Get more power with a boosted triode

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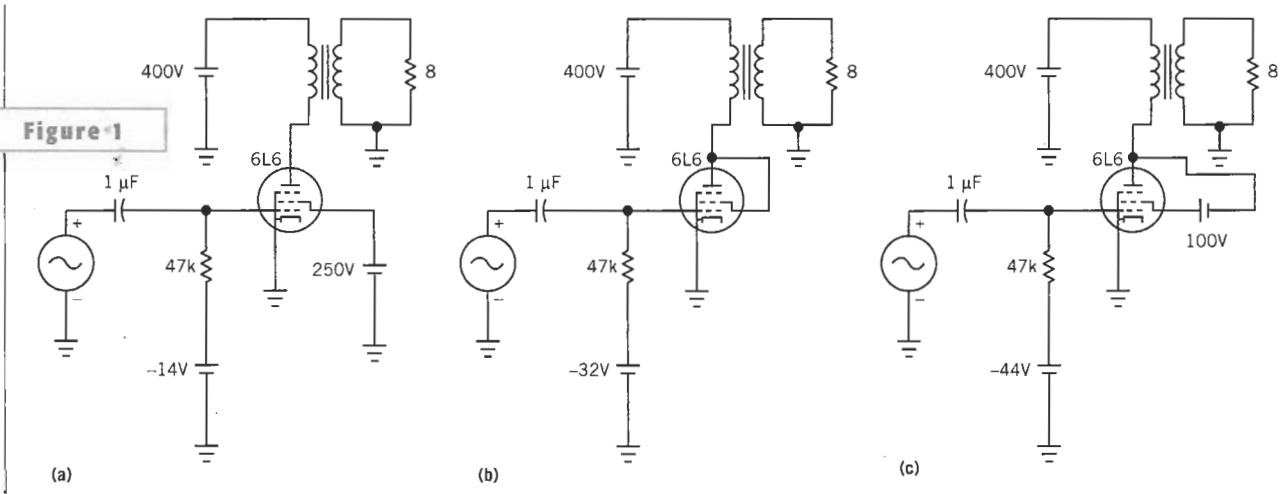
THIS DESIGN IDEA is a reprint of an earlier one that contained errors in graphics (**Reference 1**). Even though 6L6 beam-power tubes have been around for 66 years, they are still quite popular for use in electric-guitar amplifiers, and its cousin, the 6CA7 (EL34) power pentode, is a favorite among audiophiles. The developers of these tubes designed them for pentode-mode operation, and they deliver maximum audio power in this mode. On the other hand, many audiophiles prefer triode-mode operation and, until now, had to be content with a 50% reduction in output power. This reduction means that they require larger power supplies and twice as many expensive tubes to obtain pentode power from a triode amplifier. **Figures 1a**, **1b**, and **1c** show the 6L6 connected as a pentode, a true triode, and a "boosted triode," respectively. The boosted-triode configuration allows pentodes to produce pentodelike power while operating in a true-triode mode. To understand the operation of the boosted triode, it's useful to review some vacuum-tube theory. The 6L6 is a beam-power tube and has cathode, control-grid, screen-grid, suppressor-grid, and plate electrodes. The suppressor grid is actually a virtual suppressor grid provided by two beam-forming plates, but you can treat the 6L6 beam-power tube as a pentode. You can think of a pentode as an n-channel JFET with the following electrode functions:

- Thermionic cathode: source of electrons (corresponds to the JFET source);
- Control grid: controls the cathode current; operated at a negative potential relative to the cathode (corresponds to the JFET gate);
- Screen grid: electrostatically screens the control grid from the plate, thereby reducing the effect that the plate voltage has on the cathode current; operates at a

TABLE 1–PENTODE, TRIODE, AND BOOSTED-TRIODE PARAMETERS

Amplifier	DC plate current (mA)	Grid bias (V)	Grid swing (V)	Output power (W)
Pentode	75	−14	22	11
Triode	75	−32	64	6
Boosted triode	75	−44	88	10

Figure 1



A pentode (a) can deliver much more power than a triode (b), unless you use a boosted-triode configuration (c).

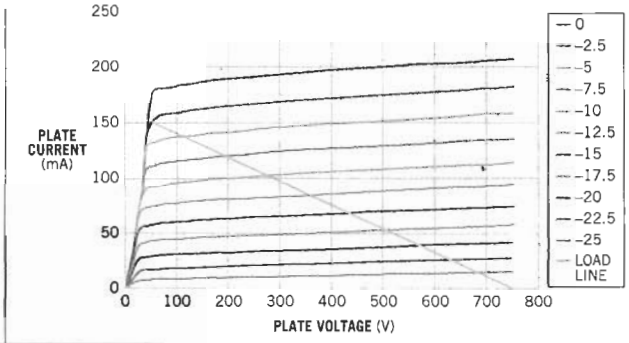


Figure 2

The load lines for a pentode show that the plate can draw 150 mA at a plate voltage of only 50V.

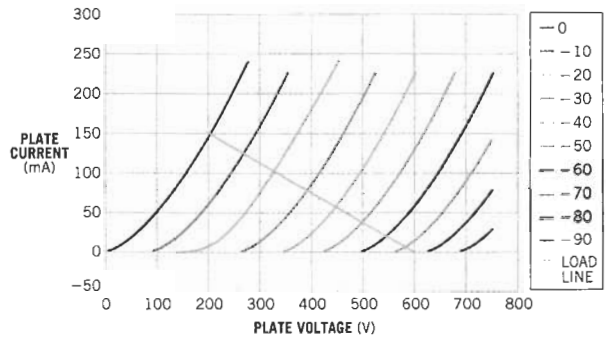


Figure 3

A pure triode needs 200V plate voltage to draw 150 mA.

positive potential relative to the cathode;

- Suppressor grid: prevents secondary electrons from leaving the plate and traveling to the screen grid; operates at the cathode potential; and
- Plate: collects the electrons (corresponds to the JFET drain).

Figure 2 shows the pentode's characteristic curves for control-grid voltages of 0 to −25V and a screen-grid voltage of 250V. Note the idealized load line and that the tube can draw a plate current of 150 mA at a plate voltage of only 50V. High voltage gain, high plate impedance, and high output power characterize pentode-mode amplification. By connecting the screen grid directly to the plate, you can operate the tube in triode mode. Low voltage gain and low output impedance characterize this mode. **Figure 3** shows how the triode curves differ from the pentode curves. The curves represent control-grid voltages of 0 to −90V. Note the load line and that, in triode mode, the plate cannot draw 150 mA at a plate voltage lower than 200V. This fact greatly limits its amplifier efficiency and power output. However, in spite of the limited output power, some people still prefer triode mode because they claim that it produces a superior-sounding amplifier.

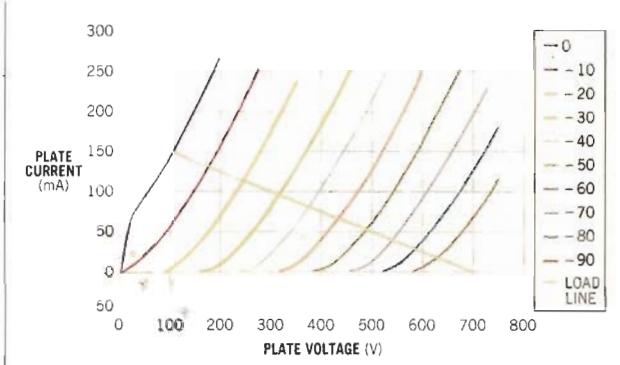


Figure 5 With a boosted triode, the plate can draw 150 mA with a plate voltage of 100V versus 200V for a pure triode.

For the boosted-triode circuit in **Figure 1c**, you simply add a 100V screen-to-plate power supply (**Figure 4**) to the standard triode-amplifier circuit. This addition shifts the triode characteristic curves 100V to the left (**Figure 5**). Note the load line and that the plate can now draw 150 mA at a plate voltage of only 100V, rather than 200V as with the pure-triode-mode circuit. You can obtain significantly higher power with boosted-triode amplification and still maintain the characteristics of triode amplification. In Spice simulations of three single-ended Class A audio amplifiers using MicroCap-7 evaluation software (www.spectrum-soft.com), the control-grid bias for a quiescent plate current is 75 mA, and the ac grid signal is just short of amplifier clipping. The transformer ratios provide a plate-load impedance of 5 kΩ for the pentode and 3 kΩ for both the triode and the boosted triode. **Table 1** details the parameters.□

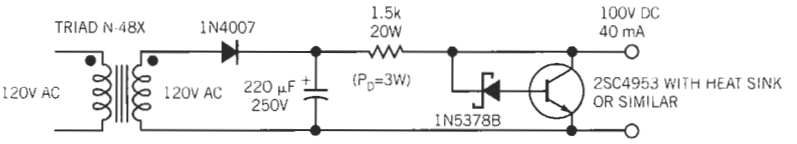


Figure 4 A 100V screen-grid power supply transforms a normal triode into a boosted triode.

Reference

1. Cuthbert, Dave, "Get more power with a boosted triode," *EDN*, April 3, 2003, pg 72.