Dual-Polarity Power Supply

This project offers a dual-polarity power source that is adjustable from ±1.2 to ±37 volts and a built-in digital-numeric metering system

By Tim Swogger

Modern electronic circuits often require a variety of voltages and two polarities. The Dual-Polarity Power Supply described here fulfills the needs of virtually all solid-state circuits you are likely to encounter or build. It offers a wide range of adjustable output voltage at moderate current. The design of the circuitry gives you a choice of adjustment ranges, from a low of 1.2 volts to a high of 24 or 37 volts, depending on the power transformer selected.

As a bonus, the Power Supply features a built-in three-decade LED numeric metering system that can be used to monitor output voltage or current. The project uses readily available components and is relatively low in cost to build compared to equivalent commercial supplies.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the circuitry used in the Dual-Polarity Power Supply. The positive and negative voltage outputs that appear at binding poses *BP1* and *BP3*, both referenced to common or ground binding post *BP2*, are adjustable. The circuit is designed to give an adjustment range on both supply outputs of from ±1.2 volts to a high that depends on the choice of power transformer *T1*. If you use a 48-volt transformer, the maximum output voltage will be about ±24 volts; alternatively, use of a 70-volt transformer, maximum output will be about ±35 volts.

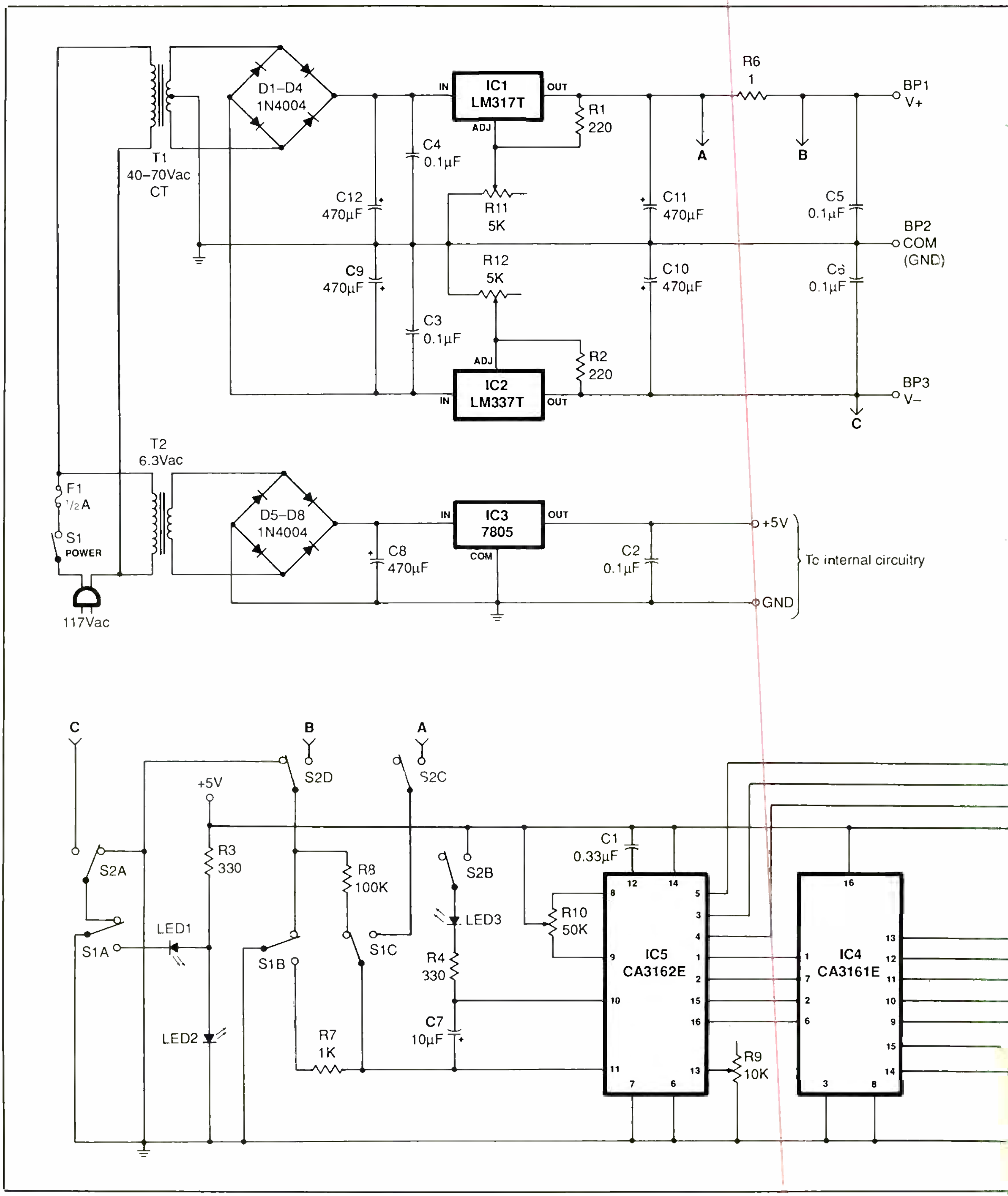
By setting switch *S2* to its alternate positions, you can monitor either the positive or negative output voltage. Switch *S1* allows you to monitor positive or negative current, depending on the setting of switch *S1*.

Operation of the circuit begins with closing POWER switch *S1*. This delivers 117-volt ac line power to the primary of power transformer *T1*. The output voltage that appears across the secondary of *T1* is applied to the bridge rectifier composed of diodes *D1* through *D4* (these individual diodes can be replaced by an integrated bridge-rectifier module).

The pulsating dc emerging from the rectifier assembly is fed to filter capacitors *C9* in the negative supply and *C12* in the positive supply sections. The reference point for the two supply sections is established by connecting the center tap of the transformer to circuit ground.

Once the pulsating voltages are filtered to pure dc, they are fed to adjustable voltage regulators *IC1* in the positive supply and *IC2* in the negative supply. From the outputs of both regulators, the final voltages are fed to *BP1* and *BP3*, where they are made available for external use. This makes up the basic Dual-Polarity Power Supply. The remaining circuitry is for metering purposes.

Adjustment range for the positive and negative supplies is provided by POSITIVE and NEGATIVE adjust controls *R11* and *R12*, respectively. Capacitors *C11* and *C10* provide post-regulation filtering for *IC1* and *IC2*,


D1–D4
1N4004
IC1
LM317T
IN
OUT
ADJ
R1
220
R6
1
BP1
V+
A
B
T1
40–70Vac
CT
C4
0.1µF
C12
470µF
R11
5K
C11
470µF
C5
0.1µF
BP2
COM
(GND)
C9
470µF
R12
5K
C10
470µF
C6
0.1µF
C3
0.1µF
R2
220
IC2
LM337T
BP3
V–
C
T2
6.3Vac
F1
1/2 A
S1
POWER
117Vac
D5–D8
1N4004
IC3
7805
COM
C8
470µF
C2
0.1µF
+5V
To internal circuitry
GND
S2D
S2C
+5V
R3
330
R8
100K
S2B
C1
0.33µF
R10
50K
S2A
LED1
S1A
S1B
S1C
LED3
R4
330
IC5
CA3162E
IC4
CA3161E
LED2
R7
1K
C7
10µF
R9
10K

PARTS LIST

Semiconductors

D1 through D8—1N4004 or similar silicon rectifier diode (or substitute 100-PIV, 5-ampere bridge-rectifier modules—see text)

DISP1,DISP3,DISP3—Common-anode 7-segment LED numeric display (MAN72A or equivalent)

IC1—LM317T adjustable positive voltage regulator

IC2—LM337T adjustable negative voltage regulator

IC3—7805 fixed +5-volt regulator

IC4—CA3161E BCD-to-7-segment decoder/driver

IC5—CA31262E three-digit dual-slope A/D converter

LED1,LED2,LED3—Jumbo red light-emitting diode

Q1,Q2,Q3—2N3906 or similar general-purpose npn silicon transistor

Capacitors

C1—0.33-µF, 16-volt Mylar or other type

C2 thru C6—0.1-µF, 50-volt ceramic disc

C7—10-µF, 35-volt electrolytic

C8 thru C12—470-µF, 50-volt electrolytic

Resistors (¼-watt, 5% tolerance)

R1,R2—220 ohms

R3,R4,R5—330 ohms

R6—1 ohm (4-watt or greater)

R7—1,000 ohms

R8—100,000 ohms

R9—10,000-ohm pc-mount trimmer potentiometer

R10—50,000-ohm pc-mount trimmer potentiometer

R11,R12—5,000-ohm linear-taper, panel-mount potentiometer

Miscellaneous

BP1,BP2,BP3—Five-way binding post (color coded for easy visual identification of polarity)

F1—0.5-ampere slow-blow fuse

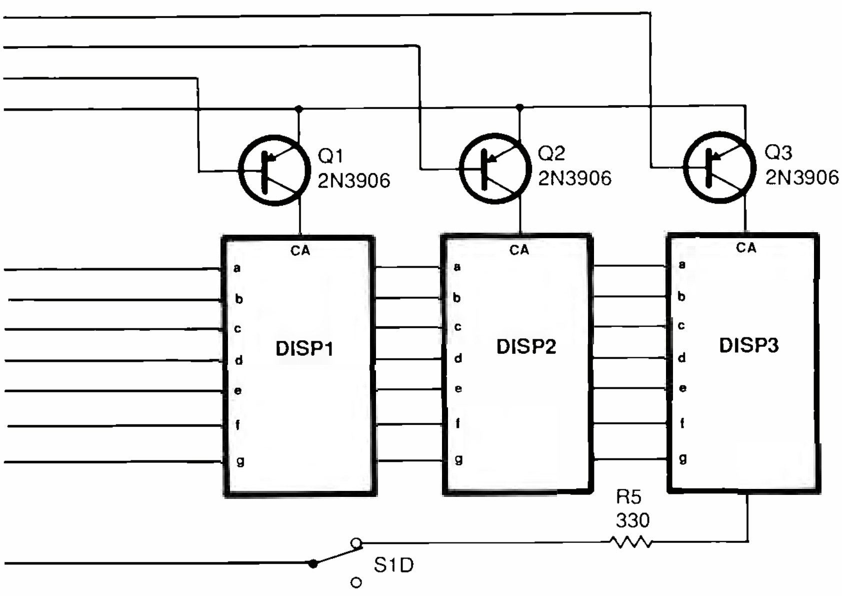
S1,S2—4pdt switch

S3—Spst toggle or slide switch

T1—40-to-70-volt rms, center-tapped power transformer (see text)

T2— 6.3-volt power transformer

Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); suitable enclosure (a 5.9″ × 5.3″ × 3.0″ metal instrument case is suitable for basic power-supply circuitry; if you add optional 5-volt power supply, select a larger enclosure—see text); DIP IC sockets; control knobs for R11 and R12; holder for F1; ac line cord with plug; small rubber grommets for mounting LEDs; rubber grommet for line cord entry hole; small-diameter heat-shrinkable or other insulated tubing; dry-transfer lettering kit; clear spray acrylic; machine hardware; hookup wire; solder; etc.



while bypass capacitors *C5* and *C6* provide noise immunity on the two output voltage lines.

A separate power supply is provided for powering the metering/display circuitry. This supply is composed of power transformer *T2*, the bridge-rectifier assembly made up of diodes *D5* through *D8* (again, the discrete rectifier diodes can be replaced with an integrated bridge-rectifier assembly), filter capacitor *C8* and fixed +5-volt voltage regulator *IC3*. The regulated output of this supply is distributed throughout the remainder of the circuitry.

Voltages fed to the pin 11 input of three-digit, dual-slope A/D converter *IC5*. This IC converts the analog voltage into a digital BCD equivalent at output pins 1, 2, 15 and 16. These outputs are directly coupled to input pins 1, 7, 2 and 6, respectively, of BCD seven-segment decoder/driver *IC4*. In turn, *IC8* provides the driving voltage for the selected segments in LED numeric displays *DISP1*, *DISP2* and *DISP3*.

The numeric displays are enabled by output lines from 4, 3 and 5 of *IC5* through driver transistors *Q1*, *Q2* and *Q3*. The collectors of these transistors are connected to the common-anode (CA) pins of *DISP1*, *DISP2* and *DISP3*, respectively. When any given transistor is conducting, it turns on (enables) the LED numeric display to which it is connected.

Trimmer control *R10* across pins 8 and 9 of *IC5* is used to zero the display. Trimmer control *R9* between pin 13 of *IC5* and ground calibrates the voltage reading displayed.

The display must always be zeroed before connecting the output of the Power Supply to the display. (Remember that minimum supply potential is approximately 1.2 volts.)

Fig. 1. Complete schematic diagram of the Dual-Polarity Power Supply circuitry.

Once the display is zeroed by adjusting the setting of *R10*, calibration against a meter of known accuracy can be accomplished using *R9*.

Three light-emitting diodes are included in the circuit. Power-on indication is provided by POWER *LED2*. Separate + and – voltage/current indications are provided by *LED3* and *LED1*, respectively. Power resistor *R6* provides current limiting for the metering circuit when the current-monitoring function is selected.

If you wish to incorporate into your bench power supply a fixed +5-volt output, you can use any of a number of regulated supply designs. You can find schematic diagrams for these in a wide variety of electronics magazines and books.

Use of a separate 5-volt supply requires a third power transformer that connects directly across the incoming ac line. Install a separate 5V POWER switch to enable and disable this supply as needed, as well as a separate LED indicator to inform you when this auxiliary supply is on and off. If you go this route, be sure to include a separate fuse of appropriate rating in series with the 5V POWER switch and primary lead of the new power transformer.

Construction

There is nothing critical about component placement or conductor runs. Therefore, you can use any wiring technique that suits you to build the project. For example, if you wish, you can design and fabricate a pair of printed-circuit boards on which to mount the basic power supply circuitry and the metering circuitry. Otherwise, use perforated board that has holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware.

Whichever way you go, be sure to use sockets for the two DIP ICs and LED numeric displays. Wire first the basic power-supply circuit and then the metering circuit and its power supply on boards that are as small as possible. Make certain in both cases that you properly orient all diodes and electrolytic capacitors and properly base any integrated bridge rectifier assemblies used and the three voltage regulators. Mount a heat sink on the tabs of voltage regulators *IC1* and *IC2*.

Do *not* plug *IC4* and *IC5* in their sockets. These ICs are to be installed only after you have conducted initial voltage checks and are certain that the circuitry is correctly wired.

POSITIVE and NEGATIVE controls R5 and *R12* in the basic power supply section mount off the board, as does power transformer *T1*. Trimmer controls *R9* and *R10* mount on the metering circuit board, while *T2* can mount on or off the board, depending on its size and weight.

Once the two circuit-board assemblies have been wired, temporarily set them aside. Now machine the enclosure. The type and size of enclosure you use will depend on how you configure your Power Supply.

The circuit-board assemblies should require very little room inside the enclosure. The power transformer(s) will have a significant effect on enclosure size, as will the amount of front-panel space required for the LED numeric display, switches, controls, LEDs and binding posts. If you incorporate a fixed 5-volt supply in your project, you must also take into account the space required for it.

Machine the enclosure as needed. That is, drill mounting holes through the front panel for the POSITIVE and NEGATIVE adjust controls, output binding posts, POWER switch(es) and LEDs. Also, cut slots in the panel for the two pushbutton switches and window for the LED numeric display. Locate these slots accurately!

Then drill the mounting holes for the circuit-board assemblies, fuse holder(s) and transformers through the floor and/or rear panel of the enclosure. Also drill an entry hole for the ac line cord. When you are finished machining the enclosure, deburr all drilled holes and cut slots to remove sharp edges, cement a red transparent plastic filter over the display window cutout and line the en-

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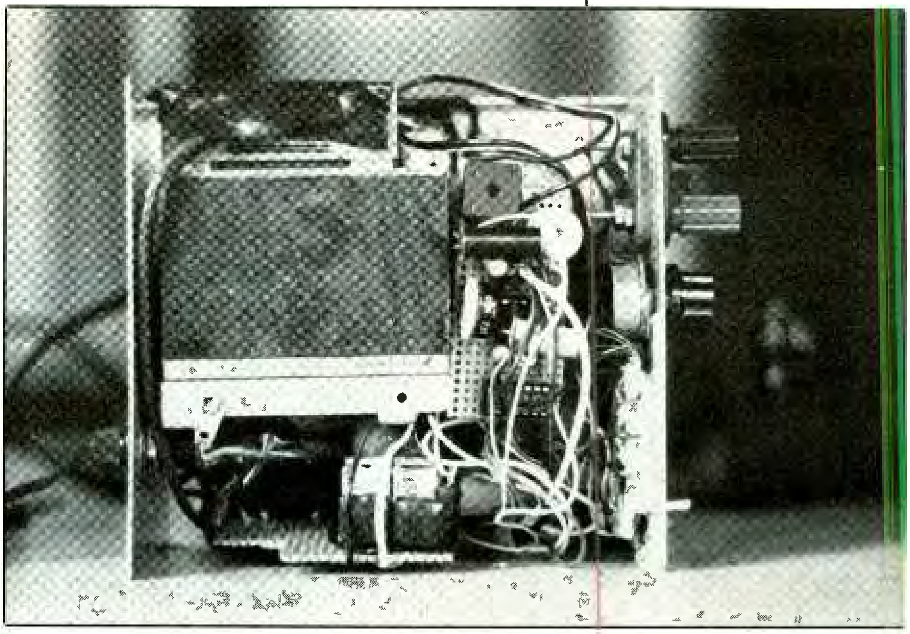

Fig. 2. Prototype of project was built on perforated board using point-to-point wiring. The circuitry is housed inside a standard instrument enclosure.

try hole for the line cord with a rubber grommet.

Mount the circuit-board assemblies in their respective locations, using ½-inch spacers and suitable machine hardware. Then mount the transformer(s), fuse holders, switches, controls and binding posts in their respective locations. Place control knobs on the shafts of the POSITIVE and NEGATIVE adjust controls.

Referring back to Fig. 1, wire together all components and assemblies. Make certain that you observe proper polarities for the LEDs and that you insulate all connections. When you are done, carefully go over the entire project to make sure all components (except *IC4* and *IC5*) are in their proper locations, that all connections are soldered and that all wire runs are correct.

The only real difficulty you may encounter in wiring together the circuit is wiring to switches *S1* and *S2*. The best and surest way to wire to these four-pole double switches is with the aid of an ohmmeter or audible continuity tester. Use the meter or tester to determine the switching action as you go along.

With all the circuitry wired together, there remains only to apply legends to the front panel of the enclosure near the controls, as shown in the lead photo. Use a dry-transfer lettering kit to apply these legends. Remove the knobs from the POSITIVE and NEGATIVE control shafts to ease this task.

Not shown in the lead photo are + and − light-emitting diodes *LED3* and *LED1*. These were added to the prototype after the photo was taken. Also not shown in the lead photo are the +5V POWER switch, LED POWER indicator and + and − 5V OUTPUT binding posts you might have incorporated into your Power Supply project. If you included this optional supply, label the panel accordingly.

When you are finished labeling the panel, mask off the controls, switch(es), binding posts and display window with masking tape. Then spray two or more light coats of clear acrylic over the legends to protect them from abrasion while the Power Supply is in use. Allow each coat to dry before spraying on the next.

Finally, when the acrylic coating has completely dried, remove the masking tape and return the knobs to the shafts of the controls.

Closing Comments

You now have a Dual-Polarity Power Supply that is tailor-made for operational-amplifier and other linear-circuit experiments. If you built into the project the optional 5-volt dc supply, you also have a power source that can be used with TTL digital circuits, as well as mixed analog/digital circuits. You will never again have to resort to an arrangement of battery cells or kludge up a power supply when you need it. **ME**