POWER OUTPUT CHARACTERISTICS OF VACUUM TUBE AND SOLID STATE AMPLIFIERS

The ability of an amplifier to deliver its rated power into a loudspeaker load depends on the impedance match between the two. The advent of solid state amplifiers, which do not use multiple impedance output transformers, has brought to light a problem which has always existed with tube amplifiers as well, but in a slightly different aspect.

Vacuum tube amplifiers, because of the high impedance of the output tubes, require a transformer to match to the typical loudspeaker, and it is easy to include several "taps" for matching speakers of different impedance. Transistorized amplifiers, however, generally do not require an output transformer because the efficient matching impedance of a typical transistor output stage is some value between 4 and 16 ohms, or close to the nominal impedance of most speakers. A transistorized amplifier has a single optimum load impedance determined by its circuit design, and therefore is not able to deliver full power into a range of fixed load impedances, as is readily obtainable with a vacuum tube amplifier.

Loudspeakers are not fixed impedance devices, however. The rated impedance of any speaker or speaker system varies over its useful frequency range. The Electronic Industry Association specifies that the rated impedance shall be the minimum impedance over the speaker's useful frequency response, but even where the manufacturer adheres to this rating procedure, combinations of speakers in systems, and the settings of cross-over controls for midrange and treble balance may significantly alter the impedance characteristics. The minimum (rated) impedance of typical cone speakers usually occurs around 400 cycles, and the impedance may rise to several times the rated value at other frequencies, notably reaching its low end peak at the resonant frequency of the speaker-enclosure system. Since a speaker's impedance is not purely resistive, other factors also limit the speaker's ability to utilize the amplifier's rated power. Large multiple-speaker systems may appear as largely capacitive loads, just like a full range electrostatic speaker, and the electrostatic speaker may drop well below its rated impedance at some frequencies.

Because the load is not a constant impedance, no amplifier can deliver its full rated power into any speaker system at all frequencies. Tube amplifiers with multiple impedance output transformers can match several specific loads (but not simultaneously), and an impedance mismatch has a similar power limitation on any amplifier - tube or transistor. The Institute of High Fidelity has chosen 8 ohms as the standard impedance for rating power amplifiers. The Dynaco Stereo 120 amplifier has been optimized for about 8 ohms, where it can deliver its rated continuous 60 watts per channel across the 20 Hz to 20 kHz audio spectrum.

A transistorized amplifier which delivers a maximum of 60 watts into an 8 ohm load is limited by the mismatch to about 35 watts into a 16 ohm load at the same rated distortion. Lower load impedances present a different problem because they draw more current through the transistors than higher impedances. While a transistor amplifier can deliver more power into a 4 ohm load than into an 8 ohm load, if you are willing to operate the output stage at higher currents, good design dictates limiting the power output to prevent excessive current. The Dynaco Stereo 120 has a patent-pending protective circuit to prevent such damage. Because the current in the output transistors also increases at the frequency extremes at high levels, the amplifier's power output is limited by the protective circuitry at very low and very high frequencies with a low impedance load. Thus, while the Stereo 120 can deliver steady-state 60 watt power at rated distortion into 4 ohms in the mid-band long enough to make measurements, the protective circuitry restricts its measureable (long-term) power capability at the extremes. For example, the typical 60 Hz and 7000 Hz IM distortion test will show a sustained power of about 40 watts at 4 ohms at the rated distortion of 0.5%. Higher so-called "dynamic" or "music" power is available into 4 ohm loads at the frequency extremes.

Because the typical dynamic speaker has a rising impedance at the lower frequencies, the Stereo 120 can deliver more power at low frequencies into a "4 ohm" speaker than it can into a resistive 4 ohm load. For practical purposes, the Stereo 120 can deliver its rated 60 watts into the usual "4 ohm" speaker over a wider range than 60 watt tube amplifiers matched at 4 ohms.

To minimize problems of excessive current, some solid state amplifiers find it necessary to require the use of series resistors with 4 ohm speakers to prevent damage. This soaks up a high percentage of the available power and greatly diminishes the effective damping of the loudspeaker. The same problem exists with speakers (supposedly specially designed for transistor amplifiers) which include series resistors in order to present a more nearly uniform impedance characteristic. Dynaco feels that because the majority of 16 ohm speakers are significantly more efficient than the most popular 4 ohm speakers, it is of greater importance to most users to have the best match between 4 and 8 ohms.

As a matter of routine product development, Dynaco amplifiers are always thoroughly evaluated on AR-3s, as a typical dynamic speaker system; the KLH-9 as a full-range electrostatic speaker system; and JansZen Z-600s, as a combination electrostatic-dynamic speaker system. These speakers also run the gamut of typical impedances. When Dynaco amplifiers deliver optimum results with all of these, we can assume comparable performance with virtually any quality speaker made today.

It should be noted that transistor power amplifiers cannot be paralleled to obtain higher power output at useable speaker impedances. When they are paralleled, the same voltage will be available only at an output impedance which is too low for general speaker use, and there is risk of damage to the amplifier through interconnection of the two outputs. For higher power applications, the preferred procedure is to drive each channel of the amplifier with identical signals, and connect each output to a separate loudspeaker system.