SWITCHING POWER AMPLIFIERS and SWITCHING POWER SUPPLIES

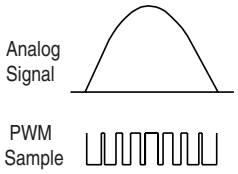
Is a switching power amplifier the same as an amplifier with a switching power supply?
No, they are two different things. A switching power amplifier processes the *signal*; a switching power supply processes the *AC mains power*. (The terms "Switch-mode" and "Switching" are used interchangeably.) A switching power amp is very efficient and produces little heat. A switching power supply reduces the weight and size of the amplifier. Let's look at each one.

SWITCHING POWER AMPLIFIER

How does a switching power amp work?
There are two basic types of power amplifiers: linear and switching. In linear designs, the output power transistors act like a variable resistance. When they amplify the incoming signal, their output is analogous to the input signal, only stronger.

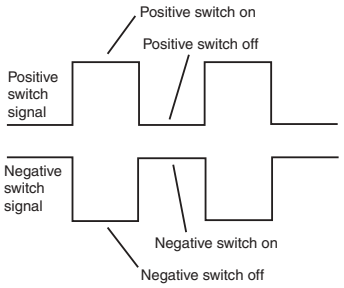
An alternative to a linear amplifier is a switching amplifier. In a switching amp, the incoming audio signal modulates the width of ultrasonic rectangular waves in the output transistors. These modulated rectangular waves are then low-pass filtered. The result is the amplified analog signal sent to the speakers. This signal processing is called Pulse Width Modulation or PWM.

Fig. 1 PWM Sampling of an Analog Waveform



You said that there are rectangular waves in the output transistors. How are those rectangular waves produced?
Remember that transistors can work either as variable resistors or switches. A switching power amp uses several pairs of power output transistors, each pair operating as switches in a push-pull arrangement. In Class D amps, one transistor of each pair turns on while the other is off, then they alternate. They switch at an ultrasonic frequency. That produces the rectangular waves. Class I (BCA) amplifiers switch in a more sophisticated way, but still create rectangular waves.

Fig. 2 The Switching Waveforms in the Output Transistors



How does the switching reduce heat?
When a transistor acts as an open switch, the current through it is ideally zero. When the same transistor acts an a closed switch, the voltage across it is ideally zero. Whether the switch is open or closed, the power dissipated as heat—current times voltage—would ideally be zero. The result is less power wasted, which means improved efficiency—theoretically 100%.

Current times voltage equals power. If either the current or voltage is zero, so is the power. Since the output transistors develop almost no current (when off) or no voltage (when on), they produce almost no power wasted as heat.

Why does a linear amp produce more heat?
In a linear amplifier, there is a voltage drop across the transistors and a current flowing through the transistors most of the time. This voltage and current dissipates power as heat, which is wasted energy that never reaches the speakers. The efficiency of a linear amp is about 30% on the average. It needs big heat sinks and fans to keep the amp cool. In contrast, a switching amp needs much less cooling. Its efficiency can be up to 80-90%.

SWITCHING POWER SUPPLY

Compared to a conventional power supply, what is the advantage of a switching power supply?
The heaviest part of a power amplifier has been its power transformer. It has to be large in order to work efficiently at the 50- or 60-Hz AC line frequency. But if the line frequency could be increased to, say, 100 kHz, the power transformer —and the amplifier—can be smaller and lighter. That's the principle behind the switching power supply.

How does a simple switching power supply work? (See Figure 3 below.)
1. The AC power-line voltage enters the power supply, and is rectified and filtered to DC.
2. The DC is "chopped" into pulses (converted to high-frequency AC) by transistor switches.
3. The ultrasonic AC goes through a lightweight isolation transformer.
4. The transformer output is rectified and filtered to the correct DC voltage for the amplifier.
5. The output voltage is then fed to the power-amp circuits.

The switches dissipate very little power when they are on or off, which results in high efficiency. This design uses ideally lossless components such as capacitors, inductors and switches. Also, the effective resistance of the power supply is low, which reduces power loss.

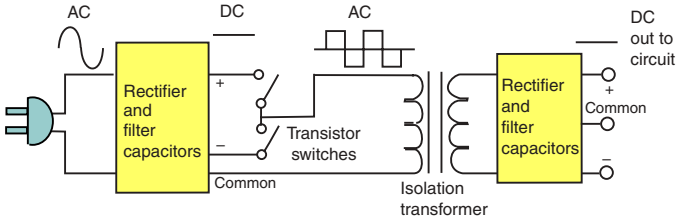


Fig. 3 Typical Switching Power Supply Block Diagram