A 12-V, 15-A Power Supply

This husky and attractive power supply is easy to build and is an ideal power platform for your solid-state transceiver or workbench.

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Most amateurs have seen low-voltage, high-current regulated supplies, from the switching supplies (*switchers*) used in computers to three-terminal linear regulators (*linears*) used in many pieces of ham gear. Although switching technology is in vogue today, switchers generally produce lots of RF noise and exhibit limited dynamic load regulation. On the other hand, linear regulators offer good dynamic load regulation and generate little RF noise. Linears are usually heavier and less efficient than switchers, however. For amateur use, weight—in most cases—is not an issue, and the loss of efficiency, which translates to higher dissipated power, can be tolerated. Therefore, the linear regulator is still the most common design in amateur use.

This supply is a linear 12-V, 15-A design with adjustable output voltage and current limiting. Supply regulation is excellent, typically exhibiting a change of less than 20 mV from no load to 15 A. This basic design, with heftier components and additional pass transistors, can deliver over 30 A.

Circuit Description

Fig 1 is the supply's schematic. The ac-line input is fused by F1, switched on and off by S1 and filtered by FL1. For safety, F1 and S1 are mandatory. F1 and S1 are rated at about one-fourth of the output current requirement (for 15-A output, use a 4- or 5-A slow-blow fuse or a similarly rated circuit breaker). FL1 prevents any RF from the secondary or load from coupling into the power line and prevents RF on the power line from disturbing supply operation. If your ac power line is clean, and you experience no RF problems, you can eliminate FL1, but it's inexpensive insurance.

When discharged, filter capacitor C1 looks like a short circuit across the output of rectifier U2 when ac power is applied. That usually subjects the rectifier and capacitor to a large inrush current, which can damage them. Fortunately, a simple and inexpensive means of inrush-current limiting is available. Keystone Carbon Company (and others) market a line of inrush-current limiters (thermistors) for this purpose. The device (RT1) is placed in series with one of the transformer primary leads. RT1 has a current rating of 6 A,[1] and a cold resistance of 5 ohms. When it's hot, RT1's resistance drops to 0.11 ohm. Such a low resistance has a negligible effect on supply operation. Thermistors run *HOT!*[2] They must be mounted in free air, and away from anything that can be damaged by heat.

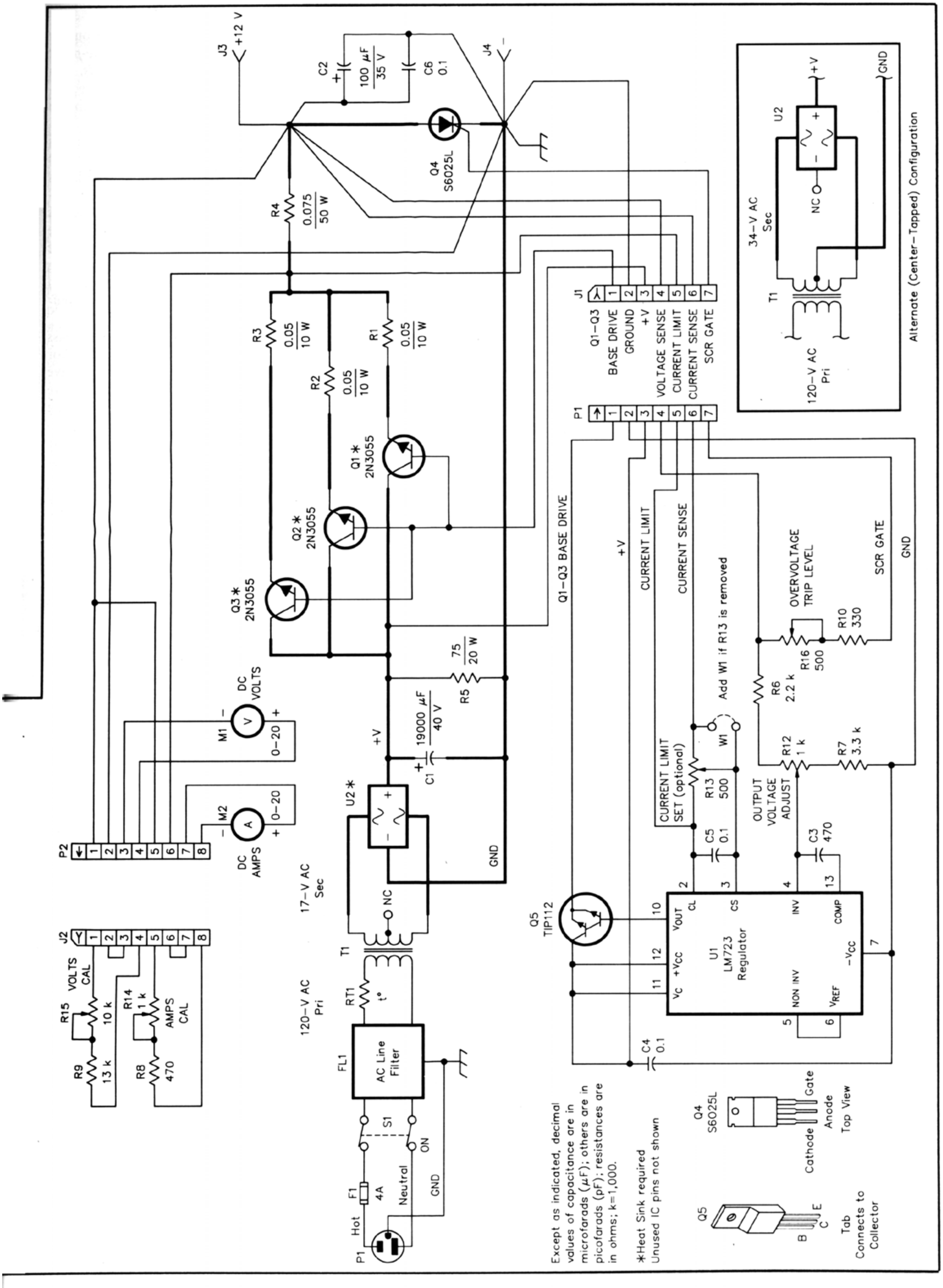
[1]Notes appear on page 41.

The largest and most important part in the power supply is the transformer (T1). If purchased new, it can also be the most costly. Fortunately, a number of surplus dealers (see Table 1) offer power transformers that can be used in this supply.

Two parameters important to the power-

Fig 1—Schematic of the power-supply. Equivalent parts can be substituted. Unless otherwise specified, resistors are ¼-W, 5%- tolerance carbon-composition or film units. The bold lines indicate high-current paths that should use heavy-gauge (#10 or #12) wire. This schematic graphically shows wiring to a single-point ground; see text. The majority of the parts used in this supply are surplus components.

C1—19,000 µF, 40-V computer-grade electrolytic capacitor.
C2—100 µF, 35-V capacitor.
C3—470 pF, 50 V.
C4, C5—0.1 µF, 50-V.
F1—120-V, 4-A, Littlefuse SLO-BLO fuse.
FL1—6-A CORCOM ac line filter (surplus model #6H1 used; new model is #6EH1).
J1, J2—8-position SIP female jack.
J3, J4—Heavy-duty binding posts (one red, one black).
M1—0-to 20-V dc voltmeter (1-mA movement, 1-kΩ coil).
M2—0- to 20-A ammeter (1-mA movement, 1-kΩ coil).
P1, P2—8-position male SIP plug.
P3—3-wire ac plug and line cord.
Q1, Q2, Q3—2N3055 NPN power transistor.
Q4—TIP112 NPN Darlington power transistor.
Q5—S6025L 25-A SCR.
R1, R2, R3—0.05-Ω, 5%-tolerance, 10-W.
R4—0.075 Ω, 5%-tolerance, 50-W.
R5—75-Ω, 5%-tolerance, 20-W.
R6—2.2 kΩ.
R7—3.3 kΩ.
R8—470 Ω.
R9—13 kΩ.
R10—1 kΩ.
R11—330 Ω, ½ W.
R12—1-kΩ multiturn trimmer potentiometer.
R13—500-Ω multiturn trimmer potentiometer.
R14—500-Ω multiturn trimmer potentiometer.
R15—10-kΩ multiturn trimmer potentiometer.
R16—500-Ω multiturn trimmer potentiometer.
RT1—Thermistor, 5-Ω no-load resistance, 0.11-Ω I_{max} resistance, 6-A I_{max} (Digi-Key KC004L-ND; KC003L-ND can be substituted).
S1—DPDT toggle.
U1—LM723C voltage regulator (14-pin DIP).
U2—50-V, 25-A bridge rectifier.
Misc: Enclosure (Hammond Manufacturing #1426Q used here), fuse holder, 14-pin DIP socket, PC board (see Note 10).



J3 +12 V
C2 100 µF 35 V
C6 0.1
J4 −
Q4 S6025L
R4 0.075 50 W
R3 0.05 10 W
R2 0.05 10 W
R1 0.05 10 W
Q3* 2N3055
Q2* 2N3055
Q1* 2N3055
J1
Q1–Q3 BASE DRIVE
GROUND
+V
VOLTAGE SENSE
CURRENT LIMIT
CURRENT SENSE
SCR GATE
P1
Q1–Q3 BASE DRIVE
+V
CURRENT LIMIT
CURRENT SENSE
OVERVOLTAGE TRIP LEVEL
SCR GATE
GND
R5 75 20 W
R10 330
R16 500
R6 2.2 k
Add W1 if R13 is removed
W1
R12 1 k
R7 3.3 k
C1 19000 µF 40 V
+V
DC VOLTS
M1 0–20
M2 0–20
DC AMPS
P2
J2
U2*
CURRENT LIMIT SET (optional)
R13 500
OUTPUT VOLTAGE ADJUST
C5 0.1
C3 470
GND
17–V AC Sec
NC
T1
RT1
120–V AC Pri
Q5 TIP112
U1 LM723 Regulator
VOUT CL CS INV COMP +VCC VC NON INV VREF −VCC
C4 0.1
R15 VOLTS CAL 10 k
R9 13 k
R14 1 k AMPS CAL
R8 470
FL1 AC Line Filter
S1 ON
F1 4A
P1 Hot Neutral GND
34–V AC Sec
120–V AC Pri
+V
GND
Alternate (Center–Tapped) Configuration
Except as indicated, decimal values of capacitance are in microfarads (µF); others are in picofarads (pF); resistances are in ohms; k=1,000.
*Heat Sink required
Unused IC pins not shown
Q4 S6025L
Cathode Anode Gate
Top View
Q5
B C E
Tab Connects to Collector

Table 1
Parts Sources

A&A Engineering 2521 W La Palma Ave, Unit K Anaheim, CA 92801 Tel: 714-952-2114 Fax: 714-952-3280	Transformers, power transistors, bridge rectifiers, heat sinks, capacitors, cabinets.
All Electronics Corp PO Box 567 Van Nuys, CA 91408-0567 Tel: 800-826-5432, 818-997-1806 Fax: 818-781-2653	Transformers, power transistors, bridge rectifiers, heat sinks.
Digi-Key 701 Brooks Ave South PO Box 677 Thief River Falls, MN 56701-0677 Tel: 800-344-4539, 218-681-6674 Fax: 218-681-3380	Thermistors, SCRs, transistors, and most other small parts.
R&D Electronics 1224 Prospect Ave Cleveland, OH 44115 Tel: 800-642-1123, 216-621-1121 Fax: 216-621-8628	Transformers, power transistors, bridge rectifiers, heat sinks.

supply design are the transformer secondary's voltage and current capability. For a 12-V supply, a secondary voltage of about 15 to 17 V ac under load is adequate. If a center-tapped transformer is used (you have to alter the rectifier connection and ground the center tap; see the inset of Fig 1), the secondary has to deliver twice that (30 to 34 V CT). Transformers with higher secondary voltages can be used, but the power dissipated (wasted) in the pass transistors (Q1-Q3) increases proportionally. If you're fortunate, you may find a transformer that has an additional secondary winding—or a tapped primary winding—that offers the ability to fine-tune the secondary voltage. For intermittent duty (such as SSB or CW), the secondary winding's current rating should be at least equal to the required output current. If continuous duty is required of the supply (such as in FM or RTTY service), increase the secondary current rating requirement by about 25%.

T1 produces 17 V ac at 20 A; the center tap is not used. Bridge rectifier U2 provides full-wave rectification. Full-wave rectification produces a low ripple component on the filtered dc, which results in dissipating little power in the filter capacitor. U2's voltage rating should be at least 50 V, and its current rating about 25% higher than the normal load requirement; a 25-A bridge rectifier will do. U2 is secured to the chassis (or a heat sink) because it dissipates heat.[3]

C1 is a computer-grade electrolytic. Any capacitor value from 15,000 to 30,000 μF will suffice. I use a 19,000-μF, 40-V capacitor in my supply. The capacitor's voltage rating should be at least 50% higher than the expected no-load rectified dc voltage. In my supply, that voltage is 25, and a 40-V capacitor provides enough margin.

As mentioned earlier, C1 dissipates power proportional to the ripple voltage. With a 15-A load and a measured ripple voltage of 1.5, that amounts to 32 W.[4] Therefore, the *physical* size of the capacitor is important, too. A physically larger capacitor is better able to dissipate the power.

R5, a 75-ohm, 20-W bleeder resistor, is connected across C1's terminals to discharge the supply when no load is attached or one is removed. Any resistance value from 50 ohms to 200 ohms is fine; adjust the resistor's wattage rating appropriately.

At the terminals of C1, we have a dc voltage, but it varies widely with the load applied. When keying a CW transmitter or switching a rig from receive to full output, 5-V swings can result. The dc voltage also has an ac ripple component of up to 1.5 V under full load. Adding a solid-state regulator (U1) provides a stable output voltage even with a varying input and load. The LM723 used at U1 is an older chip that provides voltage regulation and current limiting with few external components. Additional components can be added to provide output metering. U1 has a built-in voltage reference and sense amplifier, and a 150-mA drive output for a pass-transistor array.

U1's voltage reference provides a stable point of comparison for the internal regulator circuitry. In this supply, it's connected to the noninverting input of the voltage-sense op amp. The reference is set internally to 7.15 V, but the absolute value is not critical because an output-voltage adjustment (R12) is provided. What *is* important is that the voltage is stable, with a specified variation of 0.05% per 1000 hours of operation. This is more than adequate for the supply.

For the regulator to work properly, its ground reference must be at the same point as the output ground terminal. The best way to ensure this is to use the output **GROUND** terminal (J4) as a *single-point ground for all of the supply grounds.* Run wires to J4 from each component requiring a ground connection. Fig 1 attempts to show this graphically.

The output pass-transistor array consists of a TIP112 Darlington transistor (Q5) driving three 2N3055 power transistors (Q1-Q3). This two-stage design is less efficient than connecting the power transistors directly to the LM723, but Q5 can provide considerably more base current to the 2N3055s than the 150-mA maximum rating of the LM723. You can place additional 2N3055s in parallel to increase the output-current capacity of the supply.

This design is not fussy about the pass transistors or the Darlington transistor used. Just ensure all of these devices have voltage ratings of at least 40. Q5 must have a 5-A (or greater) collector-current rating and a beta of over 100. The pass transistors should be rated for collector currents of 10 A or more, and have a beta of at least 10.[5]

When unmatched transistors are simply connected in parallel, they usually don't equally share the current.[6] By placing a low-value resistor in each transistor's emitter lead (*emitter-ballasting resistors*, R1-R3), equal current sharing is ensured. When a transistor with a lower voltage drop tries to pass more current, its emitter resistor's voltage drop increases, allowing the other transistors to provide more current. Because the voltage-sense point is on the load side of the resistors, the transistors are forced to dynamically share the load current.

With a 5-A emitter current, 0.25 V develops across each 0.05-Ω resistor, producing 1.25 W of heat. Ideally, a resistor's power rating should be at least *twice* the power it's called upon to dissipate. To help the resistors dissipate the heat, mount them on a heat sink, or secure them to a metal chassis (as shown in Fig 2). I used 10-W resistors because that's what I had available. You can use any resistor with a value between 0.065 and 0.1 Ω, but remember that the power dissipated is higher with higher-value resistors.

At the high output currents provided by this supply, the pass transistors dissipate considerable power. With a current of 5 A through each transistor—and assuming a 9-V drop across the transistor—each device dissipates 45 W. Because the 2N3055's rating is 115 W when used with a properly sized heat sink, this dissipation level shouldn't present a problem.

The output-voltage sense is connected through a resistive divider to the negative input of U1. U1 uses the difference between its negative and positive inputs to control the pass transistors that in turn provide the output current. C3, a compensation capacitor, is connected between this input and a dedicated compensation pin to prevent oscillation. The output voltage is adjusted by potentiometer R12 and two fixed-value resistors, R6 and R7.[7] The voltage-sense input is connected to the supply's positive output terminal, J3.

Current sensing is done through R4, a 0.075-Ω, 50-W resistor connected between the emitter-ballasting resistors and J3. R4's power dissipation is much higher than that of R1, R2 or R3 because it sees the *total* output current. At 15 A, R4 dissipates 17 W. At 20 A, the dissipated power increases to 30 W.

U1 provides current limiting via two sense inputs connected across R4. Limiting takes place when the voltage across the sense inputs is greater than 0.65.[8] For a 15-A maximum output-current limit, this requires a 0.043-Ω resistor. By using a larger-value sense resistor and a potentiometer, you can vary the current limit. Connecting potentiometer R13 across R4 provides a current-limiting range from full limit voltage (8.7 A limit) to no limit voltage. This allows the current limit to be fine-tuned, if needed, and also permits readily available resistor values (such as my 0.075-Ω resistors) to be used. I normally set the current limit at 20 A because that's the top end of the ammeter scale.

Voltmeter M1 is a surplus meter. R8 and potentiometer R15 provide for voltmeter calibration. If the correct fixed-value resistor is available, R15 can be omitted. The combined value of the resistor and potentiometer is determined by the full-scale current requirement of the meter used.[9]

Ammeter M2 is actually a voltmeter (also surplus) that measures the potential across R4. The positive side of M2 connects to the high side of R4. R8 and potentiometer R14 connect between the positive output terminal (J3) and the negative side of M2 to provide calibration adjustment. The values of R8 and R14 are determined by the coil-current requirements of the meter used.

The supply output is connected to the outside world by two heavy-duty banana jacks, J3 and J4. C2, a 100-μF capacitor, is soldered directly across the terminals to prevent low-frequency oscillation. C6, a 0.1-μF capacitor, is included to shunt RF energy to ground. Heavy-gauge wire must be used for the connections between the pass transistors and J3 and between chassis ground and J4. The voltage-sense wire must connect *directly* to J3 and U2's ground pin must connect directly to J4 (see Fig 1). This provides the best output-voltage regulation.

An over-voltage crowbar circuit prevents the output voltage from exceeding a preset limit. If that limit is exceeded, the output is shunted to ground until power is removed. If the current-limiting circuitry in the supply is working properly, the supply current-limits to the preset value. If the current limiting is not functioning, the crowbar causes the ac-line fuse to blow. Therefore, it's important to use the correct fuse size: 4 to 5 A for a 15-A supply.

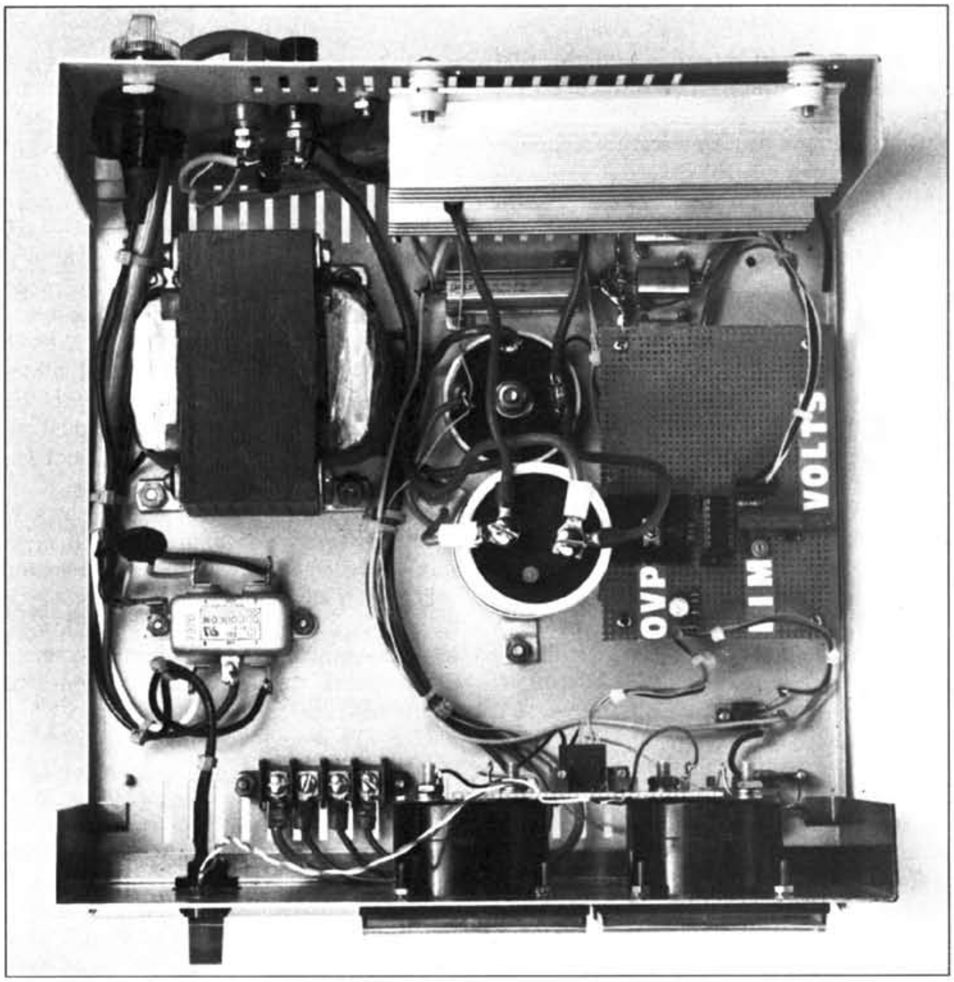


Fig 2—An inside view of the neatly constructed 12-V, 15-A power supply. There's plenty of room in this cabinet to accept the components comfortably and allow hands and tools to get at them. Vents in the bottom and rear of the cabinet provide some measure of convection cooling. For safety, all exposed ac-line leads and connections are insulated with shrink tubing. Wire bunches are secured with plastic cable ties. The terminal block at the lower left serves only to provide a resting place for unused transformer secondary-winding leads. Along the left of the cabinet are the ac-line filter, thermistor (it looks like a large, black ceramic capacitor) and power transformer. The fuse holder and line cord are behind the transformer, as are the dc output terminals J3 and J4. The black objects across the terminals are C2 and C6. Pass transistors Q1-Q3 are hidden by the heat sink fins. Note the insulated standoffs supporting the heat sink. The metal-cased power resistors are secured to the enclosure bottom beneath the heat sink. Bridge rectifier U2 is between the heat sink and C1. The parts mounted on the perfboard secured to the chassis near U2 and C1, and the perfboard mounted behind the meters, are now contained on one PC board (see Note 10). The small three-terminal device between the perf board and front panel is the SCR, Q4. Bleeder resistor R5 is secured to the chassis beneath M2.

The crowbar circuit is a simple design based on an SCR's ability to latch and conduct until the voltage source is removed. The SCR (Q4) is connected across output terminals J3 and J4. R10 and potentiometer R16 in series with the Q4's gate provide a means of adjusting the trip voltage. I set the crowbar in my supply to conduct at 15 volts. The S6025L SCR is rated at 25 A and should be mounted on a metal chassis or heat sink. (Note: Some SCRs are isolated from their mounting tabs, others are not. The S6025L and the 65-ampere S4065J are isolated types. If the SCR you use is not isolated, use a mica washer to insulate it from the chassis or heat sink.)

The bold lines in Fig 1 indicate high-current paths that should use heavy-gauge (#10 or #12) wire. Traces that are connected to the output terminals in the schematic by individual lines should be connected directly to the terminals by individual wires. This establishes a 4-wire measurement, where the heavy wires carry the current (and have voltage drops) and the sense wires carry almost no current and therefore do not have errors caused by voltage drops in the wiring. If desired, the sense wires can be carried out to the load, but that may introduce noise into the sense feedback circuit, so use caution if that is done.

Construction

Fig 2 shows the inside of the prototype supply. The larger components are chassis mounted; two perfboards contain the majority of the low-power parts of the supply. This includes the potentiometers for the regulator, meters and over-voltage adjustments. A PC board is available that contains all of the parts mounted on the two perf boards.[10,11]

Start construction by selecting a cabinet or chassis adequate to contain the components. Not only must the chassis have sufficient room inside, it must also be sturdy enough to support the weight of the components without deforming. I used an attractive Hammond Manufacturing #1426Q cabinet that measures 5.5 × 11 × 11.7 inches (HWD).

Once the chassis is selected, lay out the front panel. Drill and punch the necessary holes, apply the appropriate labels and coat the panel with clear acrylic paint.

I placed the transformer on the left side of the chassis for best access to the power switch. Wires from an unused secondary winding and the center tap are routed to an out-of-the-way location on the chassis and connected to a terminal strip, isolating them from each other and the surrounding components. On the chassis bottom, U2 is positioned near T1, as are C1 and R5. Identify the position of the regulator PC board. Don't locate components too near the rear of the chassis because the heat sink and/or circuit wiring need clearance.

Q1, Q2 and Q3 must be mounted on a heat sink. The one I used measures 1-1/4 × 6 × 3-5/8 inches (HWD). It's the minimum size I'd recommend using. If you can find a heat sink with vertically oriented fins, so much the better. Use a small amount of heat-sink compound between the transistors and the heat sink. Because the transistor collectors are at a potential of +25 V, they must be insulated from the heat sink, or, as in my supply, the entire heat sink can be isolated from the chassis. If there is adequate ventilation, you can mount the heat sink inside the chassis. The three emitter-ballasting resistors and the sense resistor can be secured to the chassis rear or bottom, but they should be located near the transistors to which they are connected. Orient the components so that they can be easily soldered to the common output connections.

Also mounted on the back panel are a line-cord strain relief and fuse holder. Use a strain relief to prevent the cord from being pulled out of the chassis. Mount the fuse holder directly above the line cord. The output terminals, J3 and J4, are placed in the same area; use heavy-duty banana jacks or terminal blocks. If FL1 is used, mount it on the chassis. Install an insulated terminal strip near the filter to hold the inrush-current limiter.

Once all of the major components are installed, some of the wiring can be done. Wire the line cord to the fuse with the black (hot) lead at the center, and the outer ring connected to the power switch. It's important to connect the green (ground) line-cord wire to the chassis for safety.

Connect the transformer secondary *directly* to the bridge rectifier. Use #12 wire to connect the rectifier output to the filter capacitor. Use crimp-on or solder-on terminal lugs as needed, as at the filter-capacitor connections. Connect C1's negative lead directly to the output **GROUND** terminal, J4. Connect a length of #12 wire from J4 (or C1) to the chassis. J4 is the single-point ground for the rest of the system. The positive connection will be made later. Attach bleeder resistor R5 to C1.

At this point, you should test the basic dc supply. When ac power is applied, about 20 to 28 V dc should be present across C1's terminals. This potential is dependent on the transformer used, but should not exceed 30 V dc. Turn off the supply.

Next, wire the output pass transistors. If the transistors are insulated from the heat sink, use #10 wire to connect together the collectors. Leave an 8- to 10-inch pigtail for later connection to C1's positive terminal. If the transistors are mounted directly to the heat sink, the pigtail can be connected to the heat sink.

Use #20 wire to connect together the transistor base leads, and provide a pigtail for attachment to U1. Using #12 wire, connect the emitters of Q1-Q3 to their respective emitter-balancing resistors. Solder together the remaining emitter-resistor leads and use #10 wire to connect them to R4. Solder the other side of R4 to J3, the positive output terminal.

Next, attach the 100-µF (C2) and 0.1-µF capacitors (C6) across the output terminals. Keep the leads as short as possible, especially those of C6.

Once the regulator board is wired, attach its mating connector to the appropriate points on the chassis. The voltage-sense wire and ground wires must connect directly to the appropriate output terminals. Use #20 or #22 wire for the voltage-sense wire and #18 for the ground.

Attach the current-limit and current-sense wires directly to R4. This is essential for proper regulation and current limiting. There is little current in the wires, so use #20 or #22 wire here and for the power, SCR gate and base-drive connections.

Q4 connects across J3 and J4. Q4's gate is attached to the PC board SCR GATE connection at J1, pin 7. Set potentiometer R16 to its maximum resistance or disconnect the SCR's gate prior to testing the supply.

Testing

Initial testing is done without a load. Use a 2-A fuse at F1 to protect the components in case of problems. If any of the steps do not produce the expected results, check the circuit wiring.

Connect a voltmeter to the output terminals. Turn on the supply. The voltmeter should read between 8 and 15 V. Adjust R12 to bring the output voltage to 12. Adjust R15 for a 12-V reading on the meter. Turn off the supply.

Connect a 12-Ω, 20-W resistor to J3 and attach the other end through an ammeter to J4. (The ammeter must be capable of reading a current flow of more than 1 A.) Turn on the supply and measure the output current, which should be 1 A. Adjust R14 until ammeter M3 displays 1 A. Turn off the supply.

The next test requires a 0.5-Ω load resistor. Use a high-power-dissipation resistor. To provide additional cooling, immerse the resistor in a plastic container (I use a discarded margarine container) of water. Connect the resistor to the supply in place of the 12-Ω load resistor previously used. If the ammeter is left in series with the load, it must be capable of reading a current flow of at least 10 A. The front-panel ammeter may also be used to measure the current. Adjust the **CURRENT LIMIT SET** potentiometer (R13) to the position where the wiper is at the same end of the potentiometer as the terminal that is connected to the output side of R4. This sets the current limit to 8.7 A (if R4 is a 0.075-Ω resistor).[12] Turn on the supply. The ammeter should indicate about 9 A. If it doesn't, immediately turn off the supply. Check the wiring of the current-limiting circuit, including R13.

If the ammeter reading was okay, remove the series-connected ammeter and connect the 0.50-Ω load resistor across the output terminals. Turn on the supply and adjust **CURRENT LIMIT SET** pot R13 for a 20-A current indication (or the desired limit point). Turn off the supply.

At this point, the output voltage and the current limit are set. You can recalibrate M2 with a 5- or 10-A load to get better meter resolution when adjusting R14.

The following sequence assumes that the desired output voltage is 12, and the over-voltage trip point is 15. Using R12, set the output voltage to 15. Decrease the resistance of R16 until the SCR trips. When this happens, turn off the power. With the power off, adjust R12 to decrease the voltage. Turn on the supply and readjust R12 for 12 volts.

Now, regulation needs to be checked. Connect a voltmeter across the output terminals with no load connected to the supply. Turn on the supply and record the output voltage. Connect a 10- or 15-A load to the supply and record the voltage. Turn off the supply. The difference between the no-load and 10- or 15-A load voltages should be less than 50 mV. (It is typically less than 20 mV on my prototype.) Higher voltage differences could be caused by the current limit being activated (if near the limit point), or by problems in the sense or single-point ground wiring.

Summary

This supply was originally designed to power a 100-W, solid-state amplifier for 10-meter FM operation. It operated fine in that application for a number of years. At that time, I used only two of the three pass transistors in the supply and was able to get 100 W output from the amplifier without overtaxing the supply. I added the third pass transistor to increase the output current to meet the requirements of some of the newer HF rigs.

The supply now powers VHF equipment in my shack and doubles as a lab bench supply. For applications that need less current, you can build the supply using a single pass transistor. This should prove capable of powering even the newer VHF rigs, many of which now provide 40 to 50 W output. I've had no problems powering a 25-W, 2-meter rig from the supply; with only two pass transistors installed, it doesn't even get warm. I've not experienced any significant RF problems with the supply. The 100-μF and 0.1-μF capacitors across the output terminals shunt any RF on the power lines to ground before it gets inside the supply. If RF problems do arise, better grounding of the equipment in the shack—or better antenna matching—is probably called for.

As presented here, the supply is as modular as possible. This allows you to add (or delete) some parts as cost or needs warrant. The transformer size, number of pass transistors, current limiting, over-voltage protection and metering circuits can all be modified to support your requirements. With a little ingenuity, the core of this supply could find its way into many useful applications in the shack. You might want to modify the supply to provide a 5-V output for a logic supply, or change the voltage-adjust circuit to provide a variable output for use as a bench supply. Whatever the application, this supply can provide you with a reliable power source for years to come.

Notes

[1]Limiters with higher current ratings are available.

[2]ARRL Lab measurements show the surface temperature of the thermistor to be about 100 °C.

[3]U2's heat dissipation is calculated by:

$$P_{(watts)} = 0.7 \times I \times 2 = 21 \qquad \text{(Eq 1)}$$

where I is the maximum delivered current (15 A), 0.7 is a typical diode voltage drop, and 2 is for the two diodes in the bridge that are simultaneously conducting.

[4]In order to determine the power, we also need either the ripple current, or the impedance of the capacitor. The impedance of a 19,000-μF (0.019-F) capacitor at the 120-Hz ripple frequency (120 Hz because of full-wave rectification) is:

$$Z = \frac{1}{(2\pi \times 120\ \text{Hz} \times 0.019\ \text{F})} = 0.07\ \Omega \qquad \text{(Eq 2)}$$

Plugging the 0.07-Ω impedance into the power equation with the measured 1.5 ripple voltage and a 15-A load yields

$$P_{watts} = \frac{V^2}{Z} = \frac{(1.5)^2}{0.07\ \Omega} = 32 \qquad \text{(Eq 3)}$$

Thirty-two watts is a lot of power, so you can see the physical size of the capacitor is important. The larger the capacitor, the better it can dissipate that power.

[5]Simply dividing the maximum required output current (15 A) by the transistor beta, you can determine the drive requirement of the LM723. If we assume betas of 10 for the 2N3055s and 100 for the Darlington, the drive current is required from the LM723 is:

$$I = \frac{\left(\frac{15\ \text{A}}{\beta_{2N3055}}\right)}{\beta_{TIP112}} = \frac{\left(\frac{15}{10}\right)}{100} = 0.015\ \text{A} \qquad \text{(Eq 4)}$$

or 150 mA.

[6]This is caused by manufacturing-process variations in the transistor die that result in different voltage drops across the part. These differences are very small, but can result in large variations in current flow among devices.

[7]The voltage range is determined by the equations:

$$V_{out}\ \text{Upper} = V_{ref}\left(\frac{(3.3 + 1 + 2.2)}{3.3}\right) \qquad \text{(Eq 5)}$$

$$V_{out}\ \text{Lower} = V_{ref}\left(\frac{(3.3 + 1 + 2.2)}{(3.3 + 1)}\right) \qquad \text{(Eq 6)}$$

where 3.3 is the 3.3-kΩ resistance of R7, 2.2 is the 2.2-kΩ resistance of R6 and 1 is the 1-kΩ resistance of R12. U1's reference voltage (V_{ref}) is nominally 7.15 This results in an output-voltage range of 10.8 to 14.1 V dc. The range can be increased by increasing the value of R12. (For example, a 2.5-kΩ potentiometer yields 9.8 to 17.3 V.)

[8]Therefore, the value of the current-limiting resistor for a fixed output is

$$R_{limit} = \frac{0.65\ \text{V}}{I_{out}} \qquad \text{(Eq 7)}$$

[9]For a 1-mA meter movement and 20-V full-scale reading, the resistance should be:

$$R = \frac{20\ \text{V}}{1\ \text{mA}} - R_{meter} \qquad \text{(Eq 8)}$$

where R_{meter} is the dc resistance of the meter movement. See the Test Equipment and Measurements chapter of The *Handbook* for information on how to determine the meter's internal resistance. In recent editions, this is Chapter 25.

[10]Bare PC boards ($15), assembled PC boards ($30) and kits of parts containing the PC board and board-mounted parts ($25) are available from Single Chip Solutions, PO Box 680, New Hartford, CT 06057. Please add $3.50 for shipping and handling charges; Connecticut residents add sales tax.

[11]A PC-board template package is available free of charge from the ARRL. Please address your request for the OSCARSON 12-V, 15-A POWER SUPPLY PC-BOARD TEMPLATE to the Technical Department Secretary, ARRL, 225 Main St, Newington, CT 06111. Please include a business-size SASE.

[12]If the sense resistor you use has a value other than 0.075 Ω, the minimum-current limit is calculated by

$$I_{limit} = \frac{0.65\ \text{V}}{R_{sense}} \qquad \text{(Eq 9)}$$

where R_{sense} is the value of the sense resistor in ohms.