Class B Amplifier Power Dissipation Calculations

Abstract

An amplifier takes DC input power, Pin, and turns it into signal power, Pout, in the speaker. Most High Fidelity Amplifiers operate in Class AB. This white paper covers power dissipation calculations for Class B amplifiers. For most purposes, that's close enough to what goes on in Class AB amplifiers, the difference being that we'll ignore quiescent current. If that statement is confusing, then just ignore it, and get ready to follow along with a simple calculator.

Input Power

The input power, Pin, is given by

$$Pin = Vps \cdot Ips$$

Where:

- Vps is the total voltage across the output stage of the power amplifier.
    - For an amplifier that uses positive and negative 36 volt supplies, Vps=2*36=72 Volts.
    - For an amplifier that uses a single supply (e.g. 0 and +72 Volts) and an output capacitor, Vps=72 Volts.
- Ips is the DC power supply current taken by the amplifier output stage. While we could measure it with a meter, the purpose of this white paper is to show how to simply calculate the DC supply current for sine wave outputs.

A bit of calculus (oh no!) can be used to find Pin, if you know Vrms, the sinusoidal RMS voltage across the load, RL.

$$Pin = Vps \cdot 0.45 \cdot \frac{Vrms}{RL}$$

Note that the input power, e.g. the DC power taken by the amplifier to produce a given output, is directly proportional to Vps and Vrms, and inversely proportional to RL. That says:

- For a given output voltage, halving RL (e.g. going from 8 Ohms to 4 Ohms) doubles Pin.
- For a given RL, doubling Vrms doubles Pin. We note the interesting effect that doubling Vrms quadruples the output power, which bodes well for increasing efficiency with increasing output levels.
- For a given Vrms, increasing Vps causes a proportional increase in Pin.

Output Power

The output power, Pout, is given by

$$Pout = \frac{Vrms^2}{RL}$$

Power Dissipated

The power dissipated in the amplifier, Pdiss, is just the difference between the input power and the output power. Pdiss is the power that heats up the amplifier and warms up the heat sinks. As a simple equation:

$$Pdiss = Pin - Pout\ ,$$

More usefully, using the previous results we can show that:

$$Pdiss = Vps \cdot 0.45 \cdot \frac{Vrms}{RL} - \frac{Vrms^2}{RL}$$

If the amplifier and the heatsinks get too hot, the amplifier can fail, or perhaps just shut down to protect itself. That's why these calculations are interesting. Let's get started.

Worst Case Dissipation

The question now arises...What value of Vrms causes the maximum Pdiss? That's the question that drives how hot your amplifier gets, and/or how large your heatsinks must be. Using a bit more calculus (oh no!) we can find the value of Vrms that causes the worst amount of Pdiss.

$$Vrms(worst\_dissipation) = 0.225 \cdot Vps$$

The worst value of Pdiss is then:

$$Pdiss(worst\_case) = \frac{Vps^2}{19.75 \cdot RL}$$

Example Calculations

Let's make this all make sense by doing an example.

The Dynaco Stereo 120 Solid State Amplifier has a 72 Volt[1] regulated power supply, so Vps=72.

The worst case dissipation for an amplifier channel occurs with and output voltage of: Vrms=0.225*Vps=16.2 Volts RMS.

The worst case dissipation, Pdiss(worst_case), with an 8 Ohm load is:

$$\frac{72^2}{19.75 \cdot 8} = 32.81 \text{ Watts}$$

The output power at that point is:

$$\frac{16.2^2}{8} = 32.81 \text{ Watts}$$

If we increase the output voltage from 16.2 volts to 22 volts RMS, the output power is:

$$\frac{22^2}{8} = 60.5 \text{ Watts}$$

In this case, Pdiss is:

$$Pdiss = 72 \cdot 0.45 \cdot \frac{22}{8} - \frac{22^2}{8} = 28.6 \text{ Watts}$$

It seems amazing, but it's true...we've almost doubled the output power, going from 32.81 Watts to 60.5 Watts, but we reduced the dissipation in the amplifier from 32.81 Watts to 28.6 Watts. That says the amplifier actually runs cooler even though it's putting out twice as much power!

It turns out that the efficiency of the amplifier increases with increasing output, reaching a theoretical peak of 78% just before clipping. However, if you're sizing heatsinks, it's the worst case power dissipation that you'll want to check.

[1] This is equivalent to an amplifier running plus 36 and minus 36 volt power supplies on the output stage.