Four-quadrant power supply provides any-polarity voltage and current

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A conventional power supply operates only in the first quadrant; positive-voltage output and current are sourced to a load or, with a deliberately miswired output, statically in the third quadrant as a "minus" supply. The conventional supply cannot, however, operate in either the second quadrant as an adjustable load for a minus supply, for example, or the fourth quadrant as a discharge-testing a battery with a specific constant current, for example. It also cannot transition seamlessly between the various modes as a function of load condition or control input. The circuit in **Figure 1** achieves full four-quadrant capability with an output topology similar to that of an ordinary audio power amplifier by using a "complementary" pass-transistor configuration. The complementary section may be the basic op-amp output in lower current designs or use external power MOSFETs in cases involving higher power. Controlling the output in the various modes is a simple matter when you use the LT1970 power op amp to manage the operation, thanks to its built-in, closed-loop, current-limiting features.

The four-quadrant supply provides at least ±16V adjustability with as much as ±2A output capability. **Figure 1** shows the basic LT1970-based regulator section. **Figure 2** shows the user-control analog section, using an LT1790-5 reference and an LT1882 quad-precision op amp. The entire circuit operates from a preregulated ±17V bulk power source (not shown). You configure the user-control potentiometers, V_{SET} and I_{LIMIT}, to provide buffered command signals: $V_{CONTROL}$ and $I_{CONTROL}$, respectively (**Figure 2**). You can adjust $V_{CONTROL}$ from −5 to +5V, and the LT1970 regulator circuit amplifies it to form the nominal ±16.5V output range. You can adjust $I_{CONTROL}$ from 0 to 5V; 5V represents the maximum user current-limit command. The V_{CSNK} and V_{CSRC}

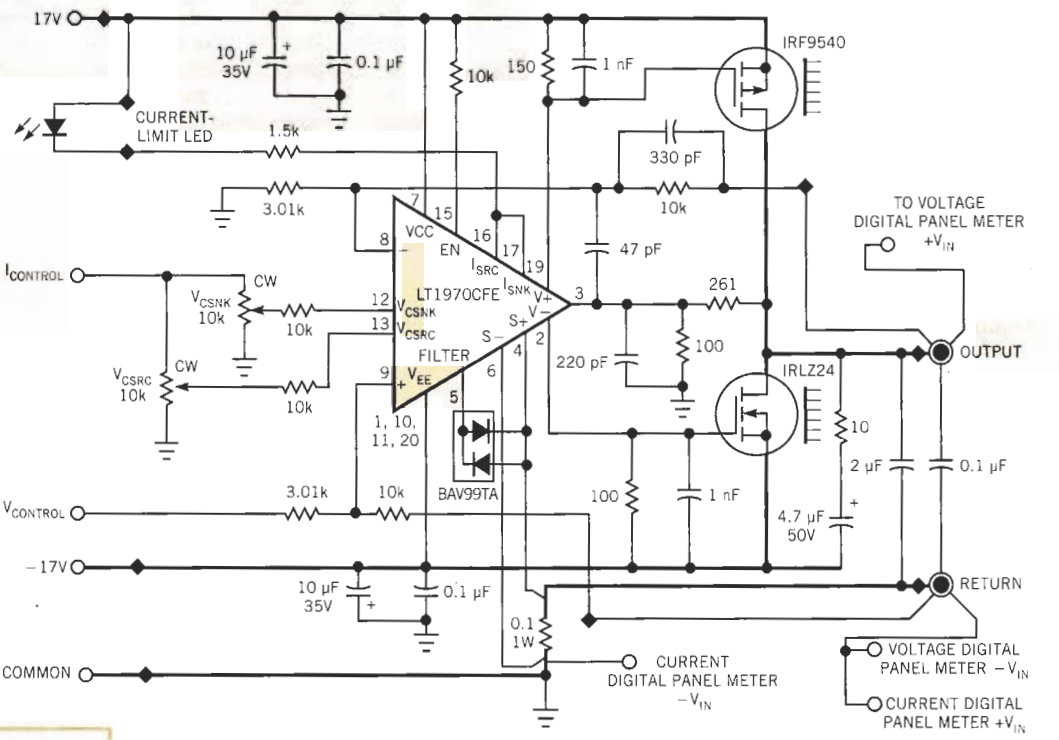

Figure 1

You can obtain four-quadrant power-supply operation by using a power op amp in the output section.

trimmers attenuate the $I_{CONTROL}$ signal to set the precise full-scale currents for sink and source modes, respectively (**Figure 1**).

A 0.1Ω resistor in the load return senses the output current 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 approximately ±5A, but, because this application requires a 2A maximum current, you set the trimmers to approximately 40% rotation when calibrated. To prevent internal control contention at low output current, the LT1970 sets a minimum-current-limit threshold that corresponds to approximately 40 mA for the sense resistance. Another nice 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. The LT1970 features split power connections that allow you to power the internal output section independently from the analog-control portion. The flexibility of this configuration allows direct sensing of the op amp's output current via resistance in the V+ (Pin 19) and V− (Pin 2) connections. This feature gives a convenient means of establishing Class B operation of the MOSFET-output devices using a current-feedback method, in which 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.

Because power supplies inherently must drive heavy capacitive loads—namely, circuits with high-value bypass capacitors—and any overvoltage could damage the circuit, pay careful attention to compensating the op amp for minimal overshoot under all loading conditions. As with most op amps, the LT1970's inner- and outer-loop feedback accomplish capacitive-load tolerance. In this situation, the op amp itself is resistively decoupled from the load. The 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. You can connect a pair of inexpensive digital panel meters to the output to monitor the output conditions in real time (**Figure 1**). (The two digital panel meters do not share "common" connections, which may complicate their powering.) Note that the selected current-sense resistance optimizes a digital-panel-meter display with the usual ±200-mV full-scale sensitivity to present as much as ±1.999A, for example. One word of caution: When you use this supply in place of a conventional single-quadrant supply to power sensitive electronics, it's good practice to connect a reverse-biased Schottky diode, such as a 1N5821 cathode, to the more positive connection, to the output binding posts. Alternatively, you could use a disconnect relay and power sequencer in the design to protect the load from any energetic reverse transients during turn-on and turn-off of the main bulk supply.

An adjustable power supply is an indispensable tool in any electronics lab. It can be even more useful in many circumstances if it provides the ability to adjust continually through 0V to the polarity, adjustably limit current, or both in either the source or the sink directions. These additional capabilities provide convenient methods of driving or loading circuits that are under development or test that might otherwise require very special or custom equipment, such as active-load units or dc-offset generators. You can readily obtain these features if you base the linear-regulator design on the versatile LT1970 power op amp, which includes built-in adjustable- closed-loop current-limiting functions.□

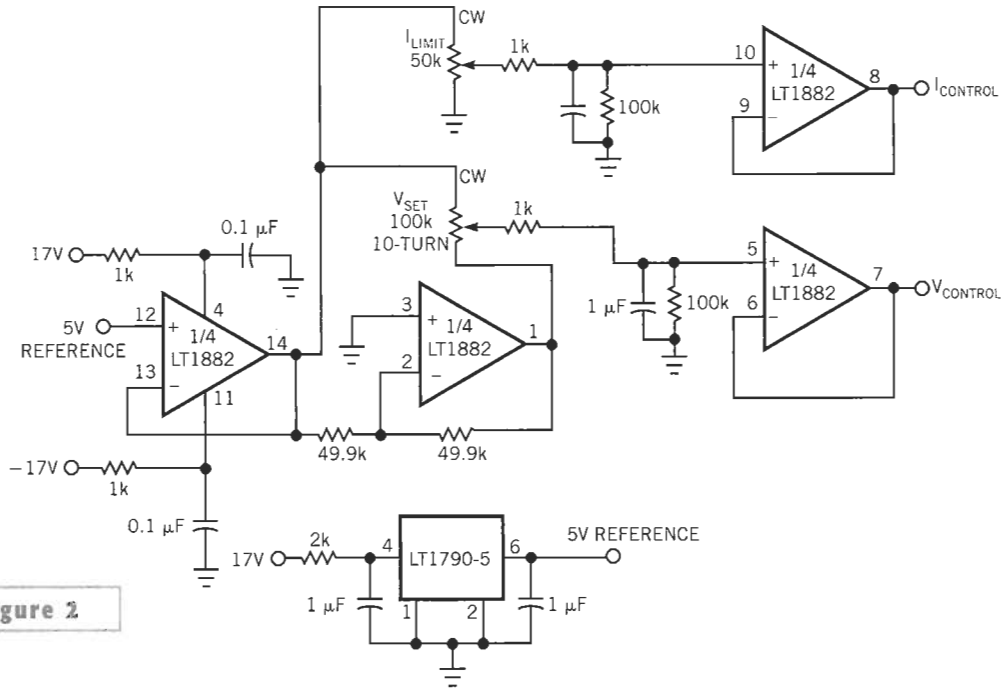

Figure 2

The user-control section allows you to set the voltage range and current-limit parameters for the output section in Figure 1.