Modify Power Supply To Enhance Performance

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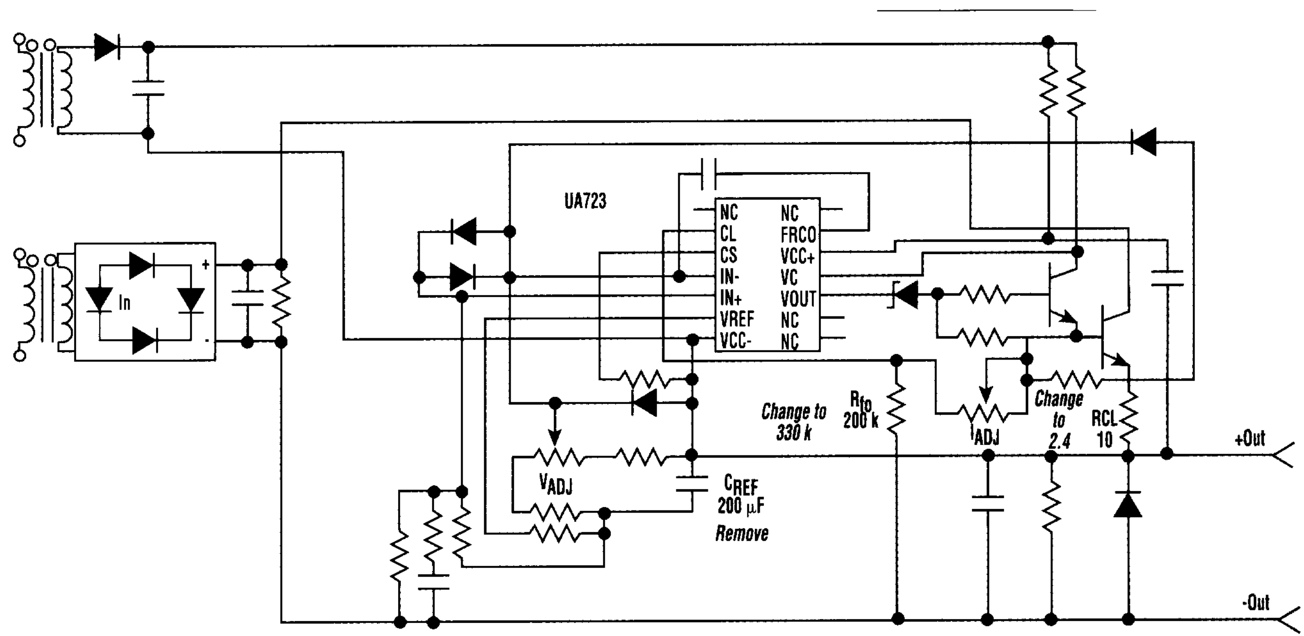
There are several sources of low-cost, open-frame, high-voltage power supplies that, in spite of their high quality, can use performance enhancements. Such power supplies, available from International Power, Power One, Condor, and others, range in output from 100 to 250 V and use an



1 **Enhancements (noted in italics) implemented into a typical power supply that uses a 723 regulator topology can boost performance. Included in the remedies are replacing the foldback resistor and the current-limit resistor and removing the reference filter capacitor.**

old floating 723 regulator topology to regulate their high voltages. The modifications discussed in this article apply to all the supplies menitioned above and to supplies of any manufacturer that use floating 723 regulators.

Figure 1 represents a typical schematic of these power supplies. Slight variations exist between the different models and vendors, but the basic schematic and components referred to in the article will be the same.

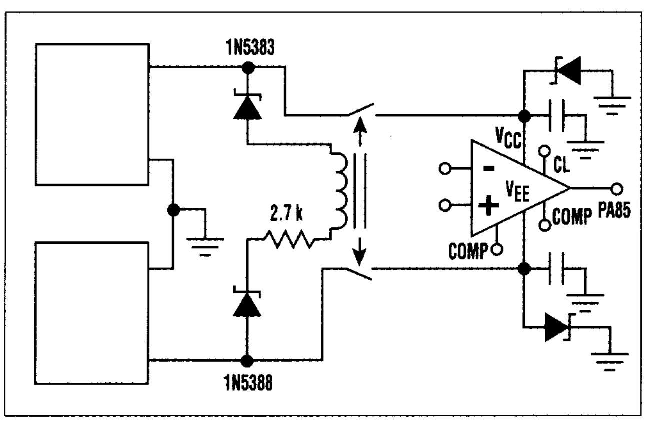
The first modification addresses output voltage overshoot. A certain percentage of these power supplies will exhibit an overshoot during power up of up to 350 V (the value of the unregulated input to the pass transistor). A simple cure to this problem is to add Zener-type transient absorbers, commonly called transzorbs, across the power-supply output. In most applications, that will suffice, but note that a typical transzorb rated to stand-off 200 V, like a 1.5-k E250, can actually break down between 225 and 275 V. Metal-oxide varistors or voltage-dependent resistors shouldn't be used, because they also have a softer knee.

The overshoot problem occurs because during power up, the 723 internal reference is required to charge a large electrolytic filter capacitor, usually about 220 μF. During the charging of this capacitor, the 723 error amplifier inputs are more negative than the negative power-supply pin of the 723, a common-mode violation of the error amplifier. Under these conditions, the 723 output goes hard positive. The proper reference-amplifier input network divider action can be restored by removing the reference filter capacitor and allowing the reference to come up immediately. The overshoot is then eradicated. However, transzorbs are still recommended to absorb load-induced transients.

Evaluation of these power supplies with the reference filter removed showed no increase in output noise. There's an output filter capacitor that adequately quiets any noise that might occur. Transient response from zero to full load and full load back to zero isn't affected. In short, there's no good reason to keep the reference filter capacitor in this design.

A second problem stems from foldback current limiting. This is necessary to keep the pass transistor dissipation within its safe operating area (SOA) during current limit and short circuit conditions. While foldback current limiting is necessary in high-voltage power supplies, it can cause problems, particularly when used with high-voltage op amps. Amplifiers like the APEX PA85 have constant-current internal biasing, which causes them to appear as a constant-current load to the power-supply pins at low and high voltages.

Typically, these amplifiers are used with two of these power supplies, one for each supply rail. With the PA85, for instance, one supply will most



2 **Using a voltage-sensing relay in high-voltage op amps that use two power supplies can cure the problem of lagging supply current caught in the foldback current limit. This occurs when one supply comes up faster than the other. The problem also arises when trying to power a group of amplifiers after successfully powering a lower-current high-voltage op amp.**

likely come up faster than the other, and the amplifier begins to draw 20 mA. Consequently, the lagging supply is now caught in its foldback-current-limit region. This also occurs when a designer has no trouble powering a single lower-current, high-voltage, op amp, but discovers the problem trying to power multiple amplifiers.

One way to cure the problem, without modifying the power supplies, is to use a voltage-sensing relay circuit that allows both supplies to reach full output before connecting the load. This is implemented with a high-voltage Zener in series with a resistor and relay coil *(Fig. 2)*. The Zener(s) should be selected to be slightly less than the total supply voltage, not including what the relay coil requires, and select the resistor to drop the remainder.

It's important that the selected Zener has a power dissipation that exceeds the product of coil current and Zener voltage. When this is done, transzorbs must be employed on the load side of the relay because of relay switching currents.

Foldover current limit can also be remedied by modifying the power supplies. This involves changing two resistor values, the current-limit resistor, and the foldback resistor, as shown in Figure 1 (this modification was designed for the 200-V output versions of the power supplies).

Prior to modification, the power supply delivers less than 10 mA at low output voltages (PA85 requires 20 mA). The modifications provide a minimum of 25 mA, yet maintain a maximum of 120 mA.

When modifying to alter these current-limit values, the foldback resistor (R_{fo}) first should be disconnected *(Fig. 1, again)*. Also, the current-limit adjustment must be set to midpoint. The current limit will now limit to the lowest value of the foldback characteristic, and can be increased by lowering R_{c1}.

It's best to consult SOA graphs for the pass transistor, and then set this current to limits according to the transistor's unregulated input. Next, the foldback resistor, R_{fo} is added. Remember that R_{fo} should be selected to limit at about 20% greater than manufacturer specification for maximum output current. Raising R_{fo} lowers this current and vice versa. ED