Secrets of XL/XE Power Supplies

by
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Few users appreciate the importance of the power supply that was furnished with their XL or XE computer. For most folks it is an annoyance, adding that much more complexity to what is already a rat's nest of computer cables. Yet, if anything goes wrong inside that mysterious little box, terrible things can happen to your data--or even the computer itself. A power supply is like a dam that regulates the flow of electrons into your machine. If the power supply fails with the electron "floodgate" wide open, the full force of the unregulated DC (10–15 volts) will be fed into the computer: your data, your computer, and maybe your peripherals could end up Kentucky-fried. Pleasant thought, eh?

If the supply fails with the "floodgate" closed, your machine dies quietly (along with your data) while you sit helplessly wondering what the heck happened. If you are the "plan-ahead" type, you frantically reach for your Sams ***Computerfacts*** for the 800XL, or perhaps the ***Atari 800XL Field Service Manual*** You arrive breathless at the page bearing the schematic diagrams, only to discover--to your horror--that the power supply diagram isn't there. Not in the Sams, not in the Atari, nowhere. A classic gotcha.

Semantics and Such

In the time elapsed since the initial publication of this article in *Modern Electronics*, I have noticed a lot of confusion regarding power supplies. Regrettably, much of the confusion has been generated by manufacturers themselves. The term "power supply" itself is frequently abused. Or at least, it is used a little too loosely.

Quite a few black boxes that go between the AC wall socket and a computer component are labelled "power supply" when the only thing inside the box is a plain old transformer (and nothing else). For this type of hardware, the label "power supply" is applicable only in the broadest sense. An external transformer should properly be called an "AC supply." Examples of AC supplies include the Atari CO17945 black box used to power the 400/800 computers, 850 interface and 1050 disk drive, or the CO61636 that powers the 1027 printer. If you look at what's printed on the bottoms of those chunky little boxes, the first words you see are "POWER SUPPLY." Nothing like a little sloppy semantics to muddy things up. Correctly speaking, these are *AC* power supplies. You can tell by looking at the output specs: you see stuff like "9VAC 31VA" or "9.5VAC 40VA." When the voltage is expressed as VAC (volts alternating current) and the power is expressed as VA (volt-amps, same as AC watts), it's an AC supply.

OK, I'm nitpicking. But to someone with a little tech savvy, "power supply" without any modifier or contextual reference usually means "DC power supply." So, AC supply, DC supply, big deal. What's the difference? And who cares, anyway? Well, there's a BIG difference. And you'll care a lot if you ever manage to somehow plug an AC supply into a jack that requires DC, or vice-versa. You'll care even more when you open your wallet to pay for the mistake.

At the minimum, a DC power supply consists of an AC supply plus a rectifier to convert the AC into DC (direct current, the kind you get from a flashlight battery). ALL common electronic appliances--computers, TV, radio, stereo--require DC to operate. The rectifier is composed of one or more solid state diodes. Usually a power supply contains lots of other stuff as well--fuses, switches, pilot lights, surge absorbers, filter capacitors, and IC or transistor regulators. The added complexity of the DC supply makes it more susceptible to failure, and more expensive to repair or replace, compared to a plug-in transformer.

A few clever merchandisers avoid the AC/DC power supply semantics problem altogether by advertising replacement power supplies as "power packs" (groan!). In tekkie parlance the term "power pack" usually implies some form of *portable* DC supply; i.e., a battery pack, used to power calculators, laptop computers or portable video camcorders. "Power pack" might mean just a battery pack alone, or a battery pack that includes a DC supply that both recharges the batteries and furnishes DC power to the appliance. I really wince when I see ads that pass off AC supplies as "power packs."

Tech Stuff

A power supply is distinguished from an AC supply by having its output rated so many volts DC at a maximum current of so many amperes. If you multiply the volts times the amps you get the total

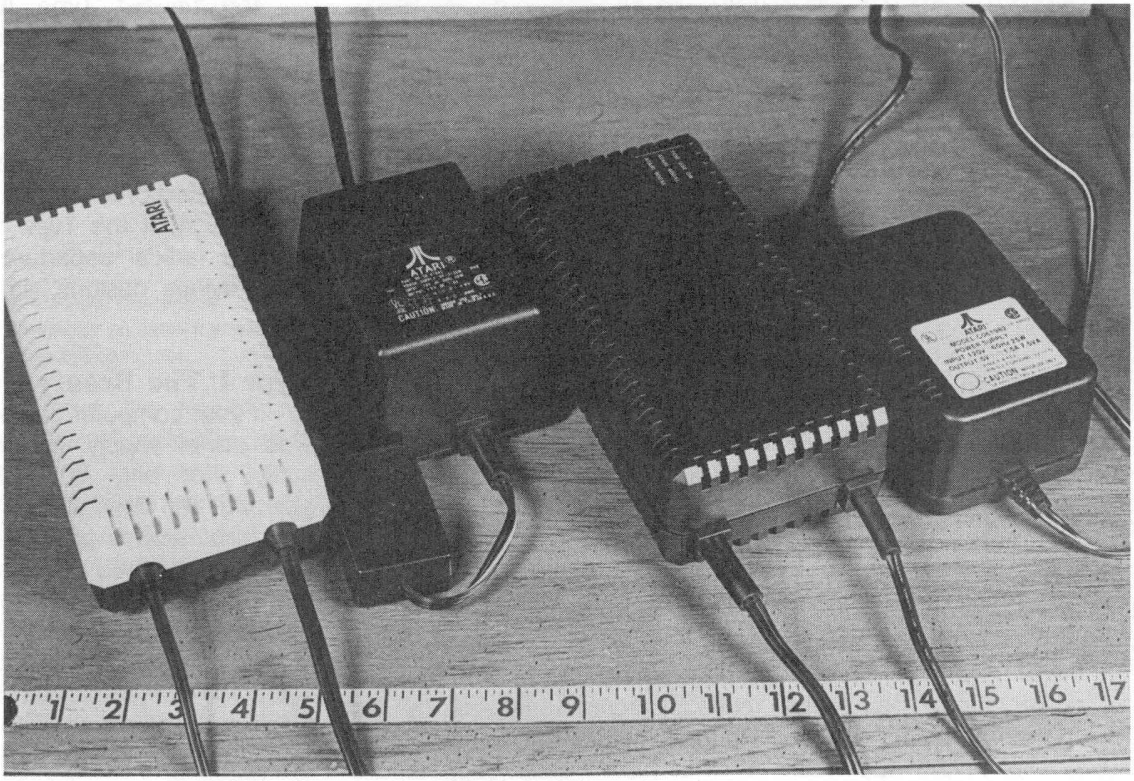

Figure 1. Pictured here are the four major configurations of power supplies furnished with Atari XL computers arranged from Type I through Type IV left to right. All photos by the author.

power output of the supply in watts. Thus, a regulated 9.5VDC supply that can put out up to 4.2 amps will produce a maximum of 40 watts. All power supplies for the Atari XL/XE computers are DC supplies that convert the 120 volt AC line into filtered, regulated, +5 volts DC. "Filtered" means all the AC components have been filtered from the DC output so the voltage is indistinguishable from the DC produced by a battery. "Regulated" means that the supply will deliver a steady +5 volts whether the computer is supporting a ROMcart plus external gadgets (and drawing lots of current) or is just idling by itself (minimal current). A computer working its butt off needs more power than one that's just loafing. Some people think that during peak demand the power supply gives the computer "a few extra volts" to "help it along." Not in a million years!

Computer microchips are very fussy about the electricity that feeds them. More than 5 volts, they burn up. Less than 5 volts, their brains get scrambled--along with your data--or they just don't work at all. So the power supply has to maintain that 5 volts rock-steady at all times. A computer that is working up a sweat gets its extra power by drawing more *current* from the supply. In other words, the power supply feeds a constant 5 volts to the computer at all times and also supplies a varying amount of current according to how hard the computer is working. For example, my 256K RAMBOed 800XL draws about 0.75 amps (750 milliamps) from the 5-volt supply at idle. With a 16K ROMcart installed, the computer might consume upwards of 800 milliamps (abbreviated mA). Start adding things that draw power from the computer--modems, interfaces, print buffers, more RAM, extra OS ROMs, etc., and the total current demand could easily get up in the 1200-1800mA range.

All the Atari 8-bit supplies are officially rated to deliver a maximum 1500mA of current at 5VDC (none of them actually deliver that much). What happens if you keep hanging power-hungry gadgets onto the computer? As increasing amounts of current are delivered, the supply gets hotter--especially the regulator. Regulators have built-in defenses against thermal destruction: they first start allowing the +5V to "droop" a little, perhaps down to 4-4.5V. If that doesn't work, and things start to get really hot, the regulator will shut down completely and not pass any voltage at all until things have cooled down to a safe temperature. Add too many power-hungry goodies onto your machine, your power supply will likely overheat and shut itself down. If you want to draw more current, you gotta get a bigger supply with a bigger regulator and a bigger heatsink to dissipate that heat.

Briefly, here is what your Atari power supply does. The transformer in it steps down the 120VAC from the wall to a safe level (around 8-12VAC), rectifies it to DC with diodes, filters the residual AC from

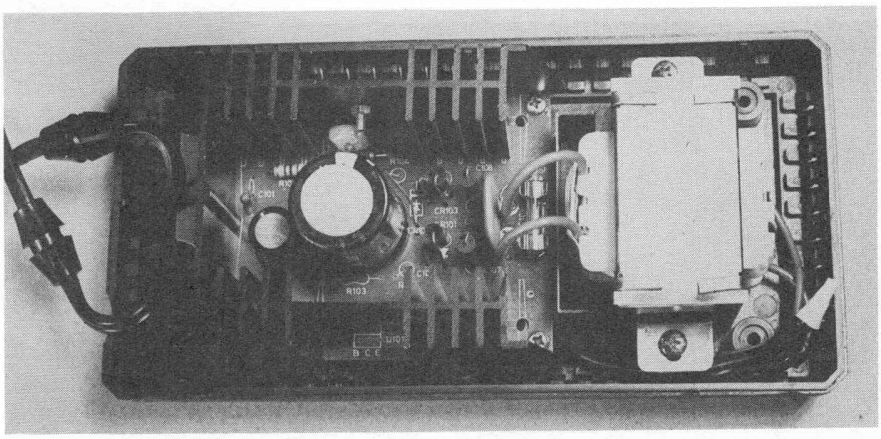

Figure 2. This is the interior view of the author's Type I power supply, slightly modified.

the DC with capacitors, regulates it down to the +5VDC required by your computer, and stands ready to defend itself against overdrafts of current. There's a lot of action going on there! And you wonder why your power supply box feels warm? Given that the power supply is absolutely vital to the operation of the computer, it's doubly mysterious that the available hardware manuals virtually ignore it. The reason may be that at least four different types of supplies were shipped with the 800XL!

A Plethora of Supplies

Figure 1 on page 43 shows the four major types of power supplies that were shipped at various times with the 800XL. The units are arranged and numbered roughly in order of their appearance in the marketplace. Type I on the left was shipped with early production models until about the winter of 1984. It is the prettiest of the power supply boxes and is the only one made in Hong Kong--all the rest are made in Taiwan.

The Type II supply appeared in 1984 prior to the Tramiel takeover. It seems to be the most frequently encountered type of XL power supply. It is also the hottest, heaviest, and ugliest.

I encountered the Type III by chance in 1985 in a shipment of 800XLs containing the most recent Type IV supply. Although black in color like the Type II, the Type III has the stylish appearance of the Type I and appears to be the only one specified for use with either the 600XL or 800XL.

The newest Type IV supply began shipping with some 800XLs in the spring of 1985. The Type IV was also standard issue for the XE computers. It is the smallest, lightest, coolest, and most electronically sophisticated of the XL/XE supplies. The design of the Type IV represents a radical departure from all the previous designs, as we shall see.

Type I: The Beauty Queen

If your computer came with this type power supply, count yourself lucky. Not only is it the most powerful and aesthetically pleasing, it is also *repairable*. Access to the interior is obtained by first removing the four rubber feet from the bottom (they are held in place by soft glue, so pull hard). Under each foot is a screw that can be removed with a Philips screwdriver. You can then remove the top cover.

Figure 2 is an interior view of this supply, and its schematic diagram is in Figure 3. The component most likely to fail in this circuit is the 3-amp fuse; you can buy a replacement inexpensively at Radio Shack. The critical component in this supply is the *U102* 7805 voltage regulator chip. The 7805 is fastened to the large heat sink that completely surrounds the circuit board. The Type I supply has the largest heatsink of the four supplies. The cooling fins on the heatsink carry

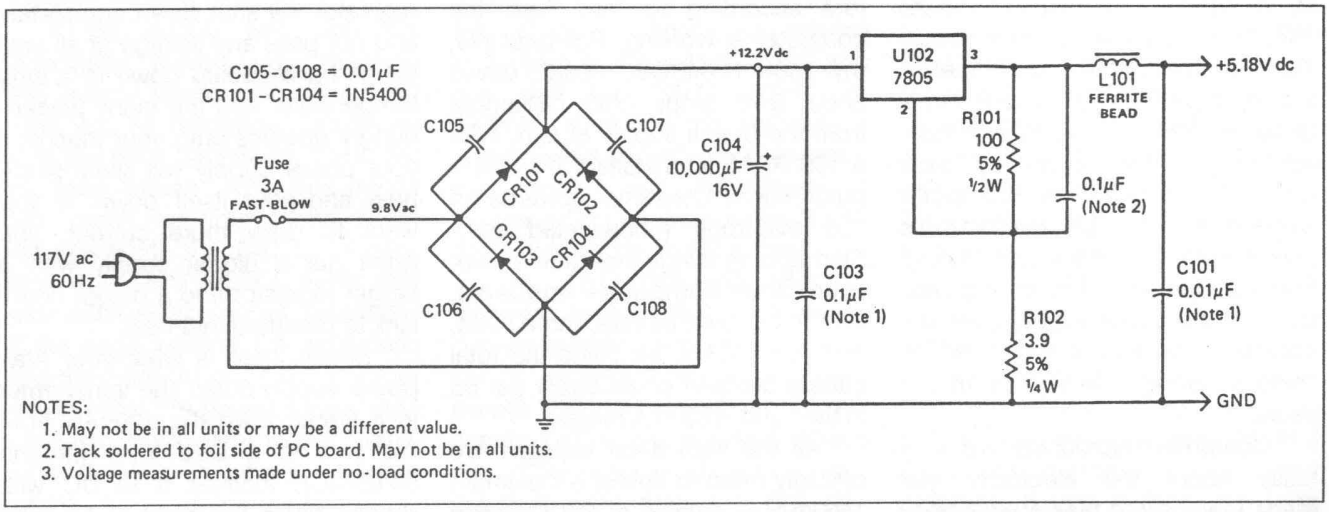

Figure 3. This is the schematic diagram of the Type I power supply. Component designations in all schematics correspond to locations screened on pc boards.

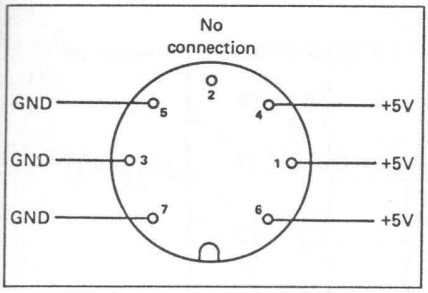

Figure 4. Pinout descriptions for XL/XE connector on cable that goes to the computer.

heat away from the regulator to prevent its thermal protection circuit from activating prematurely; this allows the Type I to deliver more current than any of the other power supplies. The connector pinout (Figure 4) of the Beauty Queen is the standard hardware for all the Atari XL/XE computers.

Eyeballing Figures 3 and 4, you can see all the usual components one would expect: the AC step–down transformer, the rectifier diodes, the filter capacitor (large round cylinder in the center of the circuit board); the 7805 regulator is hidden by the heatsink. However, there are some extra parts present whose function might not be so obvious. For example, the small ceramic capacitors *C105–C108* in parallel with the diodes: these little caps bypass any radio frequency (RF) noise to ground. The small capacitor *C103* serves a similar function. Capacitor *C101*, along with inductor *L101* and the un–designated .1uF capacitor, together form a filter to suppress any RF that might be "riding along" on the DC output.

Notice that the output of the supply is a smidge higher than 5 volts––it's actually almost 5.2 volts. This slight voltage boost is pro–duced by the trim resistors *R101* and *R102*. Apparently the idea here was to compensate for the slight resistive voltage loss in the con–necting cable, which is typically .1–.2 volts. This insures that the voltage arriving at the power jack on the computer will be pretty close to the specified 5 volts. This voltage boost is not obtained for free, however. The trim resistors them–selves consume about 50mA of the available output current; if there was 1500mA available to start with, only 1450mA are now available to the computer.

In addition to the usual Atari part number, the Beauty Queen's circuit board also has screened spaces for additional parts that probably aren't in your unit. Those empty spaces give the appearance that someone at the old (Warner) Atari tried to save money by shav–ing parts. My alter ego, the 8–Bit Alchemist, has done a thorough job of reverse–engineering the board markings to decipher what the ori–ginal circuit design might have been. Indications are that the ori–ginal design was much heftier, capable of supplying upwards of 2000mA. I understand the Alchemist plans to publish a rebuild of the Type I supply, a knock–off of Atari's original design, in one of his future columns in *Current Notes*.

Type II: The Ugly Klunker

If you're using this type supply and it poops out, you can't fix it. Atari can't fix it either! Figure 5 shows why. The *entire* circuit, transformer and all, is permanently sealed in thermoset potting com–pound. The outer plastic case is permanently sealed, too. I had to use special tools to cut open the one shown in the photo. After several hours of operation, the Klunker gets uncomfortably warm, which probably means its internal circuitry is similar to Types I and III. It's very discouraging to think that buried somewhere in the interior of that chunk of plastic may be a 50–cent fuse whose failure will result in trashing the entire unit. Man, I hate stuff that's made like that!

What do you do if your Klunker croaks? Replacements are available from Atari, some local dealers, or the mailorder houses. Prices typi–cally run $25–$40, plus shipping or taxes. You could also build your own replacement from commonly available parts, which might run you $20 or less depending on where you get your parts. The diagram for a suggested replacement using Radio Shack parts is shown in Figure 6. The AC line cord and power cable/connector assembly can be salvaged from your defec–

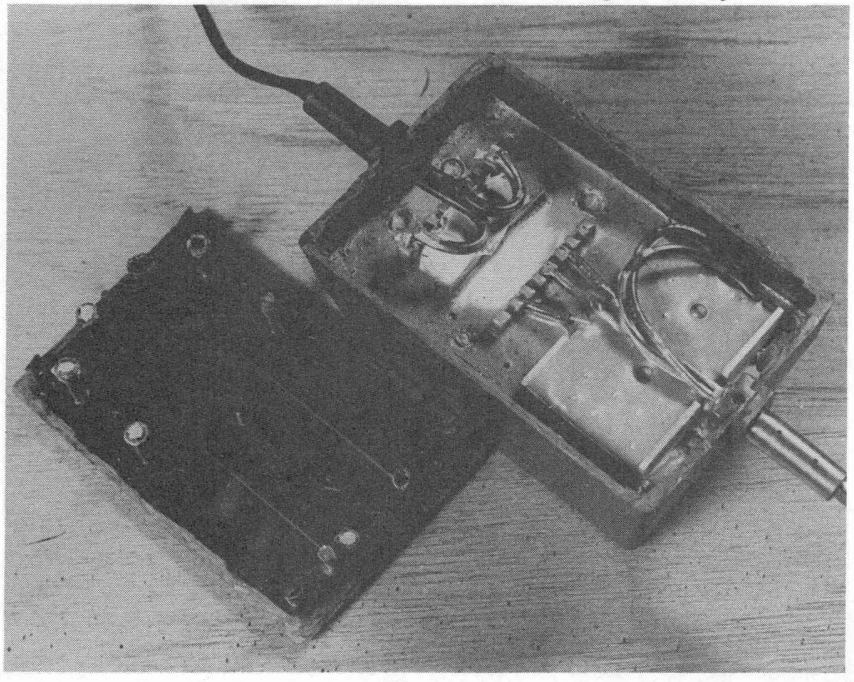

Figure 5. Note in this photo of the Type II power supply the entire unit is permanently sealed in plastic potting compound; it can't be repaired.

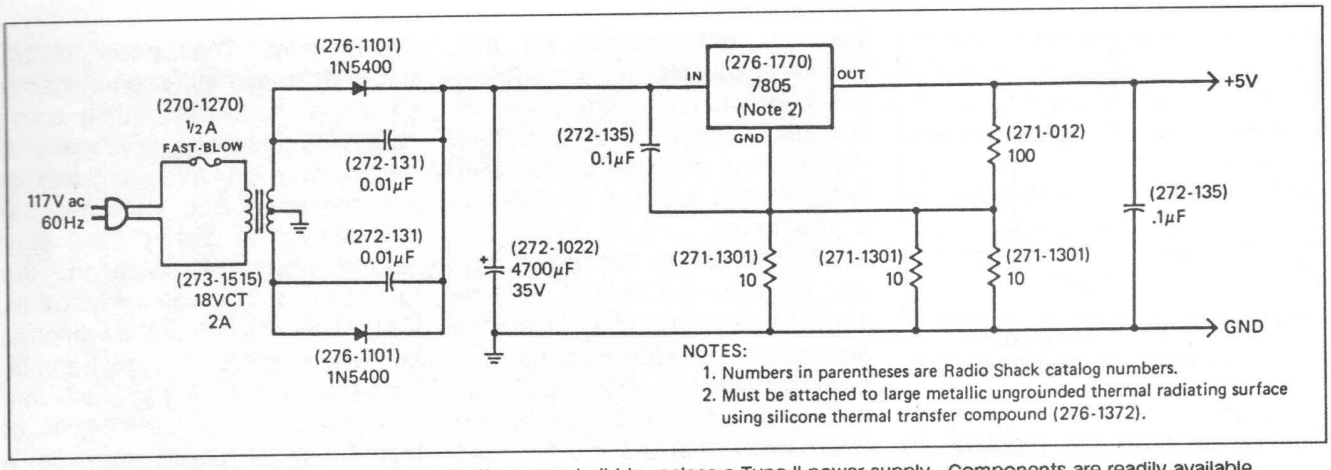

Figure 6. Schematic of a power supply circuit you can build to replace a Type II power supply. Components are readily available.

tive Klunker for re-use. A PC board isn't required, since the parts can be mounted in a suitable enclosure using 5-lug terminal strips. Be VERY careful if you go this route; since the supply connects to the AC line, a potential electrocution hazard exists if things aren't insulated from the chassis and wired properly. You MUST check the voltage at each pin of the output connector before you connect any homebrew supply to your computer. If you have accidentally wired the connector cable with reversed polarity (hey, it happens!) you will get fireworks when you boot up your machine.

The Type II is the only supply I'm aware of that came with an externally mounted device to suppress RF interference. This is the little black plastic box attached to the power cable that goes to the computer. Figure 7 shows the innards of this mysterious little box. It is just a ferrite core around which the power cord has been wound three times in one direction and three times in the opposite direction. This same device is also used on the video cable that connects the computer to a TV.

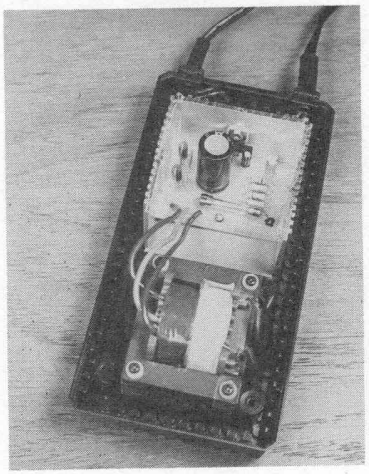

Figure 7.A radio-frequency interference suppressor for the Type II power cord is inside a plastic box near the end of the cable that goes to the computer.

Type III: The Black Beauty

This is the simplest and easiest to repair of the XL supplies. The neat, streamlined appearance of the interior of this unit is shown in Figure 8. Its schematic diagram (Figure 9) is similar to that of the suggested replacement for the Type II supply. Access to the interior of this unit is obtained in the same manner as for the Type I supply.

The transformer in the Figure 6 / Figure 9 circuits uses a center-tapped secondary winding, so only two rectifier diodes are required to provide "full-wave" rectification of the AC voltage. With its low parts count and simple layout, this looks like the power supply Atari should have furnished with all the XL/XE machines in the first place. Why they didn't is anybody's guess.

An interesting voltage trimming feature in this supply not only compensates for voltage drop in the power cable but is also capable

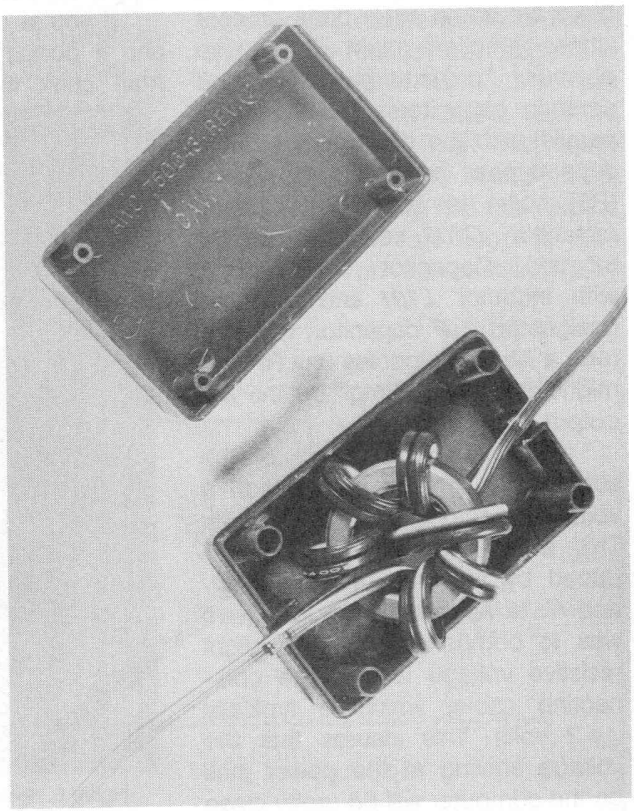

Figure 8. An interior view of the Type III supply.

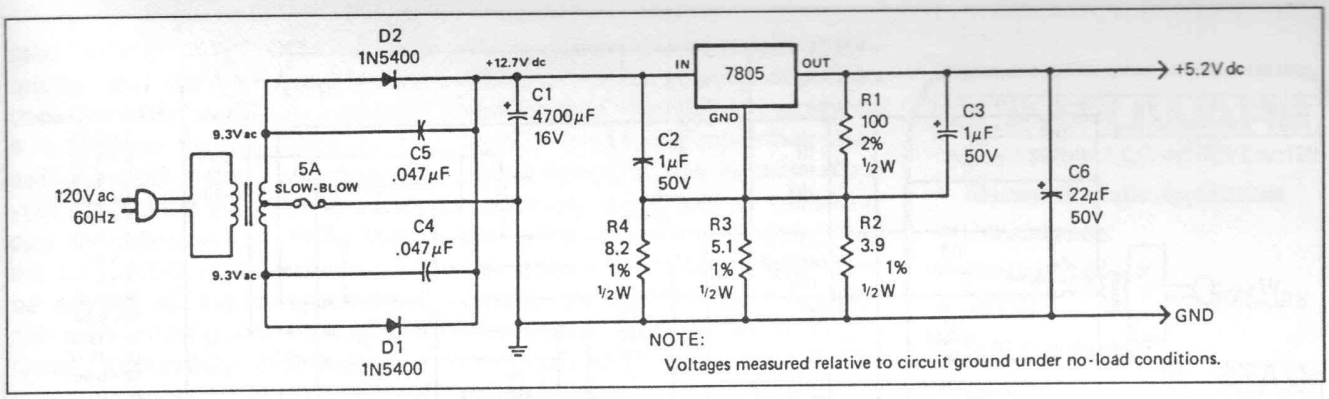

Figure 9. Schematic diagram of the Type III supply.

of compensating for slight differences in the outputs of individual 7805 regulators. The combined value of *R2*, *R3*, and *R4* is 1.8 ohms. Together with R1 they provide a 1.8% boost in the output voltage. It is possible that in some Type III supplies one or more of these resistors will be missing. This circuit has been cleverly designed so that if the voltage going into the computer is a little low, it can be raised simply by snipping out one or two resistors such that the remaining combination yields the desired voltage within a range of seven values from 1.8% to 8.2%. Whoever laid out this circuit had his thinking cap on.

Type IV: The Peanut

If the Type III supply caused Atari's power supply designer to sweat a little, then the Type IV must have given him paraplectic fits. In the Type IV, the elegant simplicity of the Black Beauty has been completely abandoned. As you can see in Figure 10, the small circuit board is densely packed with many components. The relative complexity of the circuit is fully revealed in the Figure 11 schematic.

The "brain" of this supply is the 14-pin 723 low-power voltage regulator. This chip regulates the output voltage very precisely but by itself is not husky enough to deliver all the current demanded by an XL or XE computer. To overcome this deficiency, the 2SD613 external pass transistor is used as the "muscle" to provide the heavy drains of output current.

The Peanut is really two power supplies in one. Hefty rectifier diodes *D3* and *D4* provide the primary unregulated DC voltage that feeds the pass transistor and powers the computer. The smaller *D1* and *D2* rectifiers provide a secondary supply that's used entirely to power the 723 regulator.

Various reference and bias voltages required for proper operation of the 723 are provided by the complicated-looking *R2* through *R7* network. Surge protection for the regulator chip is provided by *R1*, while *R8* serves a similar function for the pass transistor. Resistor *R9* is a sensing element used by the regulator to limit output current to a safe level. The diode *D5* is an odd part: apparently Atari didn't trust the factory to install the output cable with the correct polarity; D5 protects the computer against serious damage in the event a reversed polarity connector is attached to the computer.

The Peanut supply is repairable, but Atari has done a good job of discouraging repairs by packaging the Type IV in a permanently sealed plastic box similar to the Type II supply. It would be very difficult for most Atari owners to open the case without irreparably damaging it ("cracking the Peanut's shell"?). I had to work very carefully with a variable-speed Moto-Tool fitted with an abrasive cutting wheel to expose the innards you see in Figure 10. If you manage to get this far and complete whatever repairs are required, you must then figure out how to reseal the case. If your

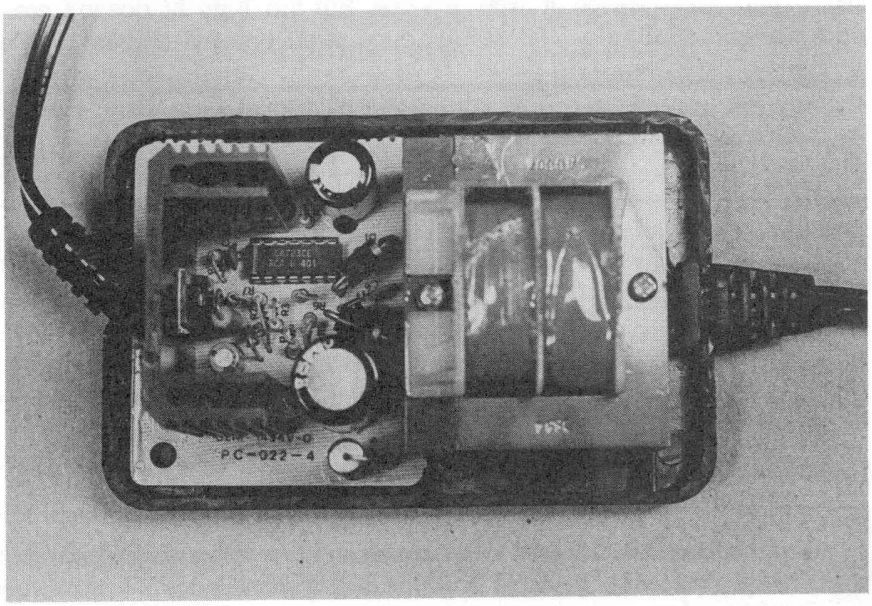

Figure 10. Peanut (Type IV supply) with shell removed.

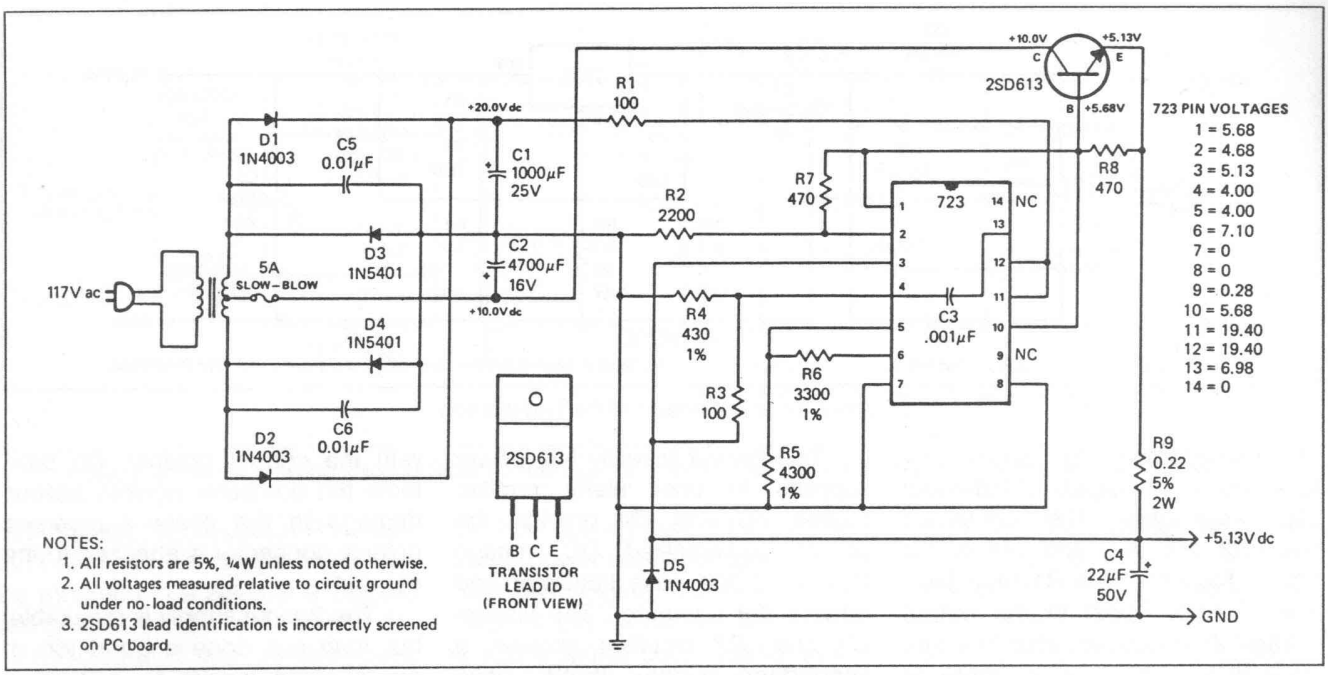

Figure 11. Schematic diagram of the Type IV power supply.

incision is relatively clean all around the base, a thin bead of Super Glue placed around the exposed cut edge of one case half will suffice to stick it back together again. Then apply heavy pressure to both halves for at least 15 minutes to insure a good bond.

Once you've gotten to the inside (kernel?) of your Peanut, you could look at the fuse, any of the diodes, the regulator chip, or the pass transistor as likely sources of trouble. If you discover a bad transistor, you can replace it with a commonly available TIP3055 device. If the 723 is defective, you'll have to desolder and remove it--without damaging the printed circuit board--in order to replace it. Both the 723 and the TIP3055 transistor are stock items at Radio Shack.

With all its hi-tech complexity, I found the Type IV supply the poorest performer of the lot when it comes to delivering current. The other supplies all deliver in excess of one ampere at their rated voltage under conditions simulating actual use. But the Type IV doesn't produce even one full ampere. While this apparently doesn't hamper normal computer operation, it does suggest a slimmer margin of reliability in locations where the AC line is subject to fluctuation or you are using a machine with lots of extra goodies plugged in.

One aspect of the Peanut's design that gives me the creeps relates to the pass transistor. As I mentioned in the beginning of this article, it is possible for a power supply to fail with the electron floodgate either closed or open. The 7805 regulator used in Types I-III almost always fails with the

Table 1
Atari XL/XE Power Supply Characteristics

Characteristic	I	II	III	IV
Aesthetic appeal	superb	rotten	nice	so-so
Interior accessibility	easy	impossible	easy	difficult
Ease of repair	easy	impossible	easy	tedious
Output: Rated Amperes	1.5	1.5	1.5	1.5
Rated Volts	5.0	5.0	5.0	5.0
Measured Amperes	1.44	1.15	1.29	0.93
Measured Volts	4.90	4.90	4.90	4.90

Test Method: Output loaded with increasingly lower values of resistance until regulated voltage drops to 4.90. Current obtained by dividing 4.90 by the measured final value of load resistance using a digital multimeter, input Z=10 Megohms.

gate "closed": your machine dies quietly but suffers no physical damage. With the Type IV, however, it is possible for the supply to fail with the gate "open" and blow up your machine. If the 2SD613 develops a collector-to-emitter short, the full 10VDC at the collector will be passed to the computer: you can start sobbing when the smoke clears. Fortunately this disastrous scenario appears to be a rare occurrence, but mostly people have been lucky. If I seem to be railing against the Peanut, well, maybe I am. Gimme a Klunker any day.

Winding Down

By now, you should know what type of power supply your Atari XL or XE computer has, what its circuitry looks like, and whether or not it's repairable. In Table 1, I have summarized the major features of the different power supplies along with a comparison of output specifications versus actually measured performance. Despite considerable variation in ability to meet their rated output specs, all four supplies do a reasonably good job of delivering the "juice" to your computer. They also appear to be fairly rugged and reliable in normal use. Hopefully, you'll never have occasion to put the information presented in this article to use.

And finally, I need to thank a couple of fellows without whose cooperation I could not have prepared this article. Leon Hall and Jack Leber deserve the gratitude of 8-bit Atarians for courageously loaning me their power supplies. They allowed me to carve up their power supplies and commit various atrocities upon them, with no guarantee they would be returned in one piece! In whom but an Atarian will you find that kind of trust?