Tracking Dual-Voltage Power Supply

Build something handy while you wait for the year's first hamfest!

Hugh Wells W6WTU
1411 18th Street
Manhattan Beach CA 90266-4025

Upon more than one occasion a ham experimenter will find a need for a utility power supply that will provide a variable voltage as well as equal values of both positive and negative voltage to power a project. Such an occasion occurs, for example, when you are experimenting with op amps, which usually require ±15 volts. But even when a dual voltage is not required, it is nice to have a variable voltage supply available.

The power supply shown in **Fig. 1** provides a regulated variable voltage output which is adjustable from 2 to 16 V per side and 4 to 32 V between the outer voltage rails. Being a utility supply, it is not intended to be a real powerhouse, but the design concept could be used to develop one. In the configuration shown, the 2 to 16 V output on one or the other side is capable of providing a maximum current of 300 mA intermittently, but should be limited to about 100 mA to keep the transistors' heating to a minimum.

Even with the high load differential between sides, the voltage between sides will remain within about 10 mV. When the load is either divided between the two sides, or the total load is taken from the outer voltage rails, about 450 mA is available. The governing factors involved in the amount of current available are the power transformer, regulator, and transistors Q1 and Q2. However, transistors Q1 and Q2 govern the output current only when there is a current differential between the two sides.

The principle of operation is based upon floating a common reference point between the two outer voltage rails and shifting it to maintain an equal value between each side. To accomplish that, as shown in **Fig. 1**, complementary transistors Q1 and Q2 are "pass" transistors, each carrying the return path current for individual loads tied between the rails and the common point. An LM741 op amp is used to "sense" the voltage differential and shift the common reference point by driving the bases of Q1 and Q2 as needed to maintain equal (+) and (-) values. Most any typical NPN and PNP TO-220 transistors will work in this application.

Heatsinking for Q1 and Q2 is not necessary unless the power supply will be intentionally operated with a high differential current between sides. Placing a one- or two-inch-square aluminum plate on each transistor tab will provide adequate emergency heat protection for the transistors as they are normally cool, because they handle only the differential current.

I recommend that a heat sink be used on the voltage regulator because it handles the total load current. In the prototype project, a pressed sheet metal heat sink (Thermalloy #6025) was used, with the legs soldered into the board for mechanical support.

A voltage balance between the two sides is created by connecting the pot R4 between the two voltage rails and using it to locate the center value. A miniature 10–15 turn pot was selected for the application to achieve a fine adjustment setting; however, a single turn pot will work OK. The actual value of the pot is not critical, but a value between 25 k and 50 k is preferred. Should it be necessary to use a 10 k, as indicated in the parts list, two 10 k fixed resistors should be added to the circuit by placing them in series with one on each side of the 10 k pot. The objective of the added resistance is to reduce the amount of current flowing through the pot.

The balance is adjusted typically at full voltage output by alternately measuring the voltage between the common

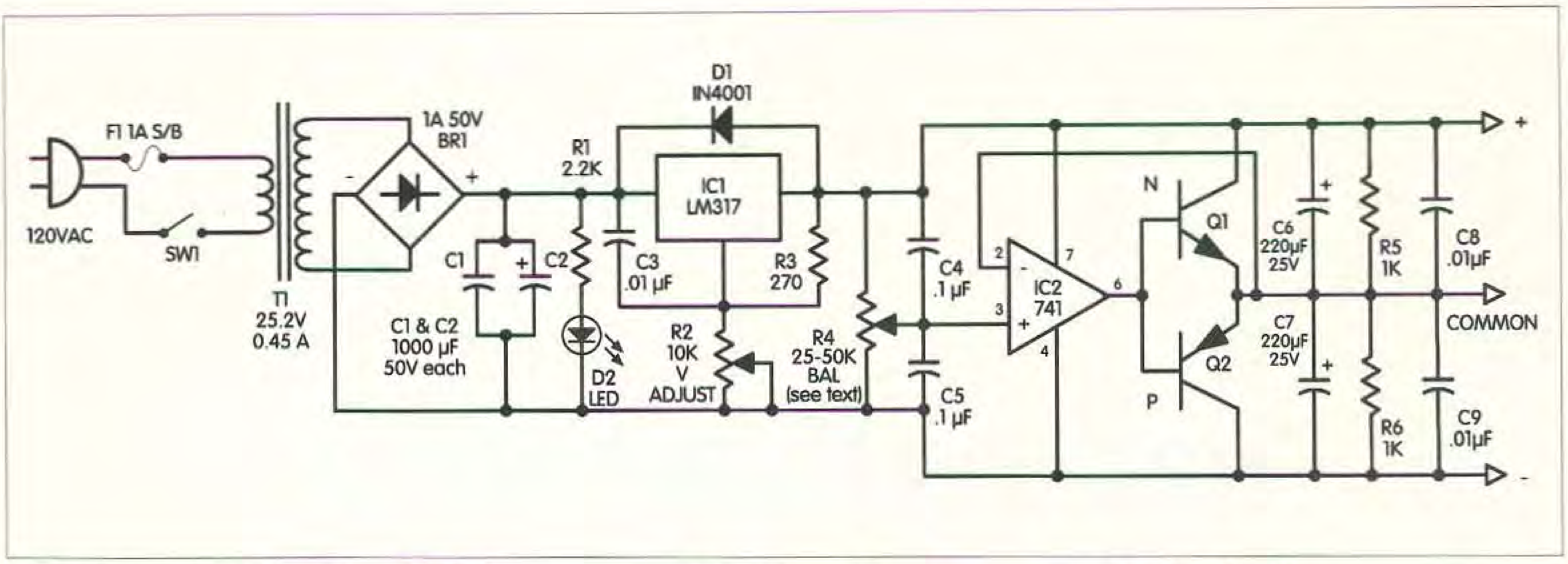

Fig. 1. Schematic of the tracking dual-voltage power supply. Positive and negative outputs track within 10 mV.

reference point and each rail while the pot is adjusted to create equal voltage values. An output load on the power supply is not required during the balance adjustment. Following the adjustment, a load may be used to verify that the circuit will maintain a balance while under a load. The 0.1 µF capacitors connected across the balance pot help reduce the noise voltage that might enter the input of the op amp. Any noise voltage, or hum, appearing at the balance pot input to the op amp will appear in the output voltage.

Power supply regulation is accomplished by utilizing one variable voltage regulator, and in this project, an LM317T was selected. The advantage of using the op amp and the complementary transistors is that only one voltage regulator is required. In the absence of the op amp, two regulators would be required, one for each rail, and getting them to track over a wide voltage range would become a real technical issue. The regulator establishes the maximum available total terminal voltage which is then divided between the two sides. As the regulated voltage is reduced, the voltage on each side will also reduce, but they will remain equal in value.

Here is a technical point that must be considered separately, although it must be considered for other supplies as well. In this case, there is a high in-rush current when the power switch is closed. As a result, the fuse selected must be able to handle that current. The actual fuse current value is typically much larger than the operating current. The high in-rush current is caused by the two 1000 µF filter capacitors connected directly across the output of the bridge rectifier. Upon turn-on, the capacitors exhibit essentially a short across the transformer's secondary. The capacitor charge current decreases after turn-on, allowing the in-rush current to subside. Where a 0.5 A fuse would be typical for the transformer used in this project, the in-rush current dictates that a 1 to 1-1/2 A S/B fuse be used.

Construction

Parts for the project are readily available from many sources (Hosfelt, Mouser, Radio Shack, etc.).

Construction of the Tracking Dual-Voltage Power Supply is straightforward, with no special mounting or critical wiring requirements. Parts may be mounted using any desired method. Perhaps the only critical item in the construction of the power supply is a vertically mounted heat sink for the voltage regulator, as it must be used (or the regulator could be mounted against the chassis and insulated from it) to achieve adequate cooling. If the regulator is remotely mounted, capacitor C3 must be placed right at the regulator terminal and not on the circuit board. The purpose of capacitor C3 is to reduce the gain-bandwidth of the regulator to prevent it from oscillating.

As an aside, capacitors C6 and C7 were selected to be axial lead for convenience and availability. However, you may choose to use radial mount capacitors. Any reasonable front-panel layout can be used. The panel will support the voltage adjust pot, binding posts, LED, and power switch. Calibration marks are placed on the front panel using a marking pen, with the marks placed around the adjustment knob. The positioning of the marks is determined using a digital voltmeter as a reference for each value to be marked on the panel. Although the marked voltage values won't be totally accurate, they provide a suitable reference for ballpark voltage adjustments.

Capacitors C8 and C9 are mounted behind the panel and directly on the terminals. Their objective is to reduce the output terminal impedance to an RF environment should the power supply be used around an RF circuit.

Wiring between the front panel and the board is divided between the AC power line and the rest of the wires carrying DC. The wires from the power switch are twisted and lie along one edge of the circuit board, traveling back from the front panel toward the rear panel. All remaining wires carrying DC are routed across the back side of the panel and along the opposite edge of the board. It is important to separate the AC power from the DC circuit in order to reduce the

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Parts List

C1, C2	1000 μF radial cap (272-1032)
C4, C5	0.1 μF 50 V disc ceramic cap
C3, C8, C9	0.01 μF 50 V disc ceramic cap
C6, C7	220 μF 35 V axial lead cap (272-1017)
R1	2.2 k 1/2 W resistor (271-1121)
R2	10 k pot, linear (271-1715)
R3	270 Ω 1/2 W resistor (271-1112)
R4	10 k–50 k pot (271-343 = 10 k)
R5, R6	1 k 1/2 W resistor (271-1118)
IC1	LM317T adj volt regulator (276-1778)
IC2	LM741 op amp (276-007)
Q1	TIP29 NPN TO-220 trans (RSU11371168) or TIP31 NPN TO-220 trans (276-2017)
Q2	TIP32 PNP TO-220 trans (RSU11371218) or (276-2027)
D1	1N4001 diode (276-1101)
D2	Red LED (276-041)
BR1	1 A 50 V bridge rect (276-1152) or (276-1146)
T1	25.2 V 450 mA pwr trans (273-1366)
F1	1-1/2 A S/B fuse (270-1022)
S1	Toggle switch

Miscellaneous Parts

Fuse holder, panel mt (270-364)
3 5-way binding posts (274-662)
1" diam pointer knob (274-416)
Cabinet (270-253)
Power cord (278-1255)
Cord grommet
8-pin IC socket
3 1/4" standoffs
Heat sink (see text)
Circuit board (as required)

Table 1. *Parts list. Part numbers listed are from Radio Shack.*

introduction of hum into the regulator and op amp circuits.

Conclusion

There is always a need for another power supply when you are working on a project. The advantage of the Tracking Dual-Voltage Power Supply is that it functions both as a utility supply and as one that will provide simultaneous positive and negative voltages which track within a few millivolts. The dual voltages are suitable when experimenting with op amps and other circuits where a split voltage source is needed.

Construction of the power supply is simple and utilizes readily available parts from many sources. Build it, and you'll always have a suitable utility power supply available! 73