But This Goes to 11...

Welcome to the world of bass rigs.

About The Author
C. ALEXANDER CLABER

Alex first picked up a bass when studying engineering at university, and his quest for sonic perfection led him to found Barefaced Audio, while also leading The Reluctant, an alt-ska/funk outfit.

IN ASSOCIATION WITH

This column is brought to you in association with Barefaced Ltd who manufacture high-output speaker cabs for the gigging bassist. Barefaced have recently launched their new Big Baby and Big Twin cabs, the most accurate and extended range bass cabs ever made. An archive of previous articles plus a glossary of terms can be found at **www.barefacedbass.com**

If you read the very first 'But This Goes To 11 …' article you may recognise the curious diagram in figure 1. We didn't go into it in great depth at the time but there's quite a lot here that may help you understand what's really holding you back when trying to get great results from your bass rig.

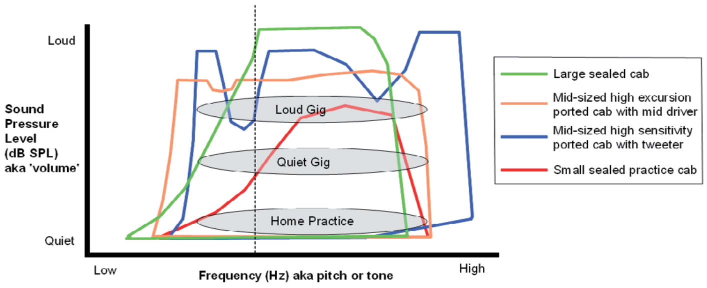

Fig 1 – Max dB SPL vs frequency

The lows: Excursion-Limited Power Handling

Trying to analyse power handling accurately is surprisingly difficult – loudspeaker drivers are simply rated by manufacturers in terms of the power they can handle before thermal failure but this doesn't actually relate to how much power they can handle before you hear them distorting or 'farting out'. The power a speaker can handle before distorting is linked to how much air the speaker can move (area multiplied by excursion), the sensitivity, the enclosure size and the enclosure tuning (if it's a ported box).

Everything Else: Thermally Limited Power Handling

It's only at lower frequencies that a speaker suffers excursion-related distortion before suffering thermal effects (compression due to voice coil heating and then thermal failure), so at higher frequencies the limiting factor is the power the speaker can handle continuously. In practice, music never has constant power, so it's reasonable to predict maximum output based on twice the thermal power handling (this is one of the reasons behind 'program' power ratings which are unfortunately more often used as a marketing trick to shout, 'WE HAS MOAR WATTZ' at the hapless consumer …)

Power Handling And Sensitivity

If you have two cabs with identical frequency response, but cab A is 3dB more sensitive in the lows (aka LF sensitivity) and across the rest of the frequency range too (aka broadband sensitivity), while cab B has twice the power handling, then cab A and cab B will have equal max SPL (loudness) both broadband and in the lows. The downside of cab B is that you'll need twice as much power to reach that loudness, while the downside of cab A is that it will be twice as large as cab B – physics will not be cheated!

The Unfortunate Relationship Between Low Frequencies And Cone Excursion

A few months back we discussed how for each octave you descend, a speaker has to move four times as far to produce the same output. So if a 10" speaker is moving 1mm at 200Hz (which would produce 111dB SPL @ 1m), then to produce 111dB @ 100Hz it would have to move 4mm (that's 4mm forward and 8mm back, so 16mm total). One of the most high-performance 10" woofers being used in bass guitar cabs has a maximum excursion of 4.2mm, so this would be taking it close to its limit. As Fig 2 shows, going higher reduces excursion demands and going lower makes them even tougher.

The Joy Of Ported Cabs

Intelligent use of tuned ports can make it a lot easier to get high max SPL from a relatively small cab. Many people believe that a port is there to let the pressure out when a speaker goes back so that the speaker can move more easily and produce more sound. In fact, the reality is totally different – the air in the port acts just like an additional woofer (like a speaker cone made of a fat lump of air rather than a thin paper membrane) which is powered by the vibrations from the actual woofers via

Freq.	Excursion (mm) for 111dB SPL @ 1m				Volume displacement (cc) for 111dB SPL @ 1m		
(Hz)	1x10" sealed	1x10" ported	2x12" ported	6x10" sealed	Sealed cab	Ported cab From woofer(s)	From port(s)
400	0.25	0.25	0.08	0.04	8.75	8.75	0
200	1	1	0.32	0.16	35	35	0
100	4	3.1	1	0.67	140	108.5	31.5
75	6.8	4.4	1.4	1.1	238	154	84
50	16	3.3	1.1	2.7	560	115.5	444.5
25	64	133	4.3	11	2240	4655	N/A

Fig 2 – Frequency, excursion and volume displacement relationships the air inside the cab. In a well-designed cab this 'additional woofer' is tuned to start producing output just as the actual woofers' output is dropping, thus extending the bass response. Furthermore, as the port starts producing sound it takes energy away from the actual woofers, thus reducing their excursion. Only once you get well below the tuning frequency does the port act like a simple hole letting air in and out in an uncontrolled fashion – at which point the speaker excursion goes through the roof!

The '1x10" ported' column shows the required cone excursion for that 111dB output if the cab has a port tuned to 45Hz. As you can see, the excursion rises with descending frequency but the rate of increase slows and then reverses as the port starts to take over the job of moving air. Once we drop well below the tuning frequency the excursion goes back up – but those frequencies are too low to be of use anyway. Note that within the useful spectrum the woofer only slightly exceeds its linear excursion ability at 75Hz, otherwise it's running nice and clean in the ported box, when in the sealed cab it would be distorting horribly as it tries (and fails) to produce 111dB as the frequency drops below 100Hz. The numbers in orange denote when a woofer starts to noticeably compress and distort your sound, while the numbers in red denote when a woofer is being asked to move an impossible amount!

Volume Displacement

The reason behind these cone excursion requirements is that you have to move air to make bass, and the lower you go the more air you need to move. This moving of air is termed 'volume displacement' and it's simply the cone area multiplied by the cone excursion. In the case of a 10" woofer the cone area is about 350 square centimetres, while the maximum cone excursion in this example is 0.42cm. So the volume displacement of that woofer is 350x0.42=147cc (cubic centimetres). To produce that 111dB output at the frequencies described you have to move the required amount of air. You can do that with a larger cone area moving a smaller amount or a smaller cone area moving a larger amount. And if you have a port to help, then as you approach the tuning frequency the port contributes more and more to the job of air moving. It doesn't matter what your speaker configuration is – that is the amount of air that has to be moved by speakers (and port) to produce that SPL at that distance at that frequency.

Sharing The Load

The more speaker area you have, the less far each woofer has to move to displace that air. Thus the '2x12" ported' column shows how much easier it is to get loud lows without distortion by having both more and larger speakers. The '6x10" sealed' column shows how you have to add a lot of cone area to get a decent amount of clean bottom from a sealed cab – there's a reason why very few small cabs are sealed and why the only really successful sealed bass cabs are very large indeed!

Maximum SPL Limits

If you look back at Fig 1 you may spot the effect of these excursion limitations. The two sealed cabs shown exhibit a gentle roll-off of max SPL from relatively high up in the bass region – this is because the speakers are reaching their Xmax due to the quadrupling of excursion with the halving of frequency problem! On the other hand, the two ported cabs exhibit a dip in max SPL as the woofers start to run out of excursion, but then the max SPL starts to rise as the port begins helping out. Then once you drop a bit below the port tuning frequency the max SPL drops very rapidly as the port starts acting like a big air hole rather than a tuned 'Helmholtz Resonator' and the woofer 'unloads'. You may have also noticed that the 'blue' cab is tuned higher than the 'orange' cab (both the dip and the 'unloading' happen higher up), and that the 'orange' cab's high-excursion woofers mean the woofers can move more air before distorting.

And On The Gig?

1. If your sealed cab is struggling, cutting the lower bass will help reduce excursion demands.

2. If your ported cab is struggling, cutting the lowest bass (below the tuning frequency) and the upper bass (before the port starts helping much) will help reduce excursion demands.

3. If you don't have PA support you have to move all the air to make the lows happen – you need plenty of volume displacement if you don't want to have to fake the bass!