

Line Level, Decibel Gain and Power Output

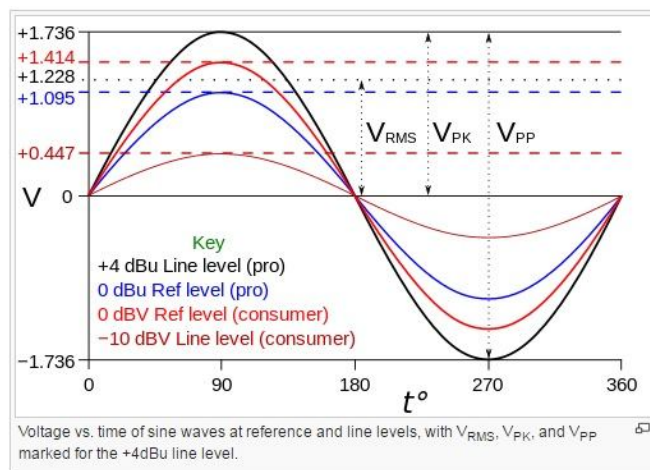
“Calculating Power Output for Small DIY Amp Boards”

Introduction

There is some confusion regarding small DIY amp boards and their output power. This paper aims to clear up that confusion and allow the reader to predict the power output they can expect.

Line Level

Line level comes in two forms: consumer line level and professional line level (aka balanced signal). Here we will deal with consumer line level that is prevalent in home electronics.



In the diagram, you can see a depiction of the two types of line levels using a sine wave. The diagram explicitly depicts the sine wave's peak level. In addition, you see consumer line level is specified at -10dB Line Level ($V_{peak} = 0.447$) and the 0dB Reference Level ($V_{peak} = 1.414$). The equivalent rms value of a sine wave is equal to the peak value divided by the square root of 2 (~ 1.414).

$$V_{rms} = \frac{V_{peak}}{\sqrt{2}}$$

Thus the 0dB Reference Line Level $\sim 1.0 V_{rms}$ and the -10dB level $\sim 0.316 V_{rms}$.

So which is it? Is a consumer level sine wave 0dB or -10dB? The VU meter 0 dB level corresponds to consumer level -10dB. This would lead many to conclude a standard line level sine wave should be at the -10dB level of $0.316 V_{rms}$.

However, music is different with a vast dynamic range and it is rarely as dense as a sine wave. So that VU meter set where the average music signal just touches 0dB on the scale is allowing for huge peaks in the dynamic range. For sine waves, there are no peaks in dynamic range. The signal is in steady state with a singular level.

We will see later that with common amplifier metrics, a sine wave input signal should be in the range of 0dB consumer line level.

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Decibel Gain

First off, decibel calculations for voltage and power are different. Here, we will be focusing on voltage. An amplifiers dB gain equates to the gain between its input voltage and its output voltage.

$$\mathbf{V_{out}/V_{in} = V_{gain} = 10^{(dB\ gain / 20)}}$$

For example: 20dB gain = 10x Vgain. 26dB gain = 19.95x Vgain (~20x Vgain).

Thus an amplifier with 20dB gain will multiply the voltage of an input signal by 10 times and a mplifier with 26dB gain will multiply its input signal by 20 times.

Maximum Power Output

In the absence of other restrictions (e.g., thermal dissipation limits), the “nominal” maximum output power for a single supply DC amplifier, in BTL mode, is dependent on its power supply voltage and the load impedance.

Most amp specifications of rms output power are specifying “nominal” maximum output power. That is, they are specifying the output power of a sine wave where the peak of the sine wave is at or close to the PS DC voltage for a given load. And that load is a resistive load. Any signal that tries to drive the output voltage higher than the rail voltage will clip the output signal leading to distortion. For example, an amp specification of 100w into 4 ohms at 10% distortion is specifying power out with some clipping of the output signal. Why do manufacturers use this type of rating? They do it to increase the impact of their marketing specifications vis-vis their competitors.

Ignoring minor losses in semiconductor circuitry, an amplifier’s nominal, maximum output power for a sine wave, without clipping, is:

$$\mathbf{P_{out} = (V_{rms})^2 / R = ((V_{peak})^2 / 2) / R}$$

For example: an amplifier with a DC PS voltage of 12v and a 4 ohm load we get $(12^2 / 2) / 4 = 18W_{rms}$. An amp with a 24v supply with an 8 ohm load can reach a nominal 36W_{rms} and 72W_{rms} with a 4 ohm load.

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Actual Power Out

Of course, to reach the nominal output power, the input signal must be increased enough so that the output signal is at the amp's DC rail voltage. This is where the amplitude of the input signal in conjunction with the amplifier's gain comes in.

$$\mathbf{V_{out} = V_{in} \times Gain}$$

We saw before that 20dB gain is a 10x gain and 26dB gain is a 20x gain.

We also saw that nominal maximum power output is:

$$\mathbf{P_{out} = (V_{rms})^2 / R = ((V_{peak})^2 / 2) / R}$$

If we have a -10db sinewave input (0.447V_{peak}) and 10x gain we get V_{out} = 4.47V_{peak}. This is well below the PS rail for a 12v amp much less a 24v amp. And at this output level, we'll only get 1.25W_{rms} into an 8 ohm load or 2.5W_{rms} into 4 ohms.

Under the same conditions but with 26dB gain (20x), we get an output voltage of 8.94V_{peak}. This translates to 6.2W_{rms} into 8 ohms and 12.4W_{rms} into 4 ohms. This is still below the capability of a 12v amp and much less than a 24v amp.

Now, if we use an input sine wave at the consumer 0dB Reference Level the input signal will be 1.414V_{peak}. V_{peak} out will be 14.14V_{peak} at 20dB gain and 28.28V_{peak} at 26dB gain.

This exceeds the DC rail of the 12V amp. Therefore, by controlling the input signal with a potentiometer, we can get maximum power output from the 12v amp and even drive the amp into clipping. For a 24v amp, you'll need the higher gain of 26dB to drive that amp to maximum and into clipping.

Conclusions

With a 12v amp with 26dB gain, it is possible to get maximum power out with a signal slightly lower than 0dB line level. At the other end of the spectrum, a 24v amp at 20dB gain will never reach maximum power out without a signal higher than 0dB line level.