Troubleshooting the Power Supply in the Bally/Astrocade Home Computer System
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This article is for the individual desiring to learn how to troubleshoot the power supply in the Bally/Astrocade home computer. Included is info and troubleshooting tips that may help locate a failure within the power supply.

I hope that this information proves helpful to those with failing Astrocades. Remember, working with power supplies can be dangerous; be careful!

My first recommendation when troubleshooting a motherboard is to plug its black power transformer into a low amp FUSED 120VAC source. The fuse may help protect your motherboard and the black power XFMR in the event a short to ground occurs within the power supply or other areas. You probably will have to build a fused 120VAC source. Jameco Electronics sells a fast acting fuse as low as 250mA (part #69404), which is what I use in my hi-res Astrocade.

A few weeks ago, I purchased a nonworking Astrocade from EBay. When I hooked it up and turned the power on, absolutely nothing happened on the TV screen. When I removed the console cover, I took just one voltage reading on a TTL chip. There was no +5V present.

My second look at this Astrocade was to determine how many of the 4 DC supply voltages were actually present, if any. I just plugged in the black power XFMR into a power strip. Little did I know that the motherboard's power supply was shorted. As I was checking the 4 DC supply voltages and pwr XFMR sec AC voltages, I wasn't paying attention to the pwr XFMR which was heating up. This XFMR just kept overheating until its primary winding burned out. I learned the hard way to never again plug a Bally pwr XFMR into an unfused 120VAC source.

THE POWER TRANSFORMER

The XFMR's rms (root means square) ratings are indicated on its plastic housing along with the secondary wire color coding. The XFMR secondary has 3 windings wired in series. The two end windings are identical and typically rated 85mA@11.5VAC. The center winding is typically rated 1.0A@7.5VAC. The center winding is used for the motherboard's +5VDC supply.

You can use an ohmmeter to check if there is a break (open) in the primary or the 3 sec windings. Use the ohmmeter RX1 range. An intact secondary winding will read nearly zero ohms and an intact primary winding will read a little higher in ohms. If the winding is open, the ohmmeter will remain at infinity. You can also check the sec AC voltages using an AC voltmeter. Disconnect the brown sec wire connector from the motherboard and tape it down. You will probably have to wind some bus wire or solid core hookup wire around the voltmeter test probe tips to make contact with the 4 color coded wire contacts. The 2 center contacts red-yel (or red-grn) are the center winding. Plug in the XFMR and measure the 3 sec voltages, end to ctr, ctr to ctr and the other end to ctr. Expect normal voltages to be a little higher than the XFMR's rated voltages because you are measuring these sec voltages with no load

(disconnected). Note also because the sec windings are symmetrical, you can "turn around" that brown connector and plug it into the motherboard. It doesn't matter which way you plug it in.

You can build a substitute power XFMR for the Bally black pwr XFMR. See my article in "The Arcadian", 1986, p.92-93 and 91, which is archived on the BallyAlley.com website. You can add a fuse to this substitute's primary winding. You can also place next to this substitute a quick connect breadboard strip. With some extra components like a sec fuse, bridge rectifier, caps, load resistor, etc., you can wire a test circuit to one of the end sec windings on the substitute XFMR or center winding depending on which motherboard component(s) you want to test. So, for example, you could de-solder a suspicious voltage regulator plus maybe a high capacitance electrolytic cap C6 or C1 and breadboard a test circuit to see if they are operating properly. This breadboard test technique would allow you to check specific components within the motherboard power supply without actually turning on the motherboard and risking further damage to motherboard components. I have ordered 2 Jameco XFMRs (part#2231152 and 102593) that may be well suited as a substitute XFMR. I plan to wire these 2 Jameco XFMRs and test/document this substitute configuration. I will also check to see if this configuration is ok for long term use with a motherboard. If the configuration is acceptable, the documentation will be submitted to the Bally Alley for review and possible archival. The documentation would include breadboard test circuit examples and more.

FULL-WAVE RECTIFIERS

The motherboard utilizes an unusual 8 diode rectifier configuration providing full-wave rectification to four power supplies, +12V (or 15V), +10V, +5V and -5VDC. Each full-wave rectifier converts the input alternating current (AC) into direct current (DC).

The full-wave rectifier CR3, CR4, CR5 and CR6 is used for the +5V supply. In this case, the AC in one direction flows thru CR3 and back through CR6. The AC in the other direction flows through CR5 and back through CR4. If the secondary center winding produces 7.5VAC rms (as rated on the pwr XFMR plastic housing), the peak DC voltage would be 7.5x1.414=10.6V, excluding the diode drop off voltages. The 10,000uF capacitor C6 tries to maintain near peak voltage. When the +5V supply is operating, you will normally measure less than 10VDC across the C6 cap.

The full-wave rectifier for the +12V and +10V supplies operates similarly in one direction flowing through CR1 and back through CR6 and in the other direction, flowing through CR7 and returning through CR4. The peak DC voltage would be (11.5+7.5)x1.414=26.9VDC, excluding diode drop off voltages. The normal operating voltage across the 1500uF C1 cap is under 25VDC.

The voltage ratings indicated on the 1500uF C1 and 100uF C10 caps are normally 25V and 16V respectively. I have seen on the 10,000uF C6 cap ratings of 10V or 16V. I measured the voltages, IMMEDIATELY at power on, across the 3 caps on several motherboards with different pwr XFMRs and here are my observations:

1500uF C1, VC1=less than 25V
10,000uF C6, VC6=less than 10V

100uF C10, VC10=at or slightly less than 16V.

The voltages across caps C1 and C6 will drop a little more when the motherboard runs for quite some time. The operating voltage for cap C10 is at or very close to its 16V rating and does not seem to change even if the motherboard runs for some time.

Note that the 10,000uF cap C6 is NOT switched off by the motherboard power switch (see motherboard schematic). When the Bally black XFMR is plugged into a 120VAC source, the full-wave rectifier CR3 thru CR6 and cap C6 ARE ACTIVE. Also, you will likely see a voltage across cap C6 near or exceeding its 10V rating. I read that the voltage rating of a capacitor is the maximum amount of voltage that the capacitor can hold. Exceeding this voltage can damage the capacitor causing its dielectric to breakdown. It may be advisable to turn on the motherboard power switch IMMEDIATELY when you plug in the black power XFMR so that the voltage across C6 drops below 10VDC. Likewise, when you are finished using your Bally/Astrocade, turn off the motherboard and pull out the black XFMR (or turn off the power strip). Note also, when the motherboard power supply is turned off and the black pwr XFMR is removed from the 120VAC source, there is still a substantial charge across C6 and takes quite some time to discharge by itself.

You can perform a basic check on a rectifier diode using an ohmmeter. A diode acts like a switch. When it is forward biased, the anode (P material) is positive with respect to its cathode (N material), it turns on and conducts current. When it is reverse biased, the cathode is positive with respect to its anode, it turns off. The cathode end of a diode is marked with a stripe.

Checking a loose diode with an ohmmeter is easy. Just place the ohmmeter's test leads across each diode end, read the ohmmeter, swap the test leads and read the ohmmeter again. The ohmmeter will read either high or low ohms. A good diode will read low (only a few ohms, on) when forward biased and very high ohms (off) when reverse biased. A diode is shorted if both readings show zero ohms. A diode is also bad (open) if both readings indicate very high ohms (infinity).

You can perform a basic check on all 8 rectifier diodes without de-soldering them and with the power off. Remove the brown pwr XFMR wire connector from the motherboard. Push the motherboard power switch to the "on" position. Look at the motherboard schematic (upper left) and use the ohmmeter to identify the line inputs 1 thru 4 and attach a label with these numbers to the metal shielding by those inputs. Place one ohmmeter test lead at the appropriate line number and the other test lead at the diode wired to that line number. Place that 2nd test lead on the diode's anode or cathode, depending on which diode you are checking. Read the ohmmeter, swap the test leads and read the ohmmeter again. If you read low and high ohms, the ohmmeter is indicating the diode is switching on and off. Repeat a similar procedure for all 8 diodes if so desired.

CHECKING CAPACITORS FOR SHORTS

It looks like you can check capacitors with an ohmmeter, to see if a cap is shorted. An analog ohmmeter would be preferable because you can watch the

needle swing right or left. Your local hardware store sells inexpensive analog multimeters. The Astrocade mentioned above that I was troubleshooting had a shorted 15uF electrolytic C8 cap. My ohmmeter indicated it was shorted reading zero ohms. If you suspect an electrolytic cap on the motherboard might be shorted, turn off the power completely (including the black pwr XFMR) to the motherboard and use a voltmeter to see if it has a charge on it. Be careful the test probe tips don't touch other components or motherboard traces. To avoid possible shock when testing the 10,000uF cap, which may have a substantial charge on it, hook up one voltmeter test lead at a time. Avoid hooking up both test leads simultaneously with both hands. Also, don't let the pos test lead fall down onto any metal shielding which is grounded. If the cap does have a charge on it, it CAN'T be shorted. If the voltmeter does indicate the cap is charged, you can let the voltmeter completely discharge the cap. If the voltmeter reads zero volts across the cap initially, you can check it for a short.

If you suspect an electrolytic cap is shorted and it has no charge on it, you can de-solder one end of it and raise that end away from the motherboard. An ohmmeter utilizes a small internal battery. So, if you check an electrolytic with an ohmmeter and that cap is not shorted and the cap will hold a charge, you will during the reading actually place a small charge on the cap. Observe polarities. You may have to put the red test lead in the ohmmeter neg jack and the black test lead in the pos jack because of that ohmmeter internal battery. Swapping the leads like this makes it less confusing (similar to testing a -5V supply). If the cap is not shorted and discharged and is able to hold a charge, you should see the ohmmeter needle briefly swing to zero and then to infinity. You can try this check just once, but then you will have to discharge the cap if you want to run another check on it. Practice this technique on a spare cap first until you get the technique established in your mind. I have tried this technique on a spare working 1000uF cap and also a 4700uF cap. I read that if an ohmmeter reads less than 500k ohms (when the needle stops swinging left) it may be leaking. Also, a damaged electrolytic cap may have a whitish deposit at the seal around the terminals.

Voltage regulator input capacitors C2, C4, C8 and C11, if shorted, have the potential to burn out the black pwr XFMR. Caps C2 and C4 have a lower risk because they are wired to a series resistor. Cap C2 is likely wired to a 24 ohm, 1/2W resistor instead of a jumper as suggested on the schematic. Note Cap C8 (6.8 possibly 15uF) is wired to all 3 positive DC supplies. If cap C8 shorts, it will shut down all 3 of these supplies. Of course the 3 filter caps C1, C6 and C10 could short out and damage the pwr XFMR. This is why I highly recommend plugging the pwr XFMR into a fused 120VAC source, to help protect the XFMR and possibly other components from a short to ground. When I used my fused substitute XFMR on my Astrocade described above, the shorted C8 cap would blow out the 1A fuse in the XFMR primary. This particular substitute did have oversized XFMRS, but the substitute I plan to build mentioned above will be closer in size to the Bally black XFMR.

The voltage regulator output caps C3, C5, C9, C12 and the downline "chip bypass" caps, if shorted, will at least, I believe, shutdown a voltage regulator which has some kind of internal short circuit protection.

VOLTAGE REGULATORS AND DECOUPLING CAPACITORS

I spent a little time on the internet trying to find some info regarding a voltage regulator's internal short circuit protection. I didn't have any luck finding info on this feature. At this time, I'm assuming it just attempts to protect the regulator should there be an output short to ground. I have seen a bad regulator with a normal input voltage, but no output voltage. A suspected bad voltage regulator could be removed from the motherboard and tested in a breadboarded test circuit. A shorted output cap or downline "chip bypass" cap would, I believe, yield a near zero voltage on the regulator's output. In the event you find a reg with no output voltage, it might be a good idea to remove the reg from the motherboard and then check the output line for a shorted cap as described above making sure first that the output line has no charge on it. If there is a little charge on the line, that's an indication no shorted cap is wired to the line. As far as I know, the +10V line has no electrolytic bypass caps wired to it. The other 3 DC supply lines do have some electrolytics wired to them, but they may not hold a charge for very long.

POWER TRANSISTOR Q1

You can perform a basic check of Q1 using an ohmmeter. De-solder the end of the 240 ohm resistor R2 which will leave the base (B) of Q1 disconnected allowing you to check Q1 from the bottom of the motherboard. This transistor is a type NPN transistor and can be viewed as 2 diodes connected together at their anodes (P material) end. The joining of the two anodes would be the base (B) of Q1. You can check these 2 junctions, B-E and B-C just like checking a diode as described above. If you check the junction C-E and the ohmmeter indicates a short (zero ohms), say good-bye to your motherboard chips because the +5V power supply line most likely exceeded well over +5V which will zap the chips.

REMOVE BOTTOM MOTHERBOARD SHIELDING

One final recommendation is to remove the motherboard's bottom shielding panel when just taking test readings along the edge of the motherboard, even if you are not clipping a lead onto a component. I made a mistake and placed an uninsulated alligator clip on the pos (+) end of the 10,000uF cap C6 because I wanted to monitor its voltage when I switched on the motherboard power. While the motherboard power was on, the alligator clip fell and touched the metal shielding which is normally grounded. Ouch! I saw a very large spark. I was lucky because the Bally black power XFMR was plugged into my home built fused 120VAC receptacle. The 1A fuse on the XFMR primary winding blew and saved, I'm sure, my motherboard from damage. So, play it safe and remove that metal shielding. Then use a clip on jumper and ground the RF modulator metal housing to the NEG lead of that large 1500uF electrolytic C1 cap on the right side of the motherboard. Watch out you don't connect the jumper on C1's pos end.

The two photos below show the locations of the 3 electrolytic filter caps within the power supply I would label as "caps of concern" because they operate close to their maximum voltage ratings. They are caps C1, C6 and C10 rated 1500uF, 10,000uF and 100uF respectively.

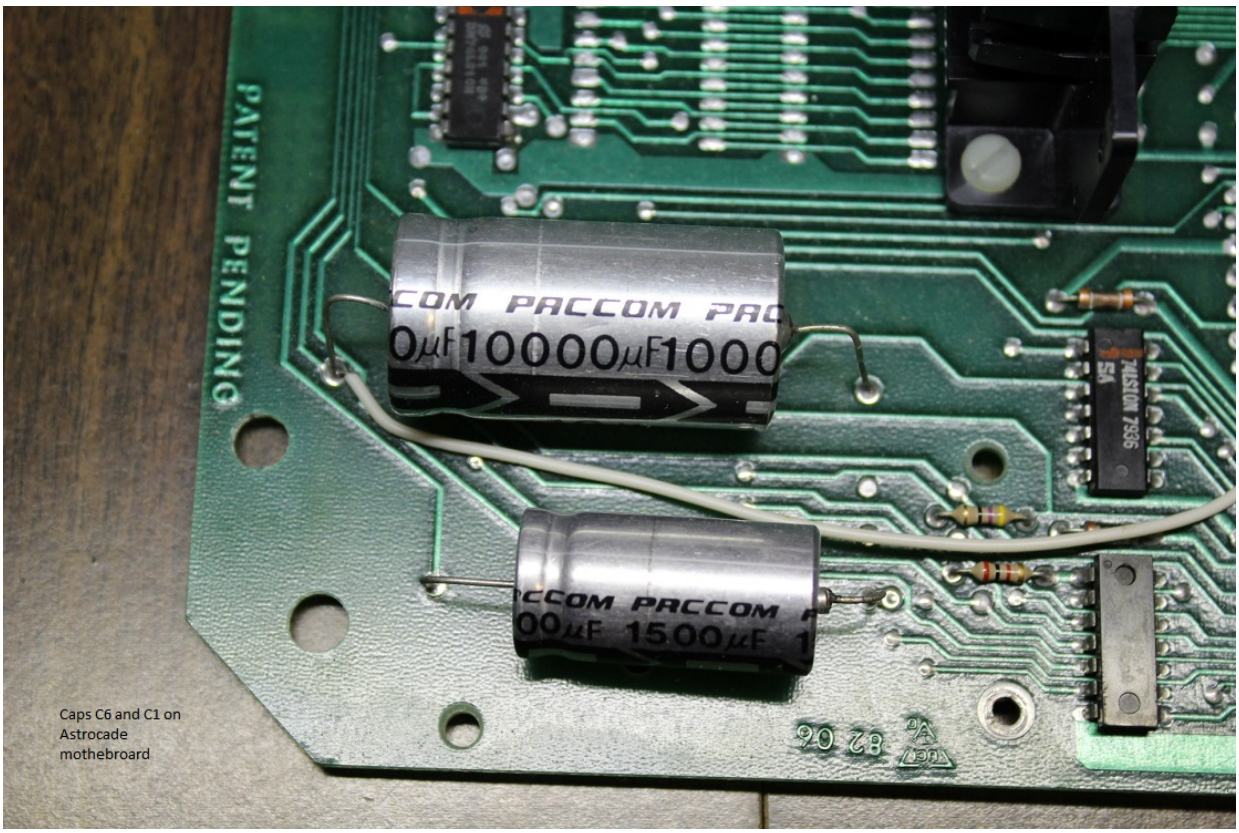
BRIEF SUMMARY

Recommendation: plug black power XFMR into a low amp fast acting fused 120VAC source to help protect it and the motherboard from shorts to ground.
The pwr XFMR windings can be checked with an ohmmeter and an AC voltmeter.
The 8 rectifier diodes and 10,000uf cap C6 are not switched off by the motherboard power switch.
A basic check of the 8 rectifier diodes, using an ohmmeter, can be performed without de-soldering them.
Capacitors can be checked for shorts using an ohmmeter.
Voltage regulators with a normal input voltage, but, near or zero output voltage can be de-soldered and tested in a simplified breadboard circuit (or just replaced). Down line caps can be checked for shorts using an ohmmeter.
A basic check on the power transistor Q1 can be performed using an ohmmeter.

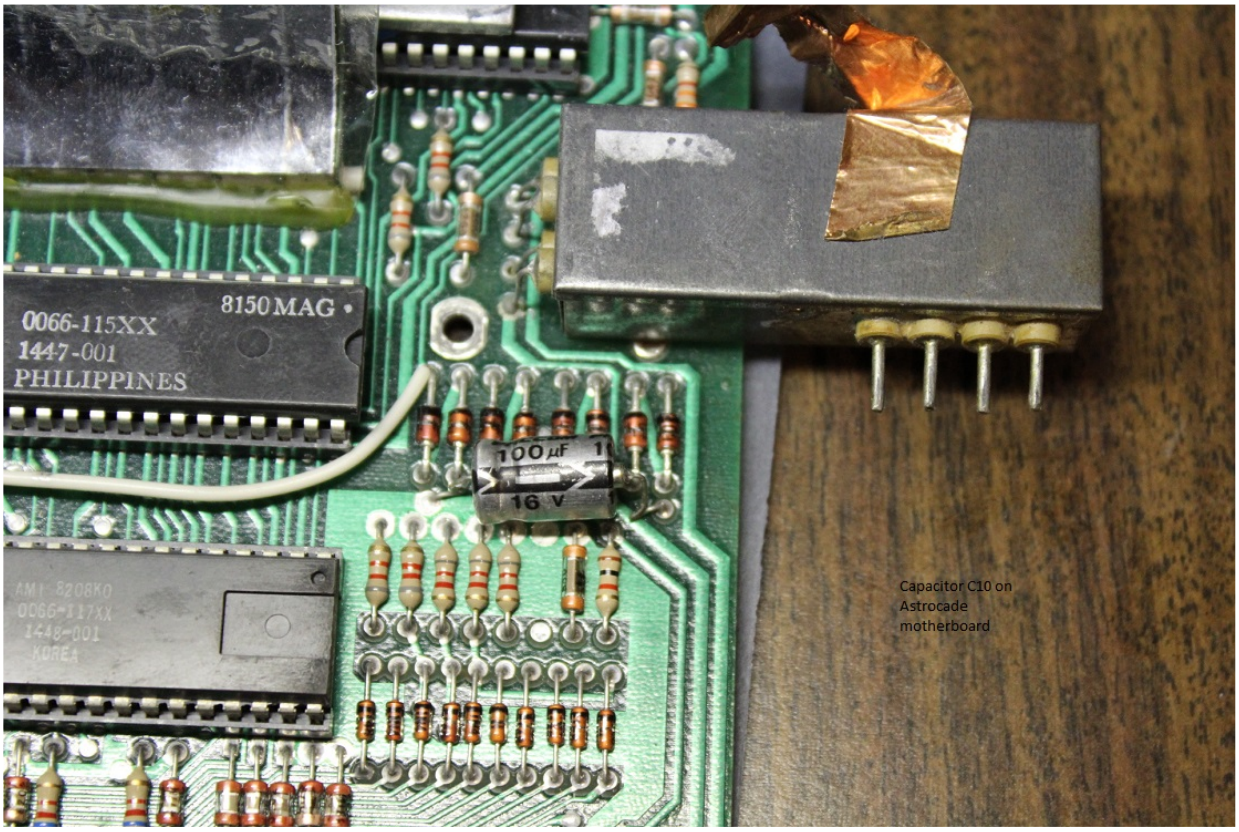
End of document.

Here are the close-up photos of Michael's Astrocade motherboard:

Caps C6 and C1:



Cap C10:


8150MAG
0066-115XX
1447-001
PHILIPPINES
100µF
16 V
Capacitor C10 on
Astrocade
motherboard