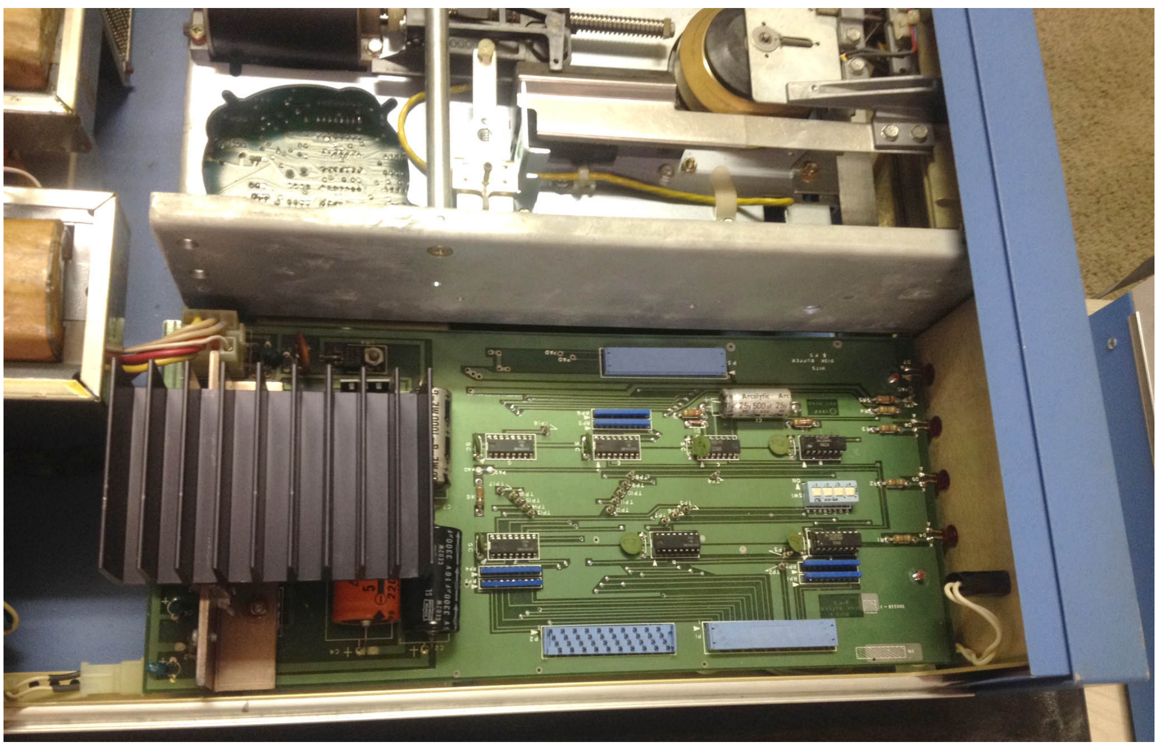
Altair 8 inch Floppy Drive Restoration Notes

This is a later version of the Altair floppy that uses ribbon cables and IDC connectors internally instead of hand-wired ribbon cables. The buffer board combines the buffering electronics with the power supply electronics on a single board. Both the front panel and the buffer board include a write protect LED position, so if the drive is equipped with the write protect electronics, the front panel LED should illuminate when protected.

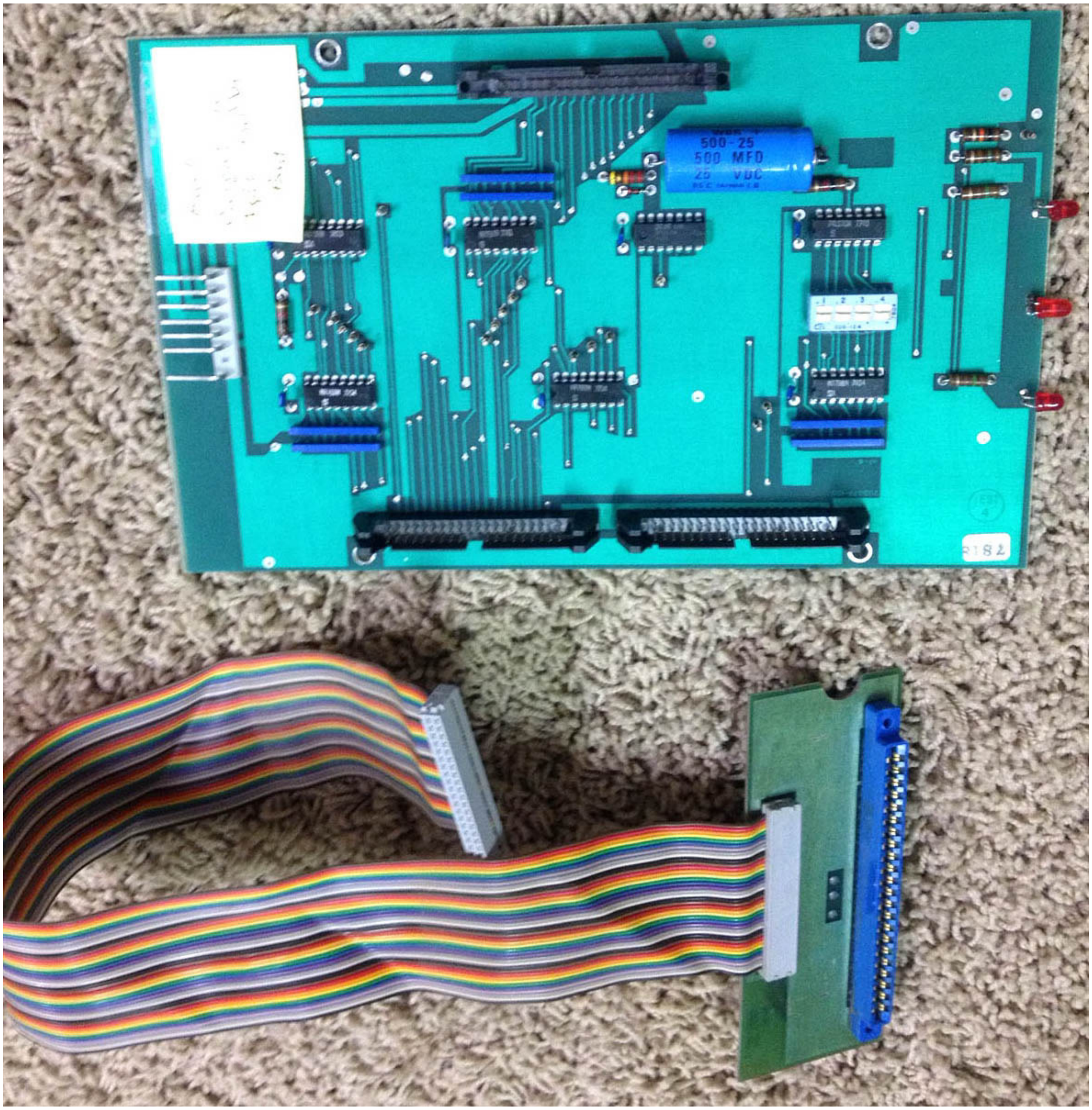
The drive was received with all ribbon cables removed from the rear panel and buffer board connectors, but the IDC connectors were left in place. The card-edge adapter board for connecting to the drive was not present either.

The buffer portion of the board is similar to the buffer board in the 3202 dual-drive cabinet in that it uses 40 pin ribbon cable connectors for the connection to the two DB-37's on the rear panel and for the connection to the drive. This drive uses the permanently soldered IDC-40 connectors on the PCB which means the ribbons cables, once assembled onto the PCB, can't be removed. This makes working on the board cumbersome. The 3202 buffer board uses standard ID-40 headers instead so the ribbon cable can be removed as needed.



Buffer Board Inside Drive Cabinet (Original Condition)

A photo of the 3202 buffer board and the drive adapter cable is on the following page. Note the similar layout of the IDC connector and components compared to the photo above. The 3202 board does not have the write protect LED and the power supply electronics are not part of the board.



Buffer Board from a 3202 Dual-Drive Cabinet

I have not been able to find any schematics for this version of the buffer board or a wiring diagram for the drive cabinet. The buffer board is similar to the original version and to the 3202 version, but not identical. Pin numbers, chip identifiers, test points, etc., are not the same.

Through testing and circuit tracing, I have identified the test points as used on this board. These are shown in the following table:

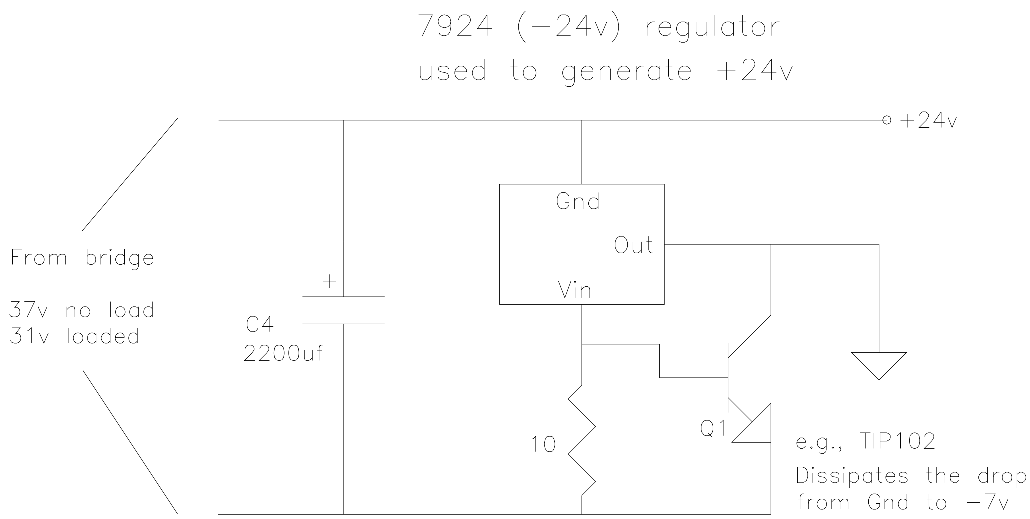
Test Points on the MITS Disk Buffer & PS Board

Signal	DB37	IDC40	Test Point
Disk Ready	1	1	18
Head Current Sw	2	3	17
Trim Erase	3	5	15
Write Enable	4	7	14
Write Data	5	9	13
Step In	6	11	16
Step Out	7	13	10
Head Load	8	15	8
Index	9	17	11
Track 0	10	19	9
Read Data	11	21	12
Disk Enable	13	25	6
Addr A	14	27	2
Addr B	15	29	3
Addr C	16	31	7
Addr D	17	33	5
Door Open (pin 6 on drive connector)			4

Power Supply Repair

Two regulators and a transistor mount vertically to the bronze colored L-bracket under the large black heat sink as shown in the picture on the first page. These three TO-220 style parts connect to the main buffer board via three pin sockets. The transistor is part of the 24vdc motor power supply. The socket had burnt from self-heating. The socket must carry 2-3 amps and this pushes the max rating of these sockets. The bracket also clamps onto two flat bridge rectifier packages with heat-sink grease. Unfortunately, this joint must be pulled apart every time you need to work on the buffer board. (See pictures are on the following page)

First, I replaced the burnt out socket for the 24v pass transistor, but still no output on the 24v supply. The 24v supply uses a –24v regulator to generate +24v. A reverse-engineered schematic of the supply is shown below. Note that the minus side of filter cap is not ground. Instead, the positive side of the filter cap is clamped to +24v by the regulator which is referenced to ground.

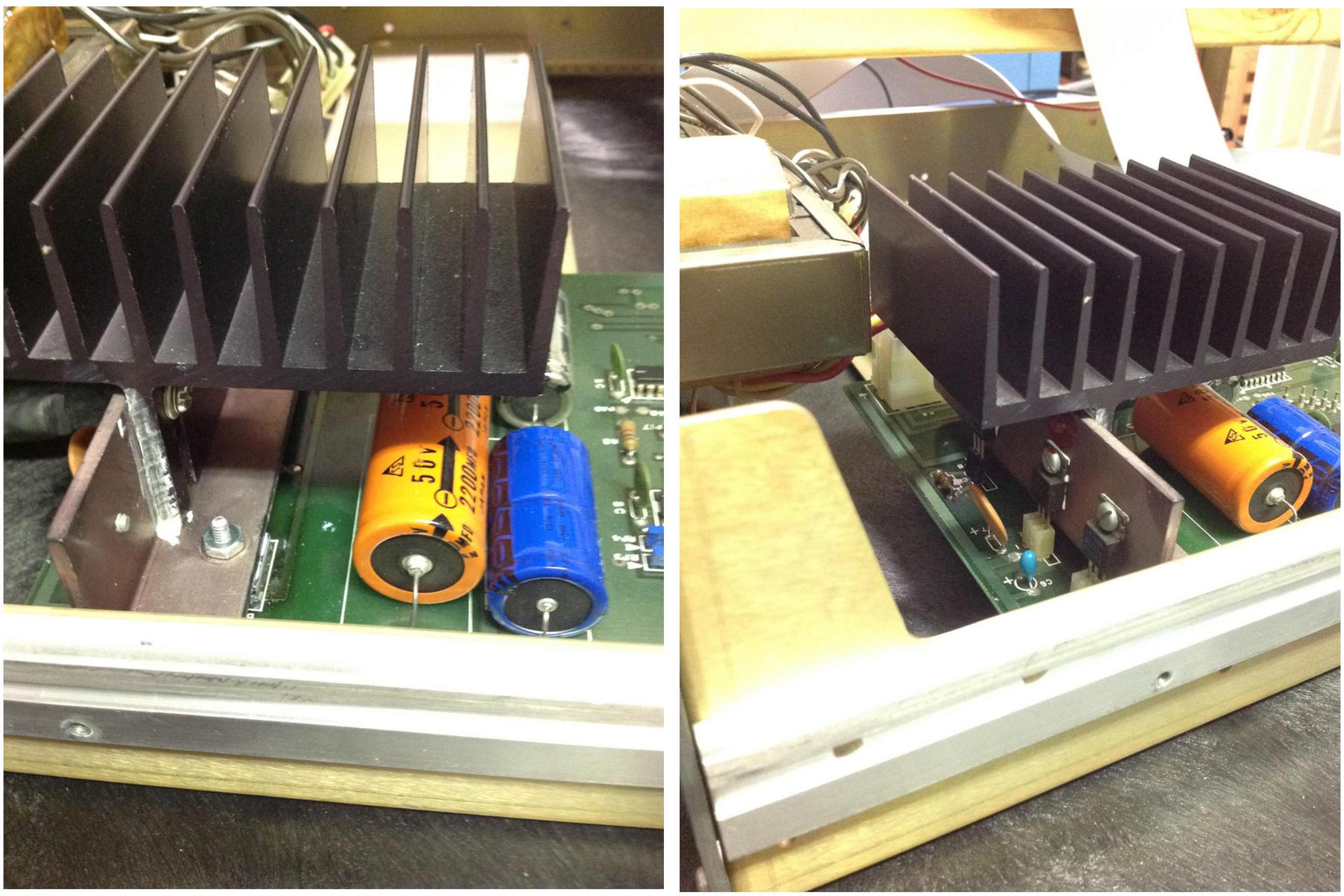


The remainder of the filter cap voltage is dissipated by a pass transistor from ground to the negative side of the filter cap.

I determined the pass transistor was bad and replaced it with a TIP102. The TIP102's I had have very wide leads and I had to trim them lengthwise to fit in the socket. After replacing the transistor, the 24v supply looks good. There is 37.5v across the filter cap with the motor off, so the pass transistor is dropping 13.5v from ground to the minus side of the filter cap. With the motor on, there is 31v across the filter cap, so the pass transistor is dropping 7v.

Initial test of the –5v supply looked like it was bad as well. However, I discovered the –5v supply is not referenced to ground on the buffer board, only to its own ground on pin "Z" on the drive connector. So in reality, the –5v supply was fine, I was just testing it wrong!

Two 5v supplies are generated from a single filter cap through two 7805s. One powers the logic on the buffer board, the second 7805 provides 5v to the drive via drive pin 21.



Heat Sink and Socketed High-Current Components

Buffer Board Repair

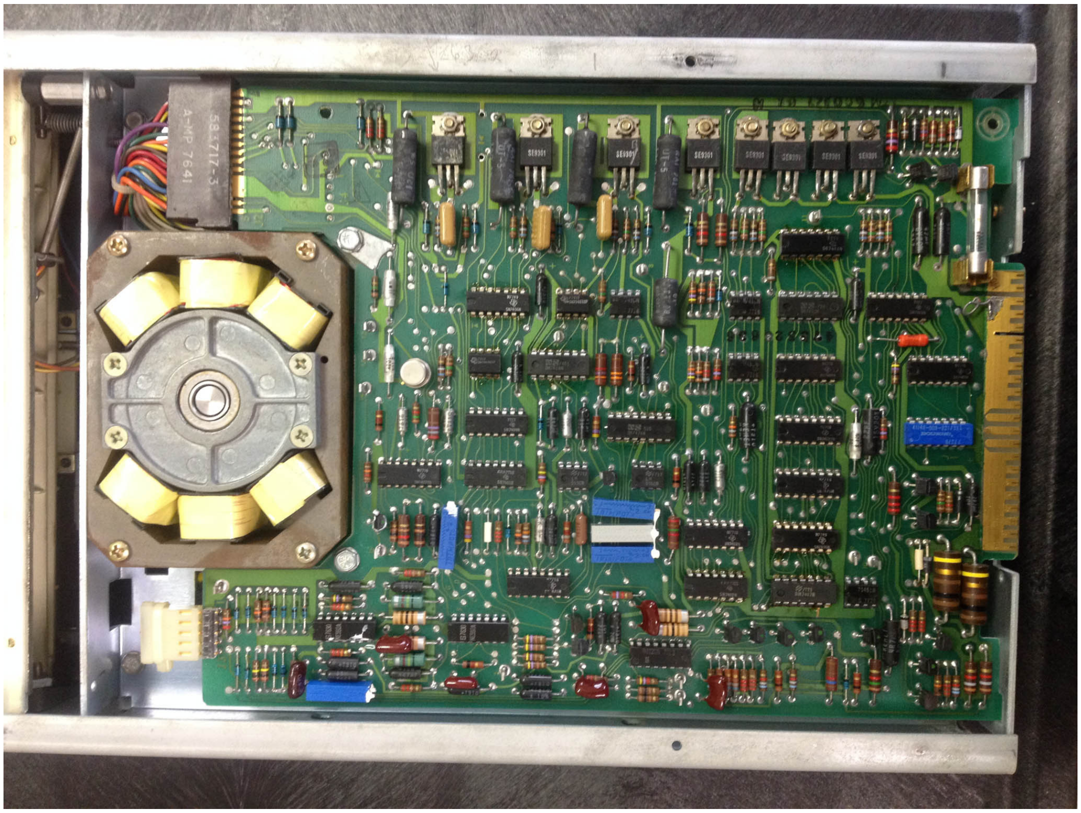
Connector P2 on the buffer board connects to the incoming DB37-M connector. P1 connects to the outgoing DB37-F connector. I discovered that P2 pin 1 (Disk Power/Ready) was shorted to ground. I traced the signal to IC G pin 13 (74LS367 or 8T97). I lifted pin 13 and the short went away on the PCB. The short was still present on the pin itself indicating a damaged IC. I replaced the 74LS367 and the short is gone.

I built and added all three ribbon cables. I used the 3202 drive adapter shown in a previous picture and installed a new ribbon cable to allow connection to this buffer board. A photo on the next pages shows the buffer board with the new cables installed.

Drive Repair

The first steps were a simple cleaning, removal of some rust, a bit of lubrication, etc. On first test, the motor started sometimes, but seized up most times. Looking at the drive PCB, it is clear the previous owner had replaced all eight power transistors (Q1-Q4, Q24-Q27) and seven IC's. Looking on a scope, the waveform at Q27 (phase C) was bad. I replaced Q27 with a new TIP-102. As part of this repair, I removed the PCB from the drive and noticed a problem with a contact in the internal-wiring edge connector (J2). One card-edge finger was bent completely backwards and was shorting against the opposite row of pins. The bent pin happened to be the signal from Q27 to the phase C coil. This short is probably what damaged Q27. I bent back the contact (very marginal condition, needs to be replaced), and with the new transistor, the drive motor now starts and runs much more reliably, but still stops now and then after it's been on for a while.

Buffer Board with New Ribbon Cables



Drive PCB

Looking at sector pulses from the drive with a disk installed, the pulses are steady for a while, but as the electronics heat up, the motor transitions to an unstable state in which the sector pulse timing waves in an out like an accordion, cycling 2-3 times a second. The motor bearings seem to spin freely, plus the problem starts instantly when it occurs, so it appears to be some sort of trip point in the electronics that starts the problem.

Once the problem starts occurring, the waveform on Q26 changed (motor phase B coil). Replacing Q26 seem to fix the problem at first, but eventually the problem returned.

Further probing revealed that the 5v supply on the drive PCB is dipping at 120hz intervals when the problem is occurring, but not when the motor is stable. Droops get as much as –0.4volts. The motor issue could be caused by the 5v droop changing the base current in the coil transistors and causing the oscillation. Or, the 5v droop could be a symptom of current spikes once the motor becomes unstable.

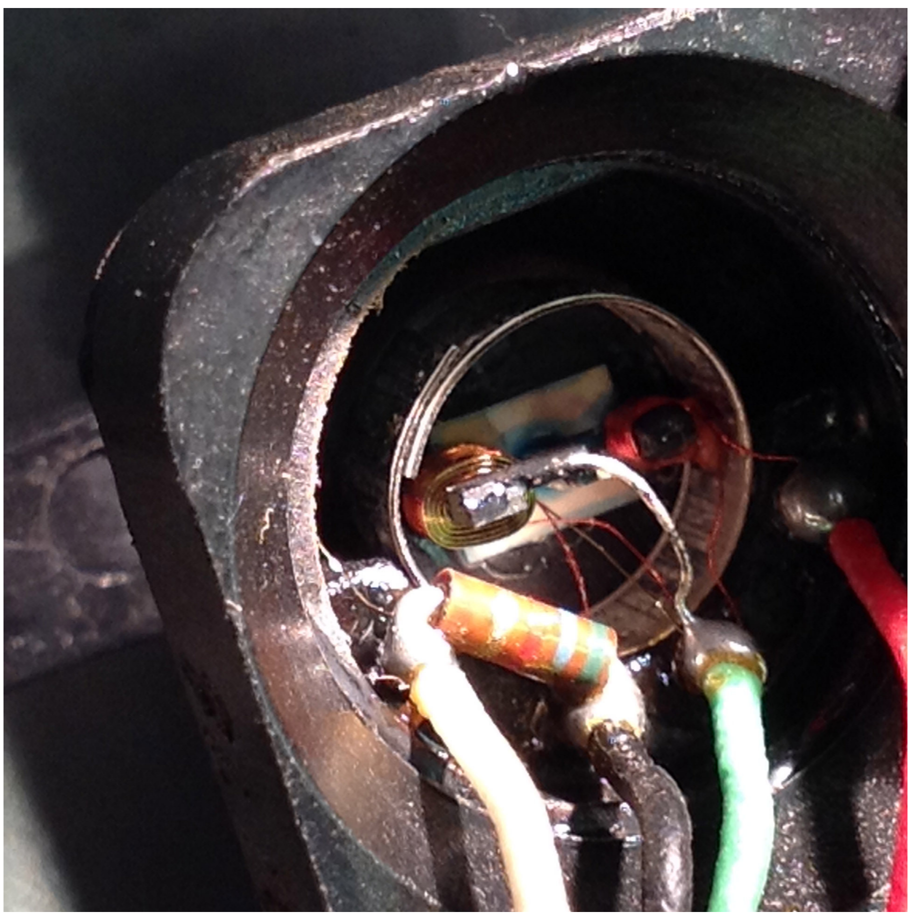
Back to the 5v Power Supply on the Buffer Board

Looking at the 5v supply for the drive, which is generated on the buffer board, it has a 2vpp sawtooth waveform on the filter cap with lows around 7.5v when the drive motor is not running. When the motor is running, the filter cap average voltage drops a little over a volt and the filter cap lows are 6.2-6.3v. The sawtooth remains about 2vpp. The 6.2v lows are causing drop-out in the 7805 regulator for the 5v supply at 120hz. I replaced the 3300uf filter cap with a 6800uf filter cap. Ripple is now about 1.2vpp and filter cap lows are improved to about 6.6v when the motor is running. Drive performance is now much more reliable, but once head stepping and/or drive read/write is added in, the drop-outs still show up. Based on the power supply design, this doesn't seem it should be happening. If the current draw is as expected, it could be a transformer problem of bridge rectifier problem. Or, the primary issue could be excessive current draw on the 5v supply due to some thus far, undetected problem.

Data Read and Write

During tests, read data appears good on a scope. Index alignment is about right as I can read the sync/track byte on the scope appearing around 400us after each sector pulse. However, these same disks won't boot.

Writing a disk produces garbage. Looking on a scope, the two R/W coils don't have symmetrical waveforms during write (generated by Q17 and Q18). I measured resistance of the coils from the head write connector on the PCB. One R/W coil measured 6.8 ohms, the other measured 4.8K. Upon disassembly of the head mechanism, the side that measures 4.8K has a broken coil wire that can't be re-attached. The 4.8K measurement is because a 5.6K resistor is still attached inside the head between the two coils. A new head will be needed. Without differential signals coming from two coils, the read data will be very unreliable and this explains why the disks wouldn't boot even though I frequently saw valid looking data. A picture inside the head is on the next page.



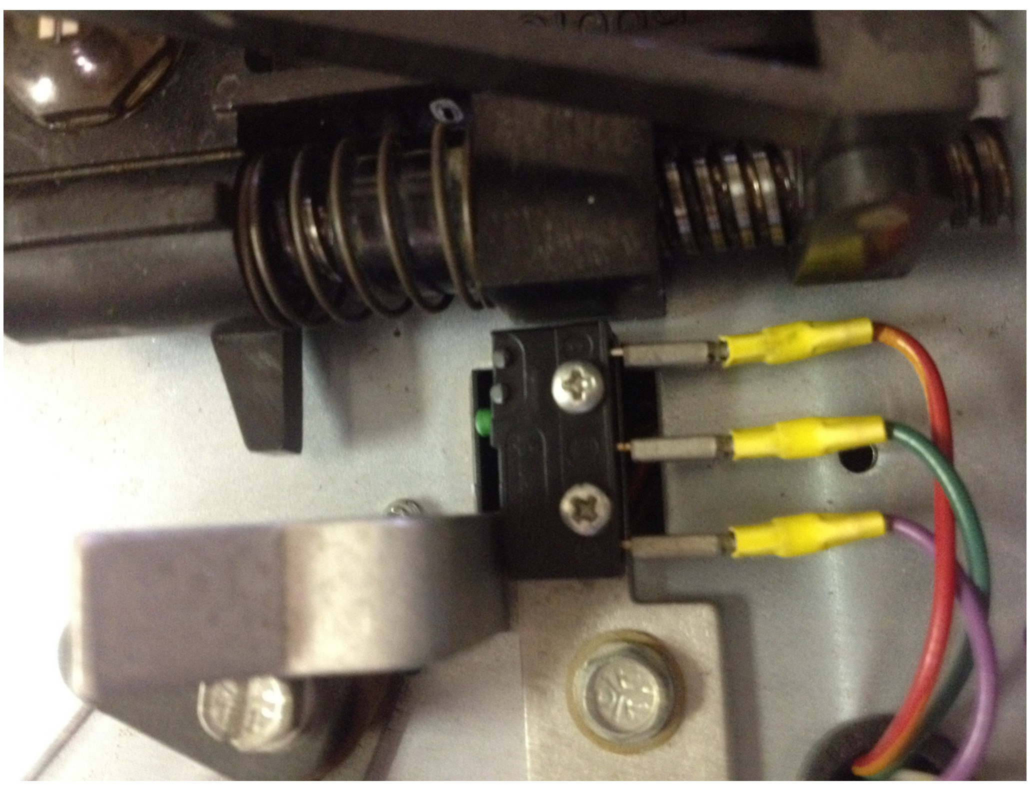
Broken Head Wire to Left of White Wire

Track 0 Switch and Stop

The drive over-shoots track 0 when seeking home. The track 0 switch comes on properly as the head moves from track 1 to track 0. So the drive shouldn't overshoot even if the track 0 mechanical stop is not properly adjusted.

The Pertec drive delays the track 0 signal to the drive for 50ms after the signal is asserted internally. A seek to zero algorithm on the 8080 steps every 10ms looking for the track 0 signal to be asserted. This delay means the software will issue 4-5 additional step out commands after the drive is actually at track 0. The drive is designed to ignore additional step out commands once track 0 is reached. The internal track 0 signal is supposed to be active within 9ms (i.e., less than the minimum track step time). This internal track 0 signal blocks additional step out commands from activating the stepper motor via an AND gate. On this drive, however, the internal signal took 35ms or so to activate. This allows three or so extra step outs to reach the stepper motor. I shot some contact cleaner in around the plunger on the switch and this reduced activation time to right about 10ms. Problem is much better, but I can tell I'm still getting an extra step out now and then. I may need a new switch to stay reliably under 10ms.

Update: The switch gets worse (slower) after I don't use the drive for a while. Though a part number is not on the switch, "Cherry" is present. Most likely it is a E6300A0 which has been discontinued. The closest replacement is the Cherry DB3C-B1AA. I purchased and installed the new switch. It was a quick and easy drop-in replacement and fixed the problem. A picture with the new switch is shown below.



New Track Zero Switch

Installation of New Head

Removal of the head requires unmounting the stepper motor. Getting the end screw out of the end of the stepper shaft is very difficult. I used a cloth and a pair of pliers to tightly grab the screw shaft behind the motor. The head never travels on this part of the shaft, so a bit of damage to the threads here won't affect stepping operation.

I obtained a new head from a friend who had a "parts drive," but he didn't want to attempt to remove the head from the stepper shaft, so he sent the stepper motor as well. Replacement of the stepper motor requires removing the four stepper motor wires/contacts from the internal drive connector J2. Since I was going to have to work on J2 anyway, I decided to buy some contacts for this connector and replace the bad contact on the phase C motor wire while I was at it. The contact housing is a 30 position Molex #583717-3. Contacts are 5-583853-3 where the 5- and the –3 vary based on plating, tape and reel, etc.

I installed the new stepper motor/head and did some quick stepping tests. The new motor and head seemed to work fine except the head hit the track 76 stop before getting to track 76. It's not hard to accidentally rotate that stop when attempting to remove the end screw, so my friend probably moved the stop during his first attempts to remove the end screw. I rotated the stop about 30 degrees and not it seeks track 76 without a problem.

I stuck in a disk to boot and it worked! Write worked as well – sort of. Read and write operation was not as reliable as it should be. Probing on the drive PCB, the 5v supply still showed 120hz ripple especially as stepping and read/write activity take place. Finding an answer to the 5v supply problems is next.

Back to the 5v Power Supply on the Buffer Board (again)

To measure current, I pulled the output pin of the 7805 that supplies 5v to the drive and clip-leaded through a meter. The current draw remained about 950ma whether the drive motor was running or not. This is right to spec for the drive, but not as expected, as the filter cap for the 5v supply clearly drops about 1 volt when the motor starts running. I assumed the buffer board, which shares the same input filter cap, must have a spike in current draw when the motor comes on. I measured current to the buffer board, but it remains about 350ma at all times. Nothing on the 5v supplies draws significant additional current when the motor comes on.

Current consumption on the 24v supply increases sharply when the motor is on (2-3 amps). However, this should not affect the 5v supply as it is a completely separate transformer. I measured the 120vac input at the power line input filter and it remains virtually unchanged when the motor starts running. Unfortunately, I cannot easily measure the voltage going directly into the transformer primaries due to protective insulation.

As I manipulated the connector between the 120vac input filter and the transformer primaries, 5v power to the buffer board and drive would occasionally cut off. This may indicate a bad crimp, and if shared between the 24v and 5v transformers, could explain why additional current draw on the 24v line affects the 5v line.

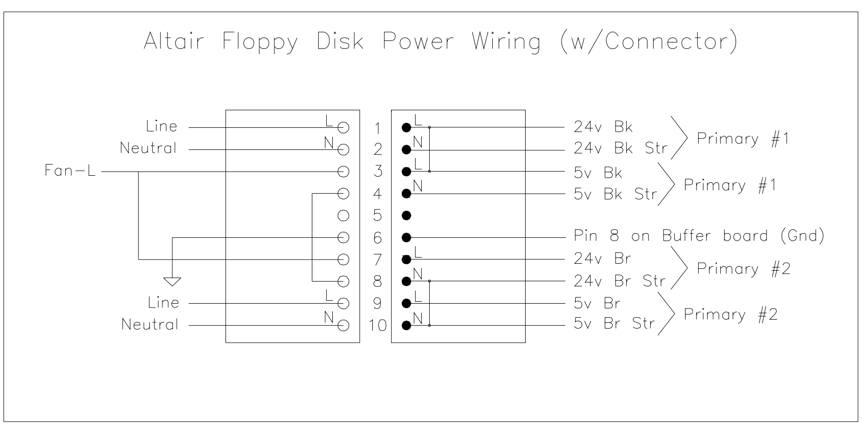
The connector block is a Molex-style pin and socket connector. Two pairs of positions are shorted to each other with a small metal tab that fits over two adjacent pins. These are often a failure point. I decided to pull out the pins and sockets to look for problems.

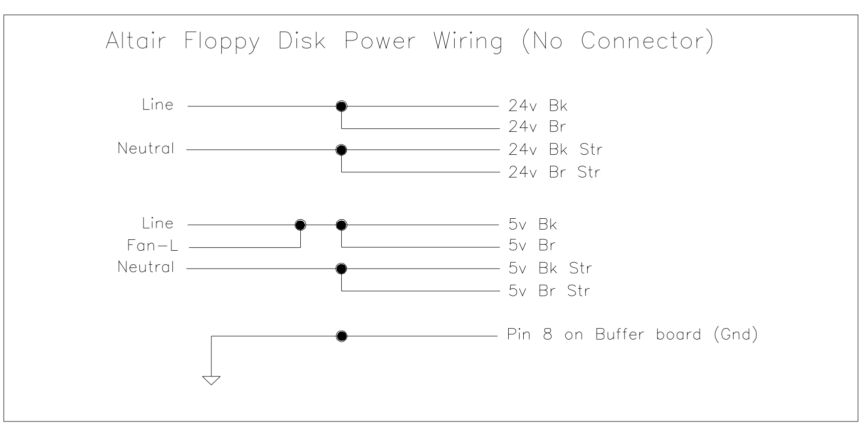
I was able to get all pins out, but even with two different extraction tools, I was only able to get about half of the sockets out. Wires were all crimped (not soldered) into the contacts, and many of the crimps were very poor. I soldered all crimps on the contacts I was able to extract. In addition, I removed the shorting tabs and soldered a short wire between the shorted pins instead.

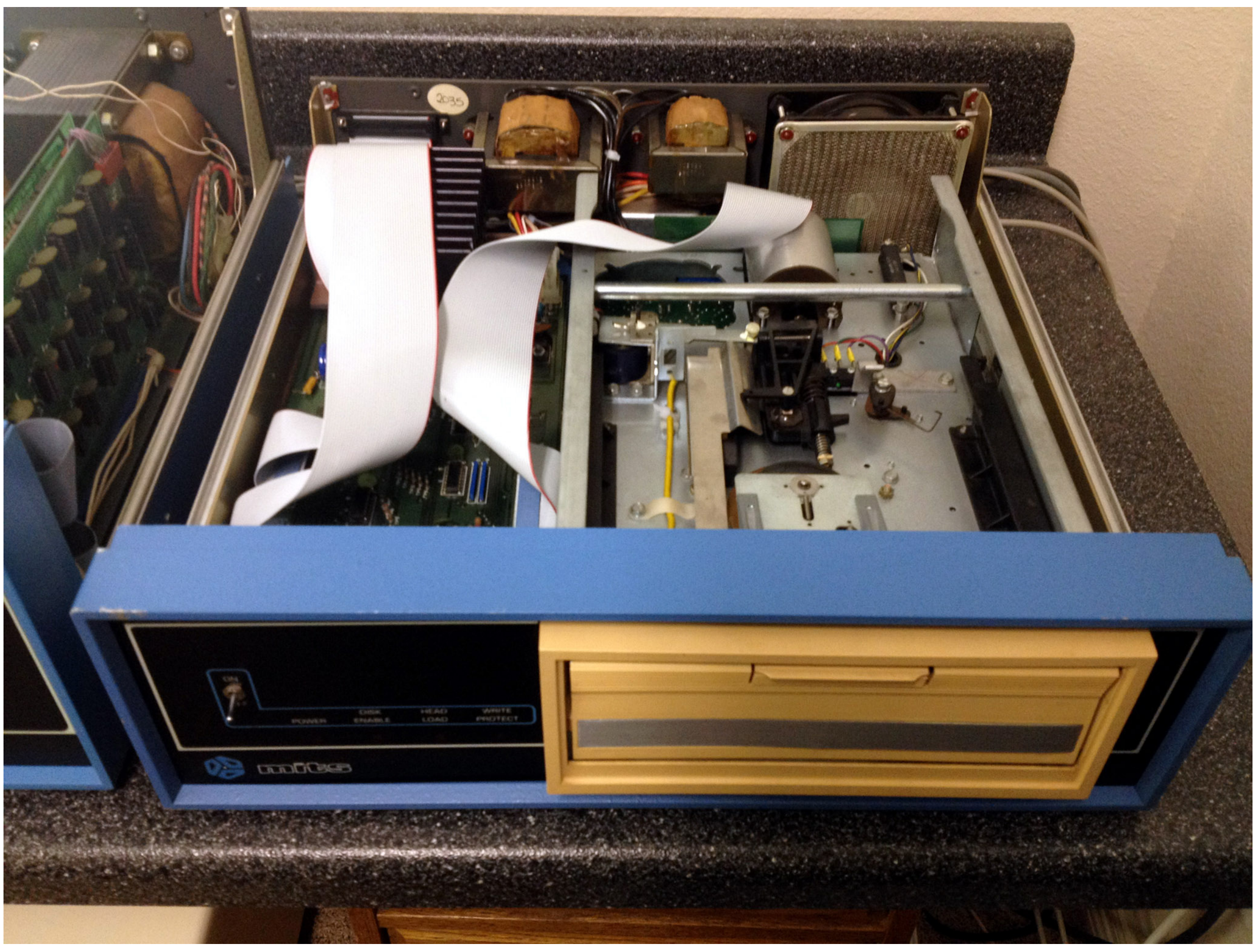
Update: This repair work fixed the problem – voltage on the 5v supply filter cap is around 10v and not affected by 24v load. With the fix, however, a new problem cropped up on the 5v supply filter cap. During the discharge phase of the 120hz ripple, a 1.2mhz, 3vpp burst appears. I still suspect connector issues and a bad contact could be causing a pole that causes the oscillation. A 0.1uf capacitor across the filter cap attenuates the burst slightly. A 4.7uf capacitor across the filter cap swamps out the oscillation completely. I soldered on a 4.7uf as a permanent fix.

Update: About a week later, after bending wires around to fully re-assemble the cabinet for the first time, I noticed the voltage on the 5v filter cap voltage was dropping with the 24v load again. The minimum voltage is staying above 7v (for now), but the root problem has not been fixed. I will probably eliminate this connector completely and hardwire AC inputs to the transformer primaries.

Update: I cut out the connector completely and hardwired the transformer primaries to the AC input. This eliminates the problematic connector and also simplifies the wiring. With this work, the 5v supply again looks good. The voltage on the 5v supply filter capacitor is about 10v and is not affected by 24v load changes. Removing the connector may also eliminate the need for the 4.7uf capacitor in parallel with the main filter capacitor, but there is no real need to remove the 4.7uf now that it is already soldered in place. The following diagrams illustrate wiring before and after removing the connectors.







Completed and Operational