

This specification gives a nice large number that many manufacturers use to make their product look as favorable as possible relative to the competition. Unfortunately, for the customer trying to use the information to compare products, it does not provide an accurate picture of how loud a loudspeaker will perform in a real world situation. To understand why, one must understand more of the acoustics involved.

Each component in a multi-way loudspeaker has a different sensitivity at each frequency across its frequency range. This means the driver produces some frequencies louder than others. This is why multi-way enclosures exist. 15-inch drivers are sensitive to low frequency audio and can reproduce these frequencies very well, but the higher the frequency, the less sensitive they become. The same is true for high frequency components like compression drivers which can reproduce the high frequencies well, but not the mids or lows. For each component, this sensitivity is not linear; meaning that one input frequency above all others will produce the highest SPL output for the same input power. This is illustrated in Figure 1 which shows the three sensitivity curves for each component in a three way system.

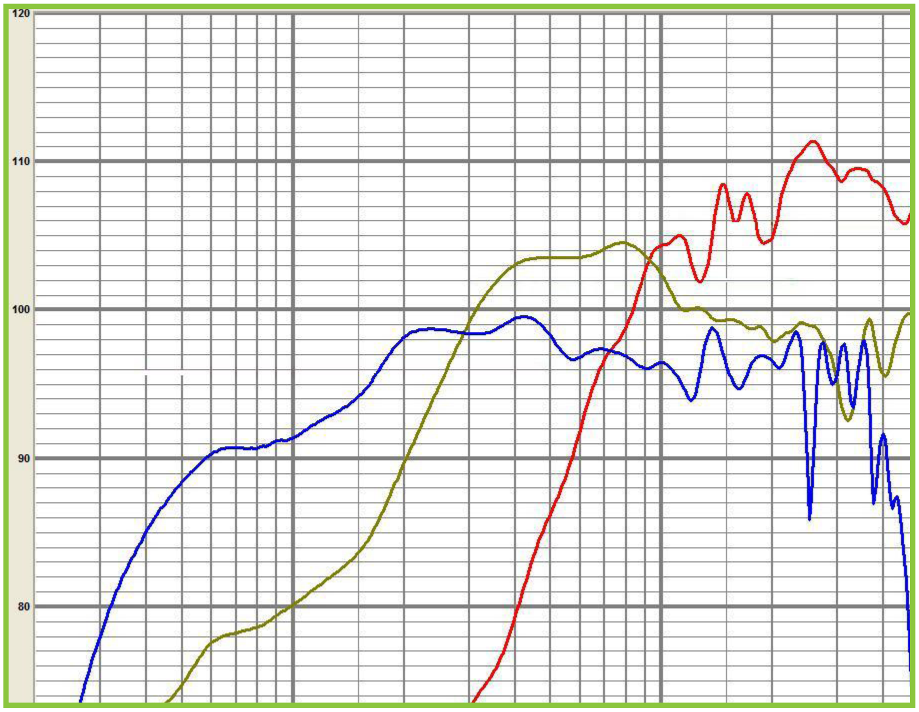


Figure 1: LF, MF and HF Sensitivity Curves

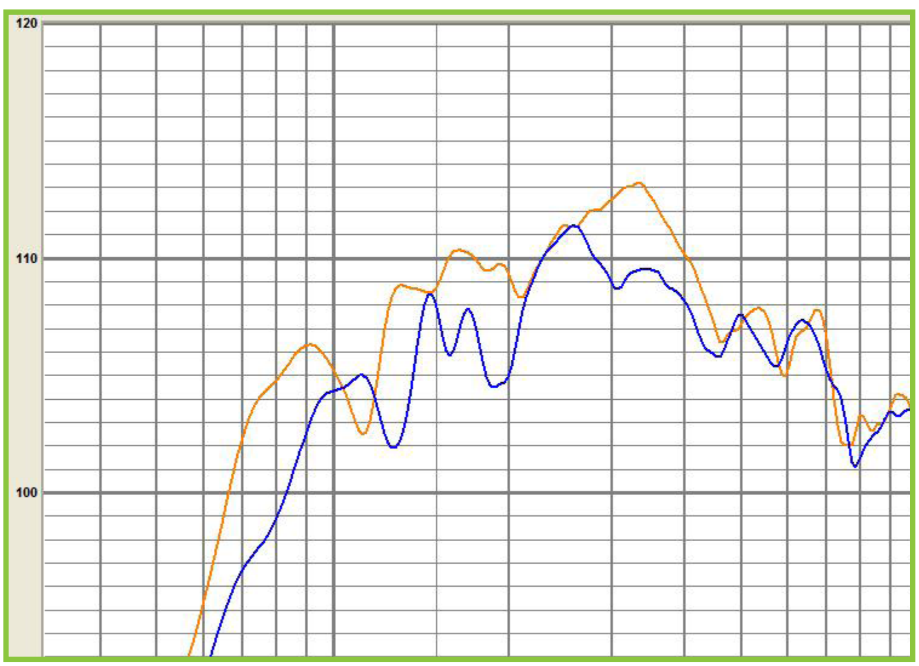


Figure 2: HF Sensitivity Curves for Two Different Systems

This most sensitive frequency for the system is usually in the compression driver between 2 and 3 kHz as can be seen in Figure 1; the highest curve is the red HF compression driver which peaks at about 2.6 kHz and is 12 dB more sensitive then the highest point of the blue LF curve.

The sensitivity curves depend not only on the device but also on the horn and enclosure to which it is mounted. So a single compression driver might have its highest sensitivity at 2 kHz when mounted to one particular horn enclosure, and at 3 kHz when mounted to another. This difference is due to the various acoustical phenomena of each particular horn and enclosure. Figure 2 shows a good example of the response of the same compression driver mounted to two different horns in two different systems.

The Calculated Maximum SPL is typically done at the most sensitive input frequency for the device. Normally, the most sensitive component of a multi way loudspeaker is the high frequency device. So if a Calculated Maximum SPL for a given powered loudspeaker is given as 133 dB SPL, this number is for a single frequency input signal somewhere between 2–3 kHz. In the example in Figure 2, the max SPL for the system with the orange HF response would be calculated using the peak of 113 dB at 3.3 kHz, and the system with the blue HF response would use the peak of 111.5 dB at 2.5 kHz, each combined with the power of the amplifier.

The problem is that this value provides information about a single frequency only. It does not provide any information about how loud the system will get with real world program material. If full bandwidth material (i.e. music) is played through the system, the driver itself may not be able to reach its maximum because it is not nearly as sensitive at the full range of frequencies it is reproducing compared to its peak sensitivity at that one particular frequency. Similarly, distortion or protective limiting may occur at other frequencies well before this high frequency driver reaches its theoretical maximum. This can be especially true in an unequally powered system where the low end might not have enough power to keep up with the highs. In this case, for music with extreme low frequency content such as hip hop or dance, the low frequency limiter will engage and the driver will distort well before the calculated maximum SPL can be achieved.

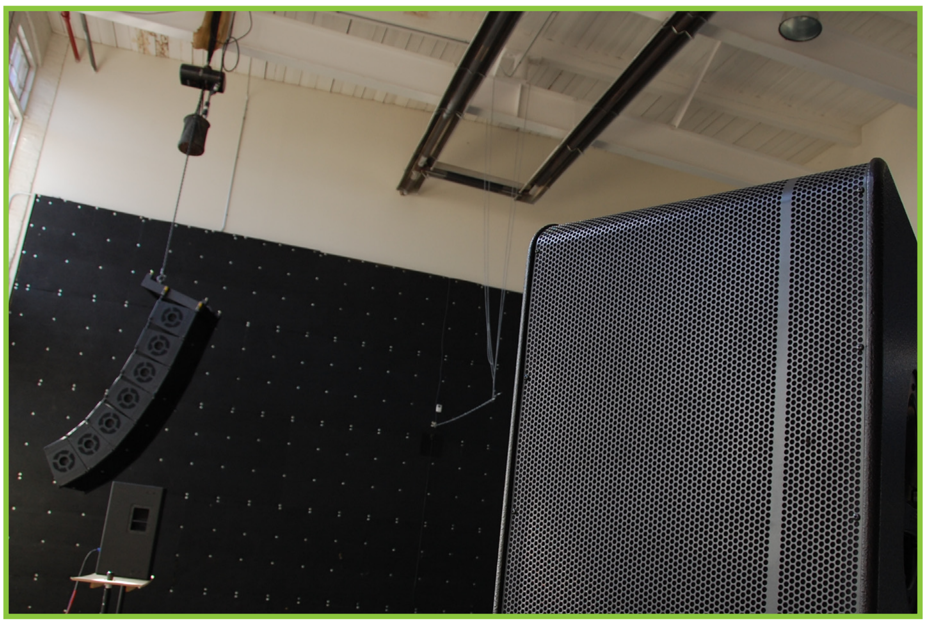
Finally, tuning or other system processing will affect the real world output of this system making it deviate from the raw driver sensitivity and thus, the measured maximum SPL will not be as reported, even at the most sensitive frequency. Unless the signal is a pure sine wave at the perfect frequency and no limiting or filtering is applied, the real-world SPL that can be achieved won't be anywhere close to the calculated value.

These types of problems will be illustrated in the case study below, but first, let's look at a better way to calculate the maximum SPL.

Measured Maximum SPL

Since the Calculated Maximum SPL method described above does not account for the full frequency range of a system, a better way to report the Maximum SPL is needed. The answer is quite simple: just measure it!

The acoustics gurus at EAW have just the place to make these high quality measurements, and they call it "The Pit".



"The Pit"

The Pit, with its large expansive volume, expertly treated acoustics and state of the art measurement system is the perfect place to do these tests, which actually are quite easy…for a highly trained EAW acoustics engineer. They turn up an input signal until the loudspeaker's limiters are kicking in, and then mute the signal. They then un-mute the signal to generate a burst of output before the limiters fully kick in, at which point the maximum SPL is measured.

The SPL measurements are conducted using pink noise as the source audio. Pink noise has equal power per octave. Band limited pink noise with a crest factor of 6 dB is used to better represent the long term spectral average of today's music. Crest factor is the ratio of the maximum level over the RMS signal level so a 6 dB crest factor accurately mimics music that is highly compressed as are many of today's mastered recordings. An RTA view of this pink noise is shown in Figure 3.

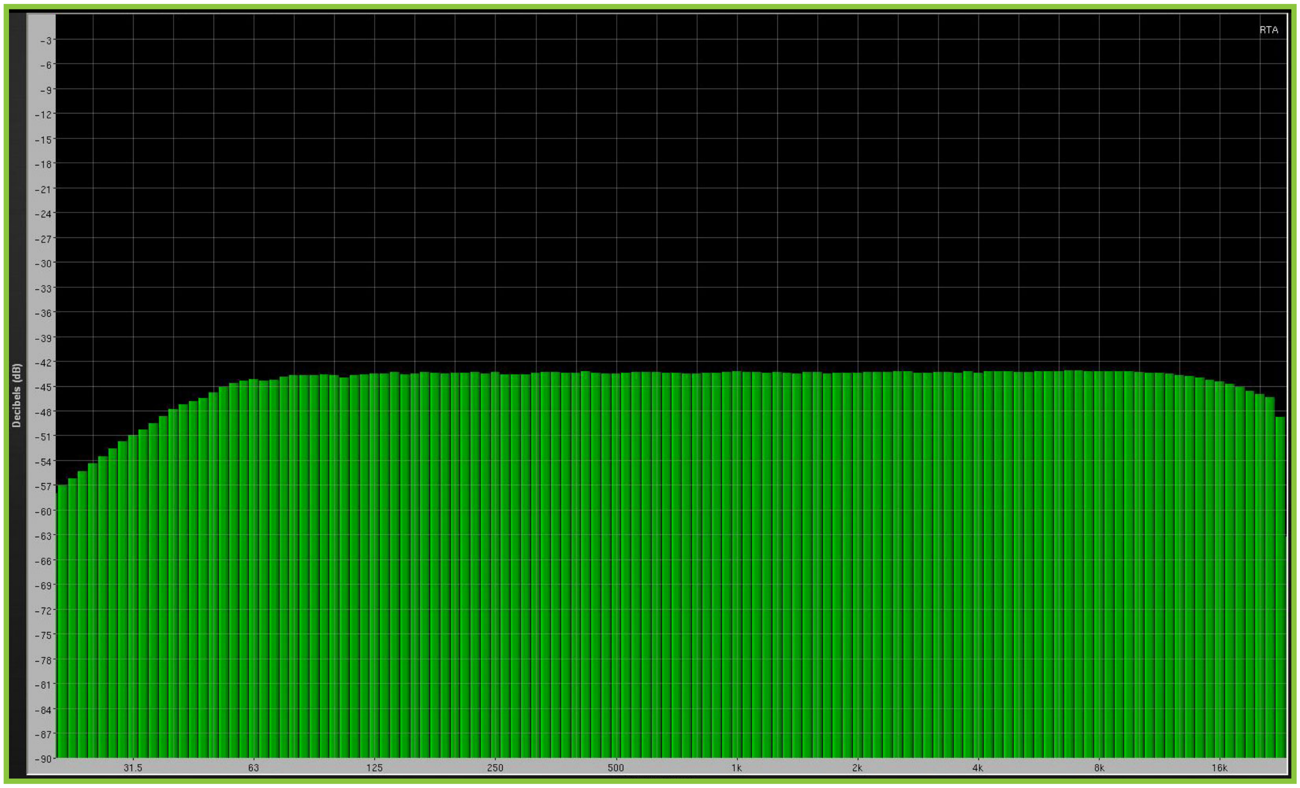


Figure 3: Pink Noise as seen on an RTA

Testing using pink noise provides an accurate representation of how loud a loudspeaker will get with a real world signal source, and thus is the best indicator of true Maximum SPL.

Case Study – HD Series vs Competitor

Both the Mackie HD Series loudspeakers and the corresponding models from a key competitor were measured in the EAW "Pit" with the following results:

	Mackie HD1521	Competitor 2-Way 15-Inch
Calculated Maximum SPL	135 dB	133 dB
Measured Maximum SPL Pink Noise Source[1]	125 dB	120 dB[2]

	Mackie HD1531	Competitor 3-Way 15-Inch
Calculated Maximum SPL	135 dB	134dB
Measured Maximum SPL Pink Noise Source[1]	126 dB	120 dB[2]

[1] – Pink noise band limited from 40 Hz to 5 kHz with 6 dB crest factor.

[2] – These numbers were not provided in the competitor specifications. They were measured by EAW engineering in the "Pit" at the same time as the Mackie HD loudspeakers.

For both the Mackies and the competition, the Measured Maximum SPL numbers are much lower than those for the Calculated Maximum SPL; this is expected and illustrates the misleading nature of the Calculated Maximum SPL.

Comparing the Mackies with the competition, it can be seen that while both models of a given type produced relatively similar Calculated Maximum SPL numbers, the Measured Maximum SPL with pink noise is drastically different. This illustrates how the Calculated Maximum SPL can be used to make a product look good on paper, while it doesn't apply in the real world.

Comparing the Measured SPL numbers with the pink noise source it should be noted just how much louder the Mackies are than the competition: 5 dB louder for the 2-way and 6 dB louder for the 3-way. Since a 1 dB SPL change is barely audible to the average human, 3 dB is a noticeable change, and 10 dB is perceived as twice as loud, the difference in SPL between the HD Series and the competition is a substantial real difference that should influence a customer deciding which speaker to purchase. Unfortunately, since the competition does not publish these numbers, the customer does not have all the information they need to make an informed decision. Instead they must compare a calculated SPL, which makes the competing products appear to have a much closer maximum output then they really do.

Conclusion

The above information illustrates how specs on paper don't always tell the whole story. Therefore, it is up to the customer to perform their own listening tests to find the right loudspeaker for them. Dealers should also look at this as an opportunity to provide the user with great service by having a completely wired listening room ready for the customer to compare loudspeakers using their own source material. If possible, an on site demo is even better.

It should now be clear to the reader that not all Maximum SPL specifications are created equal. Because of this, comparing specifications between two products from different manufacturers can be difficult. We have shown the deficiencies in the Calculated Maximum SPL specification and described the benefits of a true Measured Maximum SPL.

Unfortunately, not all manufacturers provide both specifications; some don't even accurately provide either of them. When reading spec sheets, one will notice that many different names are used to describe the maximum SPL of a loudspeaker. It will not necessarily be clear which method was used to generate the specification. Mackie strives to deliver clear and accurate specifications; the HD Series manual exemplifies this and provides both Calculated Maximum SPL and Measured Maximum SPL with clear descriptions of each.

It is hoped that this discussion has proved helpful. It should illustrate the need for customers to use their ears and not their eyes when making these crucial decisions. Only then can they can make an informed decision and find the right loudspeaker for their specific application. And remember, for a relatively small investment, anyone can purchase an SPL meter and find out for themselves which manufactures are really providing their customers with clear and accurate specifications.

References

EAW S3 - "System Specification Standard"

http://eaw.com/downloads/Details.html?u=Current_System_Specification_Standards

Audio Precision Handbook – Bob Metzler, Audio Precision, Inc.

Sound Reinforcement Handbook, second edition – Gary Davis and Ralph Jones