Continuously Adjustable Bench Power Supply Provides Any-Polarity Voltage and Current

by Jon Munson

Introduction

Continuously adjustable power supplies are indispensable tools in any electronics lab for driving or loading circuits under test. Some tests require a power supply that can change polarity and/or change current direction, traditionally implemented with made-to-suit equipment such as active load units or DC offset generators. The power supply described here provides this same capability in a simple power supply design that takes advantage of the versatile LT1970 power op amp, which includes built-in adjustable closed-loop current-limiting functions.

The polarity of power supply output voltages and currents can be summed up in a 4-quadrant diagram, as shown in Figure 1. A conventional power supply is limited to operation in either Quadrant 1 or 3—it operates with positive voltage output and current sourced to a load (Quadrant 1) or with a deliberate miswire of the output, statically as a minus supply (Quadrant 3). A conventional supply cannot operate in Quadrant 2 (for example, as an adjustable load for a minus-supply), nor can it operate the Quadrant 4 (for example, discharge testing a battery with a specific constant current), nor can it transition seamlessly between the quadrants as a function of load condition or control input.

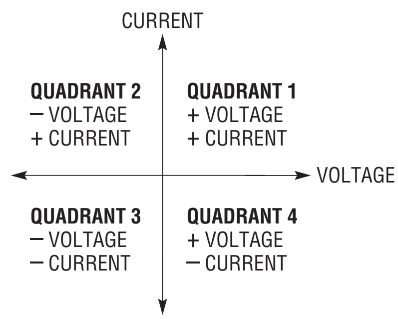

Figure 1. Quadrants of supply operation

Full 4-quadrant capability is possible with an output topology similar to that of an ordinary audio power amplifier, having a complementary pass-transistor configuration. The complementary section can be a basic op amp output in lower-current designs, or external power devices (e.g. MOSFETs) in higher power designs, such as the example below. The

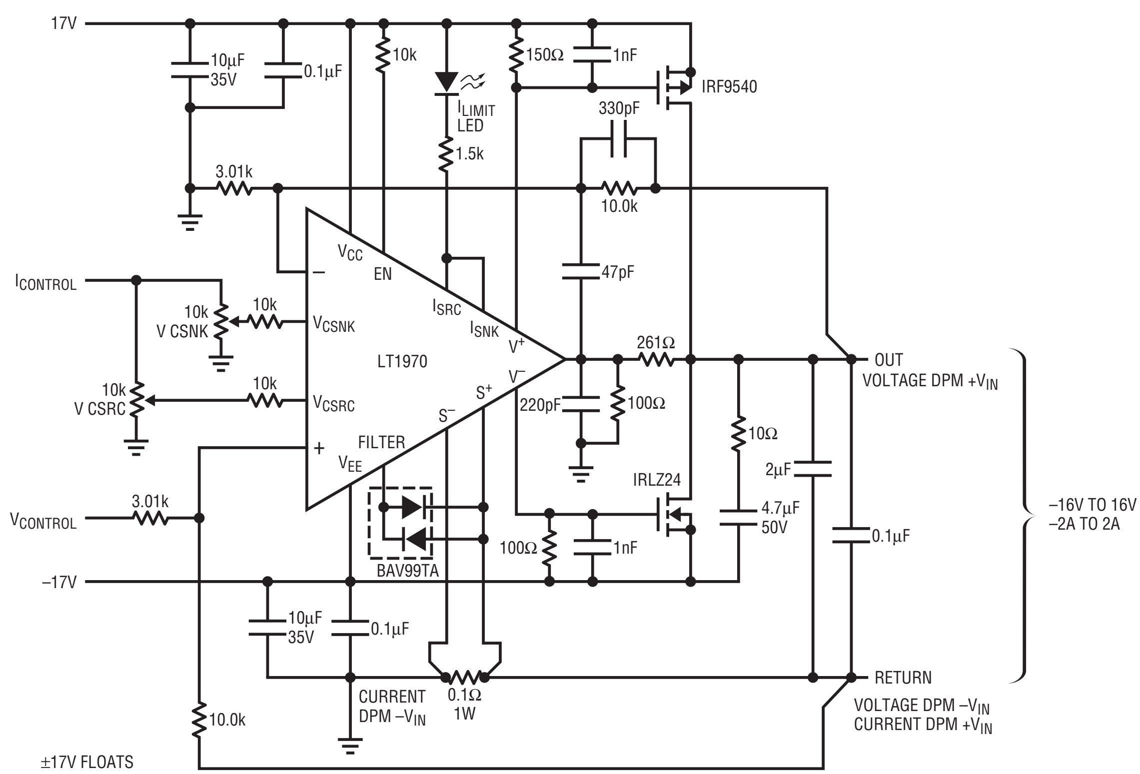

Figure 2. 4-Quadrant supply output section

LT1970 power op amp simplifies the control of the output in the various modes, thanks to its built-in closed-loop current-limiting features.

Design Details

Figures 2 and 3 show a 4-quadrant supply designed to provide at least ±16V adjustability with up to ±2A output capability. Figure 2 shows the basic LT1970-based regulator section. Figure 3 shows the user control analog section, utilizing an LT1790-5 reference and an LT1882 quad precision op amp. The entire circuitry operates from a pre-regulated ±17V bulk power source (not shown).

The user control potentiometers, V Set and I Limit (in Figure 3), are configured to provide buffered command signals $V_{CONTROL}$ and $I_{CONTROL}$, respectively. $V_{CONTROL}$ is adjustable from –5V to +5V and is amplified by the LT1970 regulator circuit to form the nominal ±16.5V output range. $I_{CONTROL}$ is adjustable from 0V to +5V, with +5V representing the maximum user current limit command. The $I_{CONTROL}$ signal is attenuated by trimmers VCSNK and VCSRC to set the precise full-scale currents for sink and source modes, respectively.

The output current is sensed using a 0.1Ω resistor in the load return and provides the LT1970 with feedback during current limiting operation. With this sense resistance, setting the current-limit trimmers to 100% would allow the LT1970 to limit at about ±5A, but since a 2A maximum current is desired in this application, the trimmers are set to about 40% rotation when calibrated.

To prevent internal control contention at low output current, the LT1970 sets a minimum current-limit threshold that corresponds to about 40mA for the sense resistance used here. Another feature of the LT1970 is the availability of status flags, which in this case, provide a simple means of driving a front panel LED to indicate when current limiting is active.

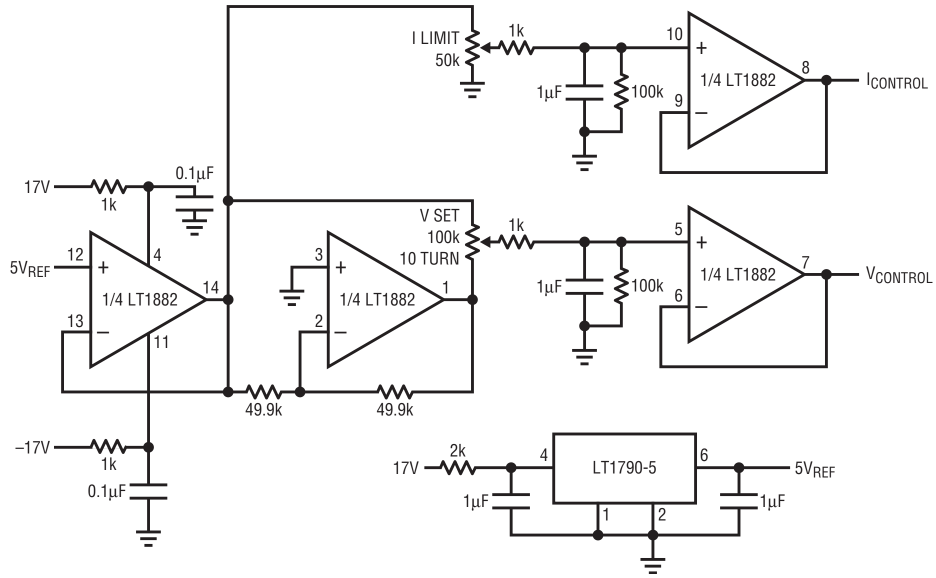

Figure 3. 4-Quadrant supply user controls section

The LT1970 features split power connections that allow for the amplifier output section to be powered independently from the analog control portion. The flexibility of this configuration allows direct sensing of the op amp output current via resistance in the V^+ (pin19) and V^- (pin 2) connections. This forms a convenient means of establishing class-B operation of the MOSFET output devices using a current-feedback method, where the op amp output current is converted to a gate-drive potential, thereby having the MOSFETs turn on only to the extent needed to help the op amp provide the output demand.

Since power supplies must inherently drive heavy C-loads (i.e. circuits with high-value bypass capacitors), and any over-voltage would present a damage potential (no pun intended!), careful attention was given to compensating the op amp for minimal overshoot under all loading conditions. As with most op amps, C-load tolerance is accomplished with the LT1970 by inner- and outer-loop feedback, where the op amp itself is resistively decoupled from the load. DC-feedback for the LT1970 uses differential voltage sensing to eliminate the regulation error that would otherwise occur with the current-sense and lead resistances in series with the load.

A pair of inexpensive digital panel meters (DPM) may be connected to the output as indicated in Figure 2 to monitor the output conditions in real time (the two DPM common connections are not shared, which may complicate the circuitry used to power some DPM types). Notice the selection of current-sense resistance was made to optimize a DPM display with the usual ±200mV full-scale sensitivity (to present up to ±1.999A, for example).

One word of caution: when using this supply to power sensitive electronics (in place of a conventional single-quadrant supply), it's good practice to connect a reverse-biased Schottky diode to the output binding-posts (e.g. 1N5821, cathode to more positive connection) or use a disconnect relay and power sequencer in the design so to protect the load from any energetic reverse transients during turn-on and turn-off of the main bulk supply.