Repair of other Pertec Drives

Common drive repair/calibration notes

This section provides notes about drive repair and calibration that are common to all drive repairs.

Index Skew

After radial alignment, but before re-tightening the stepper motor screws, index timing at track 1 and track 76 should be checked. This test verifies the stepper worm gear is parallel to the opening in the floppy disk so that the head runs along the intended radius from track 0 to track 76. This test is mentioned in the drive manual, but as part of index timing instead of with the radial alignment process.

The goal of the test and adjustment is to make the index timing at track 1 match the timing at track 76. As the motor is pried to one side or the other, index timing at track 76 will move more than the timing at track 1. In order for the two timings to converge, the adjustment should be done around the point at which the two timings "cross" each other. In other words, find the approximate point at which the track 76 timing goes from being more positive than track 1 timing to more negative than track 1 timing. Adjustments around this point allow the two timings to converge.

This procedure may leave the index timing different than specified, but that is OK since index timing is adjusted later in the manual by adjusting the position of the index sensor. The index sensor adjustment, in turn, does not index skew that was just zeroed.

After adjusting index skew, it is necessary to re-check radial alignment. Unfortunately, these two adjustments can go back and forth for a while. Once both tests look good, tighten motor mount screws incrementally while watching the scope – trying to avoid changing radial and/or index skew alignment as you tighten the screws.

FD-400 (temporary black and white face plastic)

A screwdriver bit fell onto circuit side of PCB through the A/C drive motor opening in the sheet metal while power was supplied. This caused some smoke and odor. The following problems were found and fixed.

Drive motor spins, but disks no longer boot

After the screwdriver bit shorted out the PCB, the drive would no longer boot any diskette. In addition, known working FD-400 drives would no longer boot either. This made it look like the buffer board in the drive cabinet may have been damaged by the short on the drive.

After a few tests, I determined that the 74LS367 that buffers index pulses from the drive to the Altair had failed. I replaced the 74LS367, and the known good drives then worked again with all diskettes. In addition, the damaged drive booted as well.

Buffer board repaired, disks boot, but writes fail

Further testing of the damaged drived revealed that writes were failing. The write signals that drive the bases of the head coil drivers (Q17, Q18) looked reasonable, but no current was going to the head. I later determined that the bias voltage for these transistors was too high, so that even though the write signals were transitioning, they were not dropping low enough to turn on the coil drivers (PNP transistors). The bias voltage error was due to failure of zener VR4 which generates a 20v bias voltage from the 24v supply. The zener had failed in a shorted state. This left the bias voltage at 24v instead of 20v as required.

Write bias voltage fixed, disks no longer boot, clobbers any disk inserted

With VR4 replaced and the correct write bias voltage now present, the drive would no longer boot. In addition, the diskette used was clobbered by the bad drive without ever issuing a write. Looking at the anode of the head isolation diodes (CR10 and CR11), CR10 was biased "on" (e.g., write current was present) at all times – even when not writing. This clobbered the disk immediately upon insertion.

It is normal for the head coil driver (Q17) to idle in the "on" state, but current for this transistor, supplied through Q14, is not normally present unless the drive is writing. I found the 75451 driver, which turns Q14 on/off, was not going to hi-z (open collector) when switching to the "1" state. This, in turn, left Q14 on and supplying write current at all times.

75451 write current switch replaced, drive still clobbers disks

After replacing the 75451, the output to Q14 goes hi-z like it should. However, write current is still on all the time. Diode CR8 is used to clamp the base of Q14 at a minimum voltage of 19.3v (20v – 0.7v). However, CR8 had failed in a shorted state, so it was clamping Q14 to a fixed voltage of 20v. This biased Q14 "on" at all times. I replaced CR8 (1N4446) with a 1N4148, and drive current now properly shuts off when write are not enabled.

At this point, the drive is 100% functional. Note that were two different failures – that even if write protect circuitry was in place – resulted in disks being clobbered immediately upon insertion. ***Be sure to verify the anodes of CR10 and CR11 are both at –5v (write current off) before inserting an alignment disk***.

FD-400 (#1)

Motor seizes when door is closed

Upon closing the drive door, the 0.6s detent activation takes place and releases, but the motor doesn't then begin spinning. Looking at TP3, the 105hz-432hz ramp up of phase pulses does not occur. Instead, the pulses remain at 432hz all the time. The ramp is supposed to start conincident with the 0.6s detent period via the output of a inverter in U9 going low. However, this gate remained high no matter what the input was. I replaced U9 and the ramp up of pulse frequency is now correct, and the motor starts running as it should.

Head stepping fails

When step commands are issued, the head does not move, but sound is heard as if it is the motor is trying to step. Examination of voltages at the collector of each coil driver (while not stepping) showed that the phase 1 transistor (Q1) was partially on. The output of the gate which drives the base of this transistor was 0.2v as it should be ("off"), however, the base of the transistor was at about 1v. Current was flowing through the collector and out of the base through the 68 ohm base resistor (R9) into the base driver gate. I replaced the TIP112 with a TIP102 (meets or exceeds all TIP112 specs) and now track stepping works fine.

FD-400 ($51 on eBay)

Motor doesn't try to start at all when door closed

Upon closing the drive door, the motor doesn't seem to try and start at all. The motor spins freely by hand. Testing showed that NPSEN (signal that all DC supplies are good) was false and this prevents the motor circuits from starting. Examination of the power supply sense circuits showed that the –5v supply was too low. This particular drive had the W2 strap in place instead of the W1 strap. W2 generates –5v internally from a –12v external input using a zener regulator. The W1 option is used when –5v is supplied directly via the external connector (as it is in the Altair drive cabinet configuration). Switch to W1 fixed the problem and the drive motor starts as it should.

Head won't always load at track zero

If the drive is on track zero and a head load command is issued, the head does not always load. Step to track 1, then the head will then load. Further testing showed this only occurred if a restore to track zero was done (a few steps in followed by immediately by stepping out until the track zero bit is set). This over-rotated the head in the release direction and lifted the head so far that the head load solenoid could not subsequently pull in the head. This was due to the small cap head screw on the head load solenoid allowing too much upward movement of the armature.

Drive seems to just stop working in the middle of a read, won't select anymore

In the middle of disk I/O, the drive occasionally just stops working. Single step shows that the drive is no longer selected, but software thinks it is. This ended up being caused by the door switch. When the front door was closed, the switch was barely activating – it was not even reaching the detent position. This, in turn, cause the output of the switch to glitch on occasion and deselect the drive. I added a small piece of adhesive felt to the inside of the door to further depress the door switch lever and these problems went away.

Motor gets unstable and eventually locks up as it gets hotter

Once the motor runs for a while and things heat up, the motor speed becomes erratic and the motor eventually locks up.

Base voltage consistent switch on to about 1.4, then ramp up as current increases through coil winding (base voltage going up become emitter voltage going up because of current sense resistor off the emitter). As things become erratic, the base waveform becomes jumping up and down slightly due to changes in the amount of current going through the emitter resistor.

Is the variation in current due to electronics driving the coil, or due to the coil/rotor position combination changing coil inductance. I swapped out the entire PCB with one that is known good, and the problem stays with this drive's motor. This indicates the motor itself is causing the problems. Steady drag on the flywheel with a finger behind a folded paper towel does not affect coil current. However, quickly tapping pressure through the paper towel induces the same base voltage jumping as seen as the motor becomes unstable on its own. Together, these observations point to bad bearings that become more uneven in their drag as the bearing heats up.

Update: As part of disassembling the motor for bearing replacement, the real problem with the motor became clear. One of the screws that tightens and clamps the top and bottom plates to the motor housing was loose. However, if that screw is tightened, the internal rotor scrapes on the underside of the top plate as it spins.

Taking apart the motor, three washers instead of one were installed on the top side of the rotor in an attempt to move the rotor down, away from the top plate. However, even the three washers weren't quite enough. The rotor clearly has a deeper offset into the top of the rotor than on the bottom. I wonder if this rotor is out of spec? I don't have other motors I want to disassemble for comparison since all other drives are working.

Adding more or thicker washers into the top side causes the "stack" (top plate, bearing, washer(s), rotor, washer, bearing, bottom plate) to become too thick. When this happens, the top and bottom plates cannot squarely clamp against the motor body as the screws are tightened. This, in turn, lets the shaft deviate from perpendicular and the rotor scrapes the winding poles. After five disassembly/assembly cycles, I finally found a washer combination that prevented the rotor from scraping the underside of the top plate when screwed together tightly, but was still thin enough to allow the top and bottom plates to clamp onto the motor body without bending.

With the new bearings and the newly arranged stack, the motor runs more quietly and does not become unstable or seize up. After re-assembling the motor into the drive, I repeated radial alignment, index alignment, azimuth alignment and adjusted the track zero switch. The drive now works great!

Update: After talking with another hobbyist, we figured two of the three washers installed on the top side of the rotor were probably conical spring washers to take up play in the stack. These need to be installed facing opposite directions with the small diameters towards the rotor and the bearing, and the large diameters stacked in the middle. Not sure how these spring washers were arrange originally or after I put the assembly back together, or even if the spring washers still had any “spring” left in them.

FD-510 (older 600251 board)

This drive uses an AC motor for driving the hub instead of a DC motor. It uses the 600251 PCB which is the same as the 600321 board found in most of the FD400’s, but without DC motor drive components installed. The sound of anti-static tab that rubs on the hub flywheel is a bit annoying. This drive was configured for -12v instead of -5v (3202 cabinet supplies -12v versus the -5v in the single drive Altair cabinets), so I temporarily strapped it to -5v to work with my testing/alignment setup.

FD-510 (newer 600281 board)

This drive uses an AC motor for driving the hub instead of a DC motor. It uses the 600281 PCB which is completely different than the older boards referenced in the Pertec maintenance manual that I have. Test points for picking up alignment signals are at different locations and have different names as detailed in the next paragraph. This drive was configured for -12v instead of -5v (3202 cabinet supplies -12v versus the -5v in the single drive Altair cabinets), so I temporarily strapped it to -5v to work with my testing/alignment setup.

Test Points on the newer 600281 board

Pick up the index pulse on TP4 instead of TP10 and trigger on the rising edge instead of the falling edge. Pick up differential read data at TP2 and TP3 instead of TP4 and TP5. This drive PCB also provides differential read data at TP11 and TP12 at lower voltage levels (after just one differential amplification).

Extra loud static dissipation tab

The static dissipation tab that rubs the bottom side of the hub flywheel was louder on this drive than on the earlier model FD-510. To remove the flywheel, remove the center screw, then lift the flywheel as straight as possible off the underlying axle. (The flywheel sticks on the axle if any edge has more lifting force applied than another.)

This drive had some sort of metallic splatter across about ½ inch of the flywheel underside. This causes an extra loud periodic noise as the drive spins. After cleaning with alcohol, I used 600 grit sandpaper to polish the flywheel underside. I then applied a thin coat of WD-40 and wiped it off, making sure no lubricant got on the flywheel edge where the belt rides. Finally, I over-bent the static tab away from the flywheel a bit. These steps substantially reduced noise from the drive.