

Dual Output Power Supply

*Need a positive and negative power supply for your next op amp or other project?
Here is the answer.*

The unique circuit shown in Figure 1 provides very nearly equal positive and negative dc voltages with a common ground from an ac power transformer. Plus and minus outputs from an untapped transformer secondary normally require plus and minus half wave rectifiers, but unless the loads are balanced there will be a net field in the core, which might cause it to saturate. This double bridge design prevents that from happening. D1 to D8 form two bridge rectifiers. All capacitors are electrolytic. If C2 and C3 are considerably larger than C4, then V1 and V2 will be very close to the same at any load.

This circuit can be used for op amps and many other ICs, such as comparators and function generators. It was designed by Robert Dehoney, of IEEE, and verified by extensive testing and measurements of test-bench prototypes.

How it Works

In Figure 2A, when point A is more positive than point B by a large enough margin, C1 charges through D2 and D3, C2 charges through D5 and D3, and C4 charges through C2, D5, D8 and C3. During this half cycle, voltage V_{C4} follows V_{C3} since $V_{C4} = V_{D3} + V_{C3} - V_{D8}$.

In Figure 2B, when point B is enough more positive than point A, C1 charges through D1 and D4, C3 charges through D7 and D1, and C4 charges through C3, D7, D6 and C2. During this half cycle, voltage V_{C4} follows V_{C2} since $V_{C4} = V_{D1} + V_{C2} - V_{D6}$.

Design a Dual Output Power Supply

For computerized design using these equations, download *HamCalc* (version 103 or later) and run the "Power Supply — Dual Output" program.¹ If you prefer to do the math yourself, proceed as follows:

¹George Murphy, VE3ERP, *HamCalc* "Painless Math for Radio Amateurs." This free software is available for download at www.cq-amateur-radio.com.

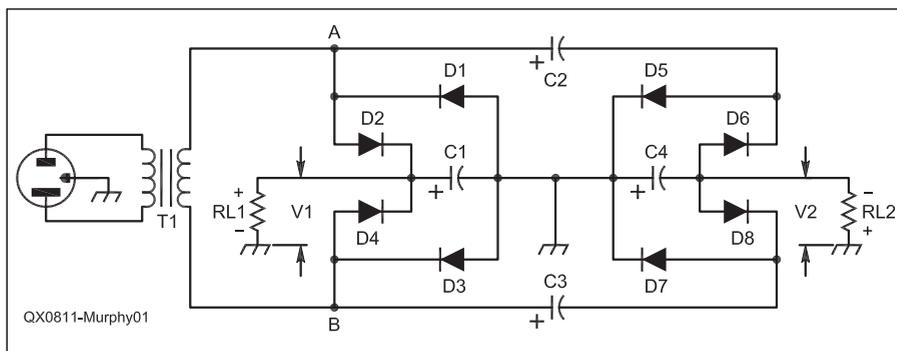


Figure 1 — This schematic diagram shows the double bridge rectifier circuit.

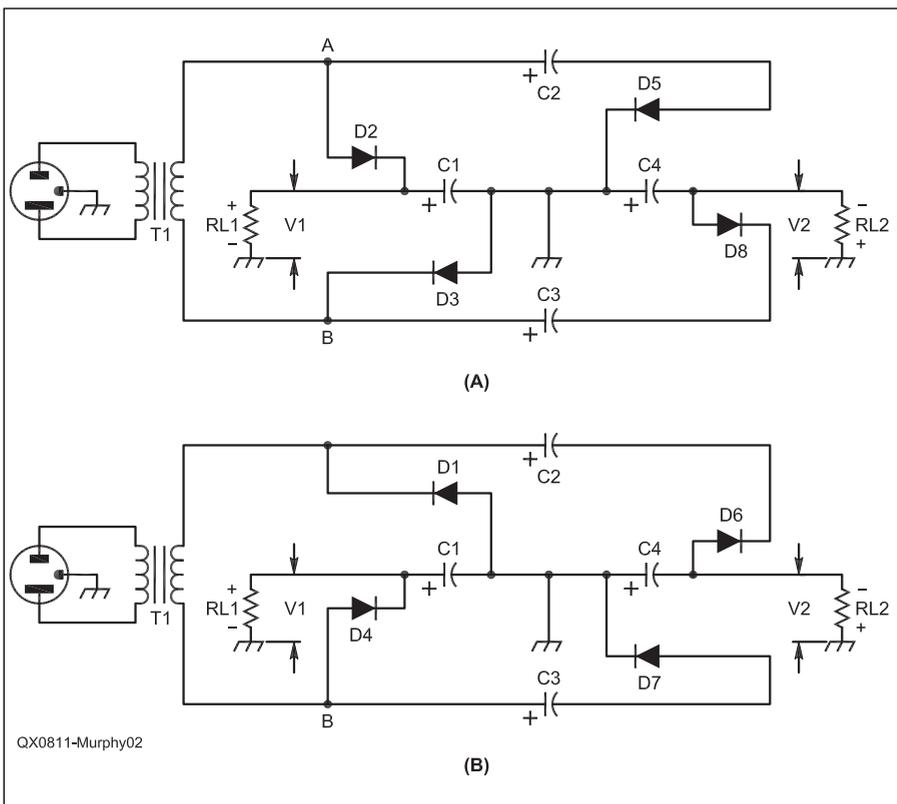


Figure 2 — Part A shows the current path through the circuit when the top of the transformer is positive. Part B shows the current path when the bottom of the transformer is positive.

a) Specify desired voltage (E) to RL1 and RL2 and current I1 and I2 through each, where:
 E is in volts
 RL1 and RL2 are in ohms
 I1 and I2 are in amps.

b) Calculate the values of RL1 and R2:
 $RL1 = E / I1$ [Eq 1]
 $RL2 = E / I2$ [Eq 2]

where:
 RL1 and RL2 are in ohms
 E is in volts dc
 I1 and I2 are in amps.

d) Specify the ac line frequency (F) in hertz.

e) Specify allowable peak-to-peak ripple voltage of V1 (across R1) and V2 (across R2).

f) Calculate the values of C1 and C4:
 $C1 = 375 \times I1 \times 10^3 / F / R1$ [Eq 4]
 $C4 = 375 \times I2 \times 10^3 / F / R2$ [Eq 5]

where:
 C1 and C4 are in μF
 I1 and I2 are in amps
 F is in hertz
 R1 and R2 are peak-to-peak volts.

g) Calculate the values of C2 and C3:
 $C2 = C3 = 3 \times C4$ (minimum) or $5 \times C4$ (recommended) [Eq 6]

where:
 C2 and C3 are in μF .

h) Estimate the required transformer secondary voltage (TE) and current (TI):

$TE = 2 + E / 1.41$ [Eq 7]
 $TI = 1.8 \times (I1 + I2)$ [Eq 8]

where:
 TE is in volts
 TI is in amps.

Design Notes

1. Rectifier diodes should have a rating not less than $1.4 \times TE$ volts at TI amperes.
2. All capacitors are electrolytic.
3. C1 can be any value not less than the calculated value of C1.

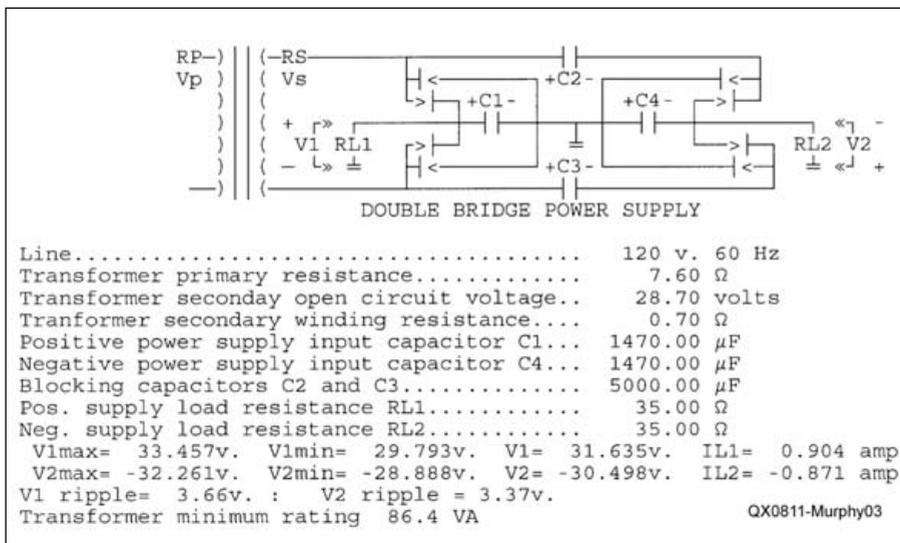


Figure 3 — Here is the HamCalc printout for prototype number 1.

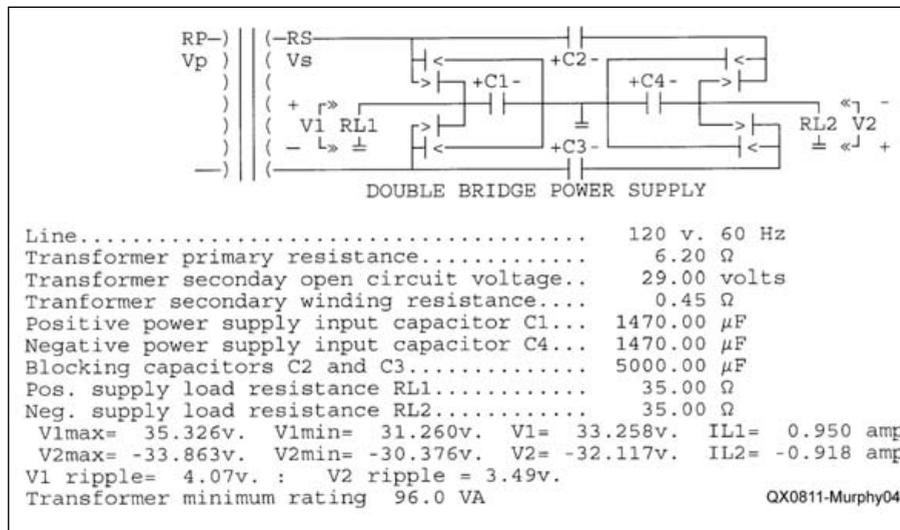


Figure 4 — Here is the HamCalc printout for prototype number 2.

Table 1
 Prototype Bench Test Values

PROTOTYPE	TRANSFORMER · 120V, 60 Hz					C1 & C4 μF	C2 & C3 μF	CALCULATED VALUES				MEASURED VALUES			
	PRIMARY WINDING OHMS	SECONDARY WINDING OHMS	SECONDARY NO-LOAD VOLTS	LOAD				V1		V2		V1		V2	
				RL1 OHMS	RL2 OHMS			Volts	Ripple volts	Volts	Ripple volts	Volts	Ripple volts	Volts	Ripple volts
# 1	7.60	0.70	28.70			1470	5000	31.7	3.7	-30.5	3.4	32.2	2.7	-30.9	2.9
# 2	6.20	0.45	29.00	35	35			33.3	4.1	-32.1	3.5	32.8	2.5	-31.5	2.6
# 3	40.50	1.00	13.76	150	150			1000	16.4	0.70	-16.0	0.69	16.1	1.7	15.7

4. C4 can be any value not less than the calculated value of C4.

5. C2 and C3 can be any value not less than 3 times the value selected for C4. (We recommend 5 or more times the value of C4, for minimum ripple.)

6. Select a transformer with a secondary voltage somewhat higher than TE and a current rating not less than TI.

7. When a suitable transformer has been found, you may verify the design and predict the actual V1 and V2 voltages using the *HamCalc* "Power Supply - Double Bridge" program or an equivalent program.

Prototype Bench Test Results

Three prototypes were built and tested using salvaged junk box transformers and capacitors.

Figures 3 and 4 are identical except for the transformers. Unfortunately, there were no capacitors on hand to allow C2 and C3 to be 5 times the value of C4, so the V2 value is less than optimum. Figure 5 indicates a situation in which the capacitor values have a 5:1 ratio, and where V2 is within a few percent of V1.

Table 1 shows the component values of each prototype, the output values predicted by the *HamCalc* program, and the actual measured output values, assuming that the values of all capacitors are exactly as marked on the capacitor which, of course, never happens in the real world. Figure 6 shows how an oscilloscope might show the output in a perfect world.

This design is very flexible, limited only by your tolerance for precision and the contents of your junk box!

George Murphy is a retired industrial designer and professional musician with no vocational RF engineering experience. Licensed as VE3ERP in 1960, his Amateur Radio hobby has led to his writing many articles for international Amateur Radio publications since 1985 and worldwide distribution of his HamCalc software since 1993. George is an ARRL member.

Robert Dehoney is a retired professional electrical engineer who worked for a defense company developing HF, VHF and UHF systems, enjoys analyzing and constructing useful circuits and has authored papers for RF Design Magazine.

Figure 6 — Part A shows the transformer secondary current and the ripple voltage on C2. During the positive current pulse, the voltage on C2 increases a bit, and during the negative current pulse the voltage decreases. This ripple is riding on the 40 or so volts dc across C2.

Part B shows the current into and out of C1 and C4. The positive going pulse is across C1. You can see the capacitor charging for about 25% of the time and discharging for about 75% of the time. In both cases, RL1 = RL2 = 220 Ω.

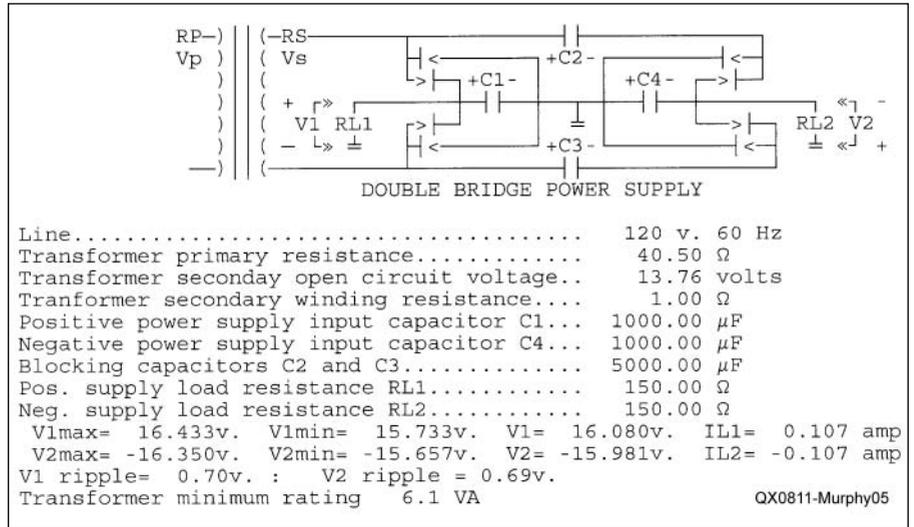


Figure 5 — This *HamCalc* printout is for prototype number 3.

