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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.

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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

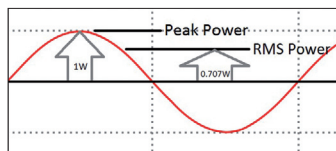
But This Goes to 11...

Welcome to the world of bass rigs.

What Exactly Is RMS Power?

Technically this isn't correct terminology, but as 'watts RMS' are used in the European standards we're stuck with them. Regardless, the crux of the matter is that power in music is never constant – if the voltage doesn't vary then you won't hear any sound because music is made up of pressure changes in the air and you won't get them from a loudspeaker without voltage changes. And if voltage isn't constant then neither is power! However, peak power ratings aren't terribly useful because they're not a great indicator of real-world performance, so we have to use average ratings and the way to get them is to multiply the square root of the mean of the voltage squared with the square root of the mean of the current squared. That sounds quite complicated, but the reason is that the mean (average) voltage of a sine wave is zero because half the wave is positive and half is negative. Square the voltage and it all goes positive, then square root the mean to get the values correct. Ditto for current. And so we have our RMS power thing.

Fig 1 – Peak vs RMS Power



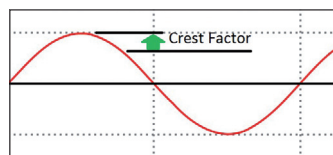
You may have now put two and two together and realised that your amplifier can thus deliver more power than it's rated for – because if you're calculating average power and the alternating wave passes

through zero, then the peaks have to be noticeably higher than the average. In fact, as amplifiers are rated with a sine wave the peak power has to be at least 1.414 x (ie sqrt2) higher than the RMS power.

Crest Factor – It's Not About The Whiteness Of Your Teeth!

Therefore, if we compare the peak and average voltage of a sine wave the ratio is 1.414:1, thus the peak and average power is 2:1, or in audiospeak 3 dB. We call this ratio the 'crest factor', and it describes the ratio of peak to average height of any wave – so it can be applied to ocean waves too. If a tsunami happens on an otherwise still day then the crest factor will be huge, while a stormy day may exhibit a very large average wave height but the largest waves may be little larger than the typical waves, hence the crest factor is low.

Fig 2 – Crest Factor



So how does this relate to playing bass guitar (or double bass)? Well, if we take a double bass and bow quarter notes fortissimo, then the average level will be high but the peaks will be little louder than the average so the crest factor will be low. Likewise, if we play steady but loud 8th notes fingerstyle on bass guitar then the crest factor will be low. On the other hand, if we play just one very loud slapped note once every couple of bars then the crest factor will be very high

– the average level will be close to zero due to all the muted sound while the peak on the slap may take your amp right to its limits.

The Joys Of Processing

Recently I had the fun of using some of our Big Series bass cabs as a rather fine PA system playing recorded music (in this case mostly drum 'n' bass). These cabs are not hugely efficient (trading off sensitivity for bass depth) but, despite that, a handful of cabs reached deafening club SPL in a fairly large venue without being driven remotely hard. Here's why: let's say that the amp that was driving them produces 1000 W/ch into 4 ohms and conveniently (often the case with PA amps) has a ladder of LEDs on the front showing how much power it's producing. One LED for -20 dB, one for -10 dB and one for -3 dB. Once things start getting loud the -20 dB LED stays on almost constantly and the -10 dB LED flickers frequently. The -3 dB LED never lights. To put this in perspective this means that the system is almost continuously putting out between 20 W (-20 dB from 2000 W total power) and 200 W (-10 dB from 2000 W) and frequently putting out more than 200 W, but never reaching the 1000 W half-power point.

Take a bass guitar, play it through a clean preamp and this same amp and complement of speakers and turn things up until the -10 dB LED is frequently flickering. At this point the -3 dB LED will also be flickering occasionally (and if there's a clip LED that might light now and again) and it will be loud and thunderous, but no one would say it's as loud as that recorded music. Then

get a compressor and use it to squish down the peaks of the louder notes from the bass guitar and you'll notice that you can turn things up more without any more activity from the -3 dB LED. Then add a soft limiter before the compressor, tweak the compressor further and you can turn things up even more. At this point the -3 dB LED is never lighting, yet the bass guitar is starting to sound almost as loud as the recorded music with similar -10 dB LED activity. For the final step stick an overdrive pedal in front of the soft limiter and you'll be able to get even more loudness without the -3 dB LED lighting – in fact this tone might be so squished that it sounds even louder than the recorded music at a similar peak level.

The key point in these five examples (recorded music, clean bass guitar, compressed clean bass guitar, limited and compressed clean bass guitar, limited and compressed overdriven bass guitar) is that despite all having relatively similar peak levels, the average level is much higher for the heavily processed recorded music (the vast majority of recorded music has significant compression and limiting applied during mixing and mastering) than for the unprocessed clean bass guitar, and as more compression is added to the bass guitar then the greater the average level for a given peak level. Adding overdrive (or distortion or fuzz) adds yet more compression to the sound (because it works by clipping off the peaks of the waveform), hence the average level increases further. In other

words by compressing the bass guitar we've decreased the crest factor.

What On Earth Is The Point Of All This?

Last time we investigated the power distribution of a typical bass guitar and what happens when you clip that signal. Our main point was that clipping increases the proportion of power in the high frequencies, and that although this is a serious issue with PA systems it isn't an issue with clean bass guitar because there's so little power up there to start with. But if we start running our bass through various effects most of them will add extra mid range and treble energy, especially overdrive, distortion, fuzz and synth pedals. If you then run those signals with greater treble content through an amplifier that's clipping, you'll further increase the treble energy and that's when tweeters start complaining. Fortunately this usually sounds pretty nasty, so most players will back off on the treble or volume before things go pop, but this isn't always the case, sadly ...

Loudspeakers And Power Handling

The main established method of determining the power handling of a loudspeaker is to play bandwidth-limited (this means removing the low frequencies which would cause overexcursion and remove the high frequencies which the speaker can't reproduce) pink noise (which is like white noise but with decreasing power

density as you go higher in frequency so it more closely matches real music) through it with a crest factor of 6 dB. This means that the peaks are four times the average level. So a loudspeaker rated at 500 W will have withstood being driven by a 2000 W amplifier so hard that the amplifier almost clips on the peaks, yet averages 500 W continuous power output over a number of hours, without thermal failure. This doesn't take into account how far the speaker can move without distortion or damage, which is the main limiting factor with bass guitar, but we don't have space to discuss that here.

Clipped Signals And Crest Factor

Last time round our main concern regarding clipping was how it changes the distribution of sound energy, skewing it towards the high frequencies. This was because we were looking at more typical, relatively clean and relatively uncompressed bass guitar sounds which exhibit very high crest factors. This high peak:average power ratio means that an amp which is frequently but lightly clipping is unlikely to sustain even 1/8 (12.5%) average power despite hitting full power (100%) repeatedly. Consequently the voice coils in our loudspeakers will not overheat unless the amp is vastly higher in power output than the speakers are rated to handle. However, if we take a signal with a much lower crest factor, such as a distorted bass sound, and then push that through an amp which is

clipping (thus further lowering the crest factor) it becomes much easier to reach a high average power level and thus overheat voice coils.

Overexcursion Issues

When you push a speaker too hard in the lows it overexcurses, causing increased distortion and compression. Continue with this and you can cause damage to the speaker. Fortunately, with clean bass sounds this is pretty obvious and a good warning sign to back off the volume or the bass knob. However, with dirtier bass sounds it can be hard to detect the difference between a deliberately grindy pedal/amp or distressed loudspeaker!

Bass Rig Power Matching Rule Of Thumb #2

If you're someone that likes messing with serious dirt and effects, then it's wise to use a larger rig than if you were playing with a clean sound in the same band, and wise to use speaker cabs with power handling similar to or greater than your amp's output. If your amp is rated at significantly more power output than your speakers can handle (like twice as much) then you could potentially overheat your speakers without pushing your amp into clipping. Using effects-heavy sounds with high-power amps pushed to clipping with lower-powered cabs can result in the magic smoke being released, which is never good!

'If we start running our bass through various effects most of them will add extra mid range energy, especially overdrive, distortion, fuzz and synth pedals.'