TC Electronic bass amp power rating & Active Power Management

About this document
This abstract outlines the power rating used on TC Electronic's bass amps as well as background and basics of our Active Power Management™ first introduced on the RH450 Bass amp.

What watt?
When rating an amps' power handling there are number of factors that need to be included, i.e. voltage, time, crest factor of the source signal and a number of other technical parameters. However to most bass amp users how it is heard and experiencedx is more important than how it measures – in other words, it all comes down to sound and loudness.

In bass amps specifically, there are very obvious differences in the perceived power handling of the two most classic categories: Tube- and solid state- (transistor) amps. In order to understand why this is, we need to take a quick look at the dynamics of a typical bass signal as well as how our ears respond to sound.

Bass signals and Dynamics
The average signal of a bass has a very wide dynamics span that ranges from a short and very high peak at the stroke of the string and quickly dropping to a significantly lower level at the sustain of the note played. This is known as the 'crest factor' and describes the ratio between the highest peak and the average energy (ratio between peak and RMS (root-mean-square) of the signal. Typically bass signals have a high crest factor of 10-15dB depending on playing style (fig. 1).

For reference, a 3dB change equals double output power and vice versa – in other words a 6dB difference between highest peak and sustained notes translates into quarter power in difference.

Figure 1: Bass signal sample

Human ear response
The human ear, being fairly slow in response, pick up on the average level of sound rather than short term peaks. In other words the level, or loudness, that we experience rarely has to do with the peaks, but is tied closely to the average level, or energy, of a certain signal.
In the case of bass signals, this means that it is not the actual stroke of the string, but the sustained note that we determine the perceived loudness by (fig 2).
Using a 12dB crest factor bass example, this means that the peak will be sixteen times as the average (RMS) signal, or opposite, the loudness perceived by our ears is sixteen times lower than the maximum peaks of the signal.
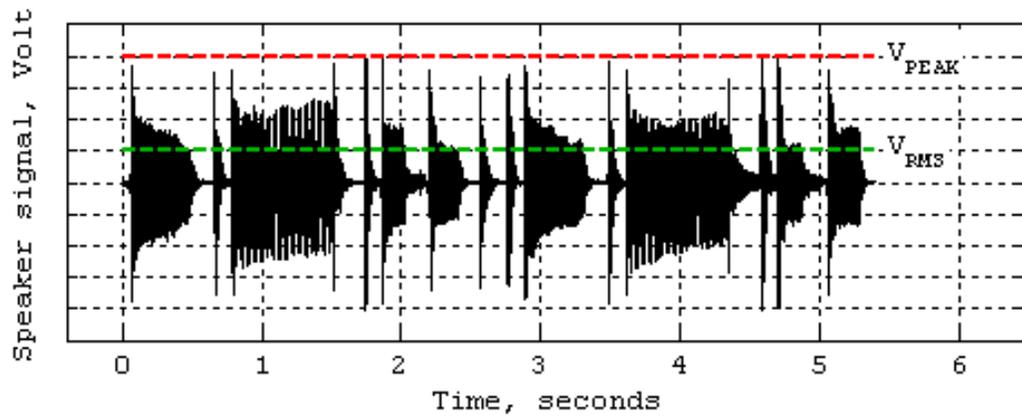
Figure 2: Bass signal with approximated RMS marking / perceived loudness, 12dB crest factor

Solid State Amps

Most solid state amps have a very clean and fast response time in the amplification but also a sharp edge of going into distortion when reaching its maximum performance level. The distortion created when the amp reaches its clipping point is very rarely desirable and most users prefer to not ever experience that in their amp.

With the dynamics of bass signals in mind, this means that a transistor amp has to be able to cleanly amplify very high peaks in order to reach a decent perceived loudness or power level without distorting.

Using the 12dB crest factor example again, this means that an 900w amp plays back the transients or peaks cleanly at its max., but because of the high crest factor of bass signals, the average loudness and power is more likely to be perceived as 56w by the listener (12dB down from the peak values) (fig.3).
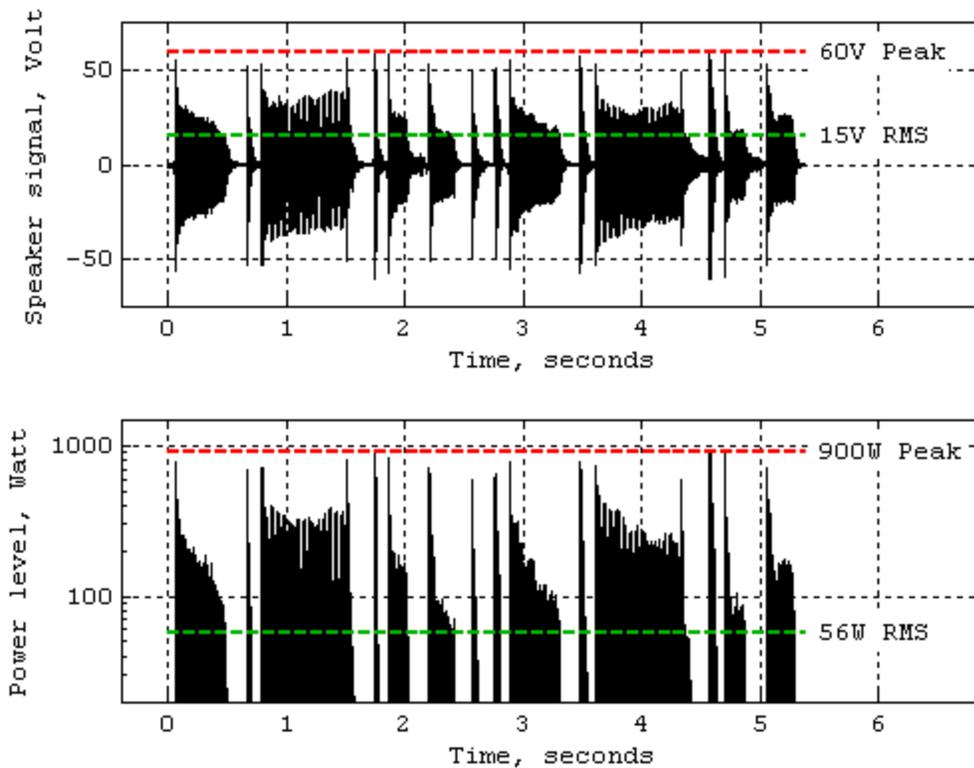
Figure 3: Transistor: Actual vs. Perceived power, crest factor 12dB

Tube Amps
The nature of tube amps is very different from that of solid state amps. Rather than suddenly hitting the distortion point, tubes gradually go into saturation and tend to 'round off' signals in a very soft way when getting to its maximum performance. The overdrive created by tube amps is quite pleasant to our ears and is known by many as a central part of the highly complex 'tube sound' that have been pursued in many bass amp designs.

Again, looking at bass signals, the gradual saturation of tubes essentially 'compresses' or limits the high peaks of the bass with only little resulting overdrive thereby altering the original crest factor to become quite a bit lower than the original signal with a consequently higher perceived loudness at a lower power rating – this is a quite known effect by many users, usually referred to as the difference between 'transistor watts' and 'tube watts' (fig. 4)

In the example below the 500W tube amp has reduced the peaks, and hereby the crest factor, also achieving a perceived level and power of 56W RMS.

Effectively this means that the 500w tube amp is perceived to have more power than the 900w transistor amp by the bass player even though they are vastly different in the actual power measurable.
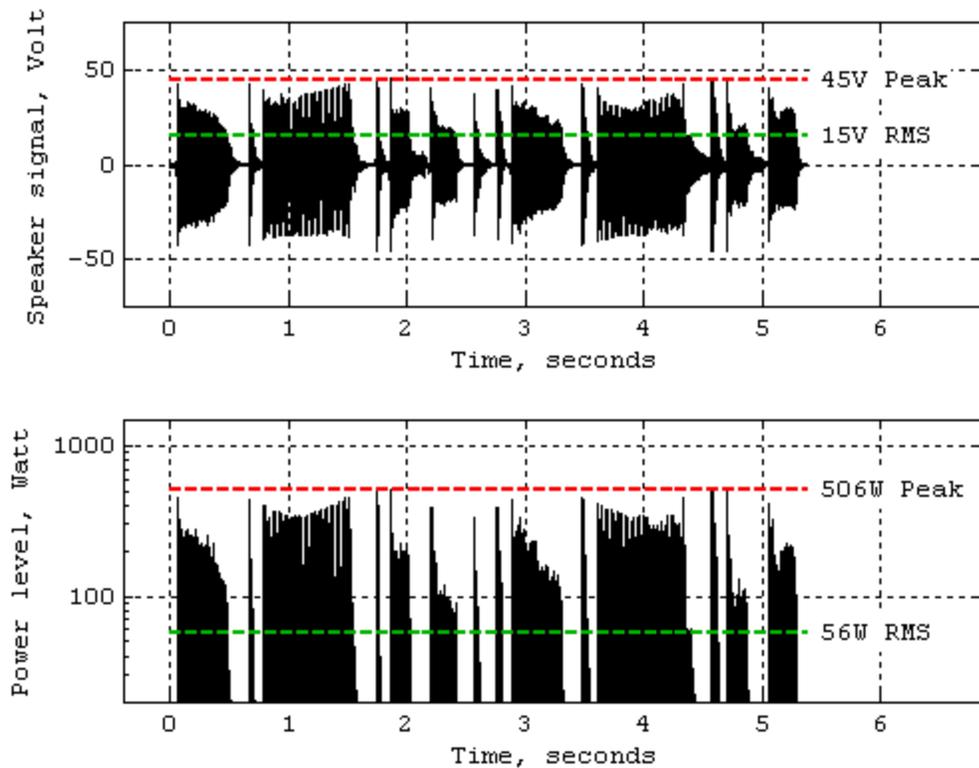
Figure 4: Tube amp: Actual vs. Perceived power

TC amp designs

When TC Electronic set out to design a bass amp range, we were highly inspired by the tube designed amps, particularly the sound and response created by the above mentioned 'tube compression'.

In order to understand where our amps ended up and how they perform, we need to take a step and look at the overall power design of our amps first.

RH450 Power design

Using the RH450 as an example of our designs, we first looked at the power supply and power amp design parts.

Starting out with the PSU section, there are numerous considerations as for life time, peak reservoir, heat development, choice of technology etc.

In the case of RH450 we choose a switch mode power supply design with a long term power performance of 250watts, backed by a peak reservoir carefully matched to reach 450 watts under terms of the crest factors of bass signals as described above

Figure 5 outlines a very simplified example of how a water analogy may be used to explain how the power source, peak reservoir and general power flow are combined:

water flow = power source
RMS power
peak power
thermal design

Volumen = capacitor size = energy stored
water level = volt available

water flow = power drain (Volt^2/Ohm)
peak power and time

250W

½*C*V^2

up to 1000W peak

Fig 5

Even though the ground water pump can only pump 250 liter/seconds, the train can still be filled up with say 1000 liters/second, as long as the train does not arrive too often.
Similarly, a power supply with the right peak reservoir will be capable of feeding an amplifier with sufficient power as long as the power requirements are matched to the signal source being amplified.

On the power amp side of things, we chose an amp capable of 450 watts (20ms burst @1kHz) (fig. 6).
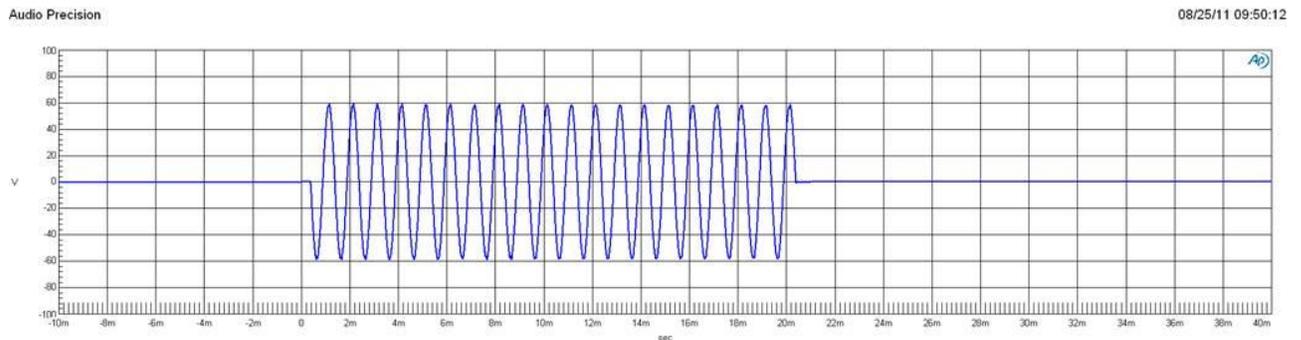

Fig. 6

This Audio Precision measurement shows a 1kHz sinus burst (20 ms) that have a peak value of 60V, corresponding to 42.42Vrms → 450W in 4 Ohm

However, as mentioned in the 'Solid state amp' section, designs like these have inherent challenges when it comes to their maximum performance handling, in particular when being concerned about how it sounds.
To meet this challenge we therefore decided to combine our PSU and Amp solution with what we call 'Active Power Management'.

Active Power Management™
Active Power Management™ is inspired by the nature and response of tube amps and is in essence an adaptive part of the amp that actively reacts to the source signal.
Active Power Management™ is controlling an integrated circuit that kicks in when the amp gets close to its maximum performance and starts to compress and limit the peaks of the bass signal as well as pulling up the smaller signals similar to the way a tube amp would perform.

The result of adding the APM to our amp design was significant in multiple ways.
On the listening side of things, we managed to produce an amp that behaves very much like a tube amp in the sense that it creates a similar 'tube compression' sensation by reducing peaks and pulling up lower signals, achieving performance that matches the ear sensitivity discussed earlier.
What's more, in i.e. our RH450 this means a higher energy output density than that of a conventional 500 watt solid state amplifier.

On the measurement part of things, we had to sacrifice. In order to give the APM room to work and guarantee no hard clips, opposite of traditional solid state designs, we chose to limit the max. output peak voltage to 46V.

The differences between the two different approaches can be seen in the comparison of the RH450 and a traditional 500W solid state amp (fig. 7).
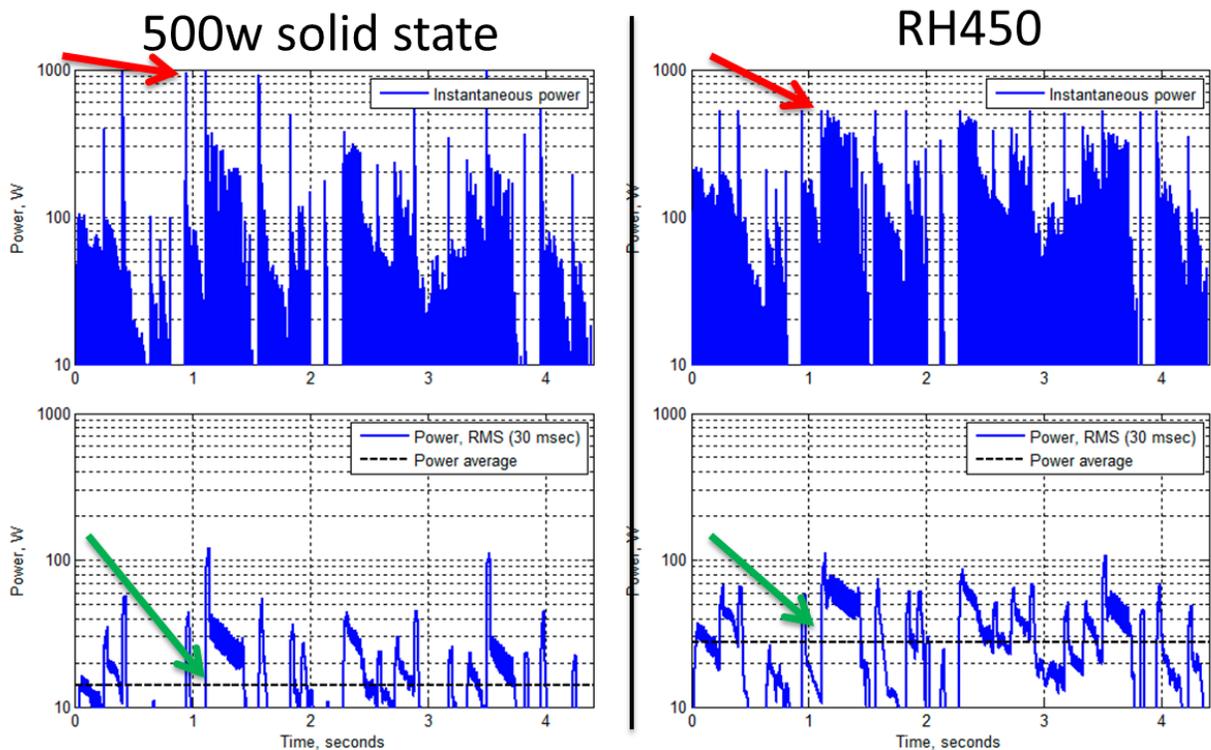

Fig. 7

The comparison between RH450 and a 500W solid state amp clearly shows how peaks are higher on the solid state amp (red arrows), while average energy and density is higher on the RH450 (green arrows).

The difference between the raw power module of RH450 with no APM and and APM active: 60V vs. 46V or 450W vs. 236W.The difference is sound is drastically different as the 'No APM' setting is prone to hard clip, while the APM active sound will guarantee no hardclipping due to its 'tube' nature, while pushing out the higher long term energy density.

Power ratings on TC amps

Based on our findings in both APM, power design and the response of the human ear, the power rating of the TC amps become somewhat different than that of traditional designs.

There are numerous ways of expressing exactly how an amp performs based on frequency content, time, input signal, output impedance etc etc.
We have chosen to label our amps based on the power section inside each amp model as well as mentioned the maximum peak (maximum instantaneous peak power) achieved at minimum load of the respective amp models.
However, in order to avoid any misunderstandings, here are the background facts of amps' performance under various setup conditions:

+/- 60V = 450W
No APM

+/- 46V = 236W
APM active
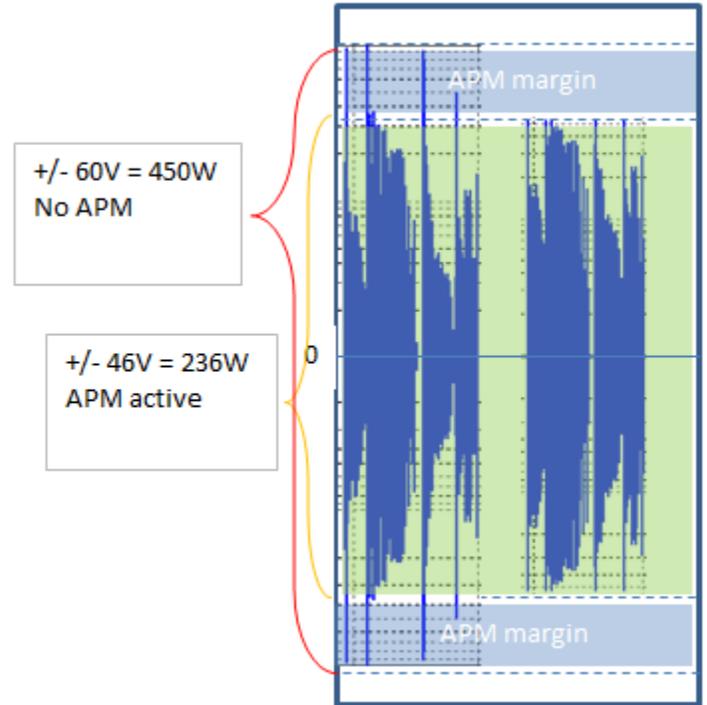
| Amplifier | Official rating | | Power Section stand alone | | | | Power Section w/ Active Power Management | | | | | | | |
	Power module Rating	Peak rating at min. Load	Output peak voltage	Burst 20msec / 1kHz W_RMS 8R	Burst 20msec / 1kHz **W_RMS 4R**	Burst 20msec / 1kHz W_RMS 2R	Output peak voltage	Burst 20msec / 1kHz W_RMS 8R	Burst 20msec / 1kHz **W_RMS 4R**	Burst 20msec / 1kHz W_RMS 2R	Min. load	Peak power at min. Load	Long term W_RMS 8R	Long term **W_RMS 4R**
BH500	500W	1000W	60V	225W	**450W**	n/a	51V	162W	**325W**		2R	980W	225W	**250W**
RH450	450W	800W	60V	225W	**450W**	n/a	46V	132W	**264W**		2,66R	800W	225W	**236W**
RH750	750W	1200W	77V	370W	**741W**	n/a	60V	225W	**450W**		2,66R	1350W	236W	**236W**
Blacksmith	1600W	3000W	110V	756W	**1512W**	3024W	86V	462W	**924W**	1848W	2,66R	2780W	462W	**924W**