AUDIO UPDATE

Efficiency and amplifier design

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An audio amplifier *of any design* can be considered a sort of complex electronic valve between the AC wall outlet and your speakers. The audio-signal voltages from the program sources serve as control signals that vary the much larger power-supply voltages and currents provided by your local public utility.

The power-supply section of an amplifier has the task of converting the AC supplied by a wall outlet to a direct current of the desired voltage and current capabilities. Limitations in a power supply's ability to deliver voltage and current ultimately determine the amount of output power available to drive speakers. Of course, another potential limitation is the amount of current that the output transistors can handle. But today's high-power output transistors are relatively cheap compared to heavy-duty power-supply transformers and heat sinks—and certainly less bulky.

Power supply performance

What demands do we make on a power supply besides that of converting AC to DC? Ideally, it should be able to instantaneously supply all the current and voltage needed by the output transistors to produce the desired output wattage in the speaker load. A standard—if not particularly cost-effective—way to achieve that goal is to build in a power supply designed to stand up under any signal contingency. That means a massive power transformer with heavy low-resistance windings (around an appropriate core) capable of supplying the needed current, one or more heavy-duty bridge rectifiers, and very large filter/reservoir capacitors that are kept charged to a high-voltage level to cope with transient peak voltage/current demands. A few audiophile amplifiers are built that way, and their owners take pride in the fact that they can't be lifted without risk of a hernia.

The operating theory of a conventional power supply is somewhat similar to that of the standard home hot-water heater. A large storage tank of water is maintained at a high temperature against the time that several family members might decide to take a shower and/or run both the dishwasher and the washing machine. To guarantee enough hot water reserve for several persons to shower comfortably (assuming they don't do it together), the storage tank would have to be bigger, the heating elements larger, and/or the water hotter. The need to hold large amounts of water at a constant high temperature despite the intermittent usage makes the typical hot-water heater a thermally inefficient waster of both space and fuel. There are high-efficiency, on-demand, tankless hot-water systems available on the market, but for some reason they've never become popular.

Toward higher efficiency

Supposing an amplifier designer set himself the goal of designing a more efficient and cost-effective power supply that would nevertheless provide all the power needed for musical contingencies: How would he go about it? In much the same way that some hot-water system manufacturers did: He would have the power supply "turn on" only when required, and to the degree that it is needed, rather than running continuously at full output. Such an approach has significant advantages. Much of the thermal inefficiency of conventional amplifiers arises from the fact that the power output transistors are required to handle the full potential of the power supply even when the amplifier is being driven to a very low output level, or when there is no output at all! Current flow through the output transistors creates the need for the large finned heat sinks that line the rear or side panels of conventional power amplifiers. The heat sinks radiate that wasted power and thereby protect the output devices against thermal breakdown and stabilize the operation of other circuit elements that are affected by high temperatures.

Super efficiency

Amplifiers with "smart" or tracking power supplies monitor the audio signal level and continuously adjust the power-supply voltage to the levels needed to support the required output level. There are several high-efficiency designs that use this technique. Soundcraftmen's "Vari-Portional" circuit was probably the first to reach the market. The Vari-Portional circuit uses a fixed-level, low-voltage power supply plus an "on-demand" signal-controlled high-voltage supply.

Because of music's low average signal level, the amplifier operates as a low-power unit using its low-voltage supply 90% of the time. This means that the dissipation (heating) of the output stage is substantially reduced, since dissipation is directly proportional to the voltage applied across the output transistors. And even when a momentary signal peak turns on the high-voltage supply, its moment-to-moment voltage level is raised no higher than necessary to handle the signal peak, rather than being constantly fully on as with conventional output circuits. Two other, smaller companies that use similar smart power supplies come to mind: QSC and Crest.

About 10 years ago, Bob Carver introduced a "magnetic-field" power amplifier that startled the audio world by its ability to produce a total of 400 watts from a 9-pound, 6½-inch cube. It included several innovative design concepts that both reduced the size of its internal components and increased efficiency to unprecedented levels. The unconventional "magnetic field" power transformer operates with a solid-state phase-controlled

Triac in series with its primary. The Triac controls the voltage reaching the primary of the transformer in the same way that Triacs in light dimmers adjust the voltage reaching a lamp bulb—except that it does so it under electronic rather than manual control. An isolating photocoupler sensing element responds to voltage variations at the transformer secondary caused by changes in power demand, and adjusts the phase angle of the Triac to allow more or less AC to reach the transformer primary. At the transformer secondary there are up to four separate bridge rectifiers that supply ±25, 50, 80, or 125 volts to the output stages, also depending on the signal level.

The extraordinary efficiency of the Carver design is due both to the varying AC input to the "magnetic field" power transformer and the to the varying levels of power-supply voltage, *both* of which are controlled by the moment-to-moment amplitude of the audio signal.

A final note: I've not meant to imply in my discussion that high-efficiency in amplifiers necessarily correlates with their sonic quality—any more than it does in speakers. But, as with speakers, if you can get efficiency *plus* all the other desired properties, then it seems to me that high efficiency (meaning reduced size, cost, and heat radiation) is obviously the way to go. **R-E**