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## H/Z-207 Floppy Disk Controller Troubleshooting

In addition to the typical part failure experienced by any electronic product, the Floppy Disk Controller is subject to drift caused by aging parts on the card. If you are experiencing increasing read/write errors, but the card is still working, it might be prudent to have the card recalibrated by someone with the tools to perform that function or you may attempt to apply the following troubleshooting procedures.

The following information is compiled from the Z-100 Technical Manual, the Floppy Disk Controller Card Model H-207 Assembly Manual, and personal experience. The intent of this article is to provide troubleshooting information for those wishing to repair their own Floppy Disk Controller Card. However, please understand that there is a risk to further damaging your controller and your computer. **Please proceed only at your own risk.**

### Troubleshooting Chart

**PROBLEM:** Drive access light does not turn on when a diskette is booted.

#### POSSIBLE CAUSE:

1. Check for proper connections of the floppy cable inside the computer, paying particular attention to the location of pin 1 and the red edge of the ribbon cable.
2. Remove and reseal the Disk Controller in the S-100 bus connector.
3. Check the S-100 pins for corrosion. Use a pencil eraser to gently remove any dirt or staining from the gold fingers. **CAUTION:** Do not remove any more material than necessary.

## H/Z-207 Floppy Disk Controller Troubleshooting

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3. Be sure the DIP switch on the Disk Controller is set to the correct address. See the section **H/Z-207 Port Address** below.
4. Check the connector positions on P1 or P2 on the Disk Controller.
5. Be sure the drive is properly jumpered for unit 0 or 1 as appropriate.

**PROBLEM:** All diskette access lights turn on and remain on.

#### POSSIBLE CAUSE:

1. Drive cable is connected with the marked edge on the wrong side.
2. Drive(s) configured incorrectly.

**PROBLEM:** Both drives turn on when a boot operation is selected.

#### POSSIBLE CAUSE:

1. The two drives have their selection jumpers programmed the same.

**PROBLEM:** Computer will not accept a boot command, returns to hand prompt, or starts to boot, but freezes and requires reset.

#### POSSIBLE CAUSE:

1. Be sure diskette is bootable.
2. Be sure diskette is installed in selected drive before boot command is given.
3. Be sure DIP switch on Disk Controller is set at the correct address. See the section **H/Z-207 Port Address** below.
4. Be sure drives are properly jumpered.
5. Be sure DIP switch bits 0 and 1 are selected for the type of drive being used.

**Note:** This last step is not applicable to the MTR-ROM v4.3 and later.

**PROBLEM:** Upon Power Up, the message "Primary Z207 Controller Error" or "Device Controller Error" is displayed before the hand prompt.

**PROBABLE CAUSE:**

1. The controller card of the Default Boot Device is not installed, or has a failure.
2. Check the positions of the S101 DIP switch on the motherboard.
3. Check DS1 on the Disk Controller for incorrect settings or markings. A number of switches have been found to be mis-marked, or assembled with the cover upside down. A quick check is to check continuity of each section. When DS1 is set as required, sections 0-3 and 6 should be shorted when positioned toward the bottom of the board.

**PROBLEM:** Capacitor C35 fails on 85-2807-1 model Disk Controller cards.

**POSSIBLE CAUSE:**

1. According to Field Service Bulletin FSB-Z100-31, if the Disk Controller has the model number "85-2807-1" printed in the lower left corner of the board, the silk screen of the board is printed **WRONG** and capacitor C35 is installed reversed. Replace the capacitor with the "+" toward the left.

**PROBLEM:** The disk drive does not stop running or runs longer than about 20 seconds after the last access.

**POSSIBLE CAUSE:**

1. Check and/or replace C30, a 47 uF, 6v capacitor in the one-shot time out circuit. To reduce the run time, a 20 uF capacitor will time out in about 9 seconds.
2. Check for model "#85-2807-3" in the lower left corner. If the board is a -3 model, the silk screen of C30 is **WRONG!** Remove C30 and reinstall with the positive "+" sign toward resistor R20, which connects to +Vcc.
3. If operating at 8+ MHz CPU speeds, replace U15 N9202N integrated circuits with faster 92LS02 chips.

**PROBLEM:** The computer is reporting softread/write errors.

**POSSIBLE CAUSE:**

1. Aging parts on the Disk Controller may have drifted off calibration.
2. Pre-compensation failure. See the next two problems for further checks.
3. Early Disk Controllers may have a 10uF capacitor at C6. This was increased by FSB-Z100-016 to 33uF in later models to reduce soft errors. **NOTE:** All 85-2807-2 and -3 models already have this modification.
4. According to FSB-Z100-024, soft errors may be reduced by connecting a 10 uF capacitor in parallel with the 0.1 uF capacitor at C32, located just above the controller chip U22. Be sure the positive "+" lead of the 10 uF capacitor is positioned to the left when facing the component side of the board.

**NOTE:** All 85-2807-2 and -3 boards already incorporate this modification as a separate capacitor at location C32-1.  
5. According to FSB-Z100-019, floppy disk errors in a Z-120 All-in-One may occur when a hard drive is mounted above the floppy drive, causing EMI radiating from the hard drive to affect the floppy disk drive. Check to ensure a shield is installed between the two drives in this configuration.

**PROBLEM:** FORMAT verification fails after track 23 on 5" drives; after track 43 on 8" drives.

**POSSIBLE CAUSE:**

1. Failure in the Pre-compensation Circuit.
2. The Disk Controller needs calibration.

**PROBLEM:** Pre-compensation will not adjust.

**POSSIBLE CAUSE:**

1. According to Field Service Bulletin Z100-041, if the pulse width at CP3 cannot be adjusted, or is missing, check for an open circuit to U3-17 or an open wiper at R3.

**PROBLEM:** Erratic Write Operation

**POSSIBLE CAUSE:**

1. According to FSB-DK-025, early model #85-2807 boards did not include base resistors for the Q2 and Q3 transistors. To eliminate write irregularities, the newer models included 100 ohm resistors in series with the base lead of Q2 or Q3. The bulletin says to install the resistors only when needed.

**PROBLEM:** Running DIAG, the Heath/Zenith Diagnostics Program, shows a Head Load Time Error and suggests checking U33 and U15.

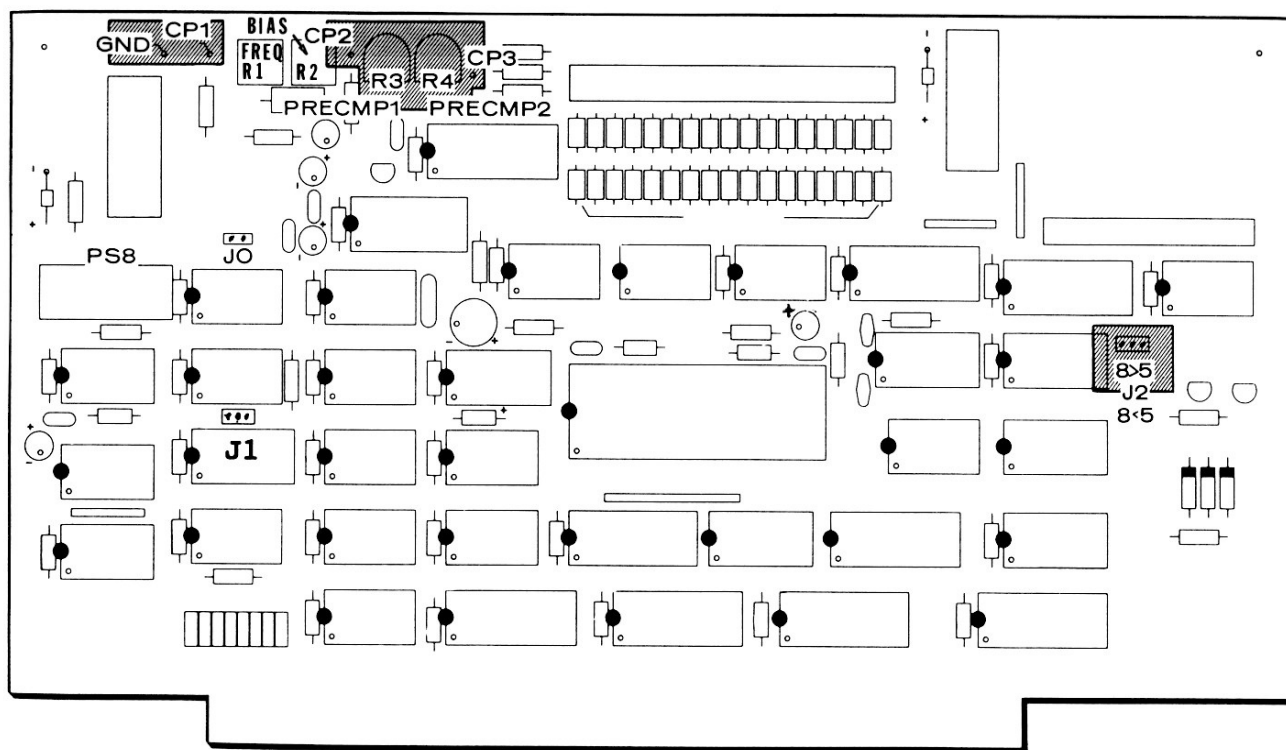
**POSSIBLE CAUSE:**

1. Replace U33 and U15 as recommended.
2. Replace C48, located between U15 and U21, which controls the timing for this circuit. This is a 1.0 uF capacitor of a type with a known history of problems; for me at least.

**PROBLEM:** CP/M will boot from a floppy, but Z-DOS gives an I/O error.

**POSSIBLE CAUSE:**

1. According to FSB-DK-027, check U31 (74LS365A, #443-1039) for a defective gate.
2. Check DS1 switch section "0" in the wrong position or open.



**Pictorial 1**  
**Calibration Locations**

## Calibration Procedures

### Equipment Needed:

You will need the following equipment to most precisely calibrate your Disk Controller Card:

- \* A digital voltmeter (DVM) with at least a four-digit readout.
- \* The special Calibration Circuit (provided in issue #98) **OR**  
A 10 MHz bandwidth, calibrated, laboratory-quality oscilloscope with a sweep speed of 50 ns/division and a vertical deflection of 2 V/division, and a low capacitance (X10) probe.
- \* A frequency counter capable of six-digit accuracy at 4 MHz.
- \* A blank 8" diskette (or a 5.25" diskette if you are using only 5.25" drives in your system).

**Note:** The H-207 Assembly Manual provided a simple circuit for calibrating the Disk Controller kits. I found it accurate enough for those that do not have access to a professional oscilloscope. The circuit, construction, and use are provided toward the end of this article.

Usually, two values of pre-compensation are needed: one for 5.25" drives and one for 8" drives.

Accordingly, there are two pre-compensation adjustments on the Disk Controller Card. Potentiometer **R3 (PRECMP1)** is used to set the lower value of pre-compensation and potentiometer **R4 (PRECMP2)** is used to set the higher value of pre-compensation. Pictorial 1 shows the locations of these potentiometers.

Jumper **J2** selects whether the 5.25" or the 8" drive will receive the lower value of pre-compensation. Pictorial 1 shows the location of **J2** on the Card.

While referring to Pictorial 1, perform the calibration as follows:

1. Locate **R3** and **R4** on the Disk Controller Card. Turn **R3** fully counterclockwise. Leave **R4** alone.

**Note:** Some documents have you adjust **R4** fully clockwise. However, doing so may disable **Q1** by placing zero resistance across the **S** and **D** legs of **Q1**. **R4** is used to adjust pre-compensation for 8" drives. If you are NOT using 8" drives, do not adjust **R4**. If it is adjusted fully clockwise, you may not be able to get **R3** to light the LED at all!

2. Insert the Disk Controller into the S-100 bus. Turn the power on and wait five minutes to reach operating temperature.

3. Attach the oscilloscope's probe to CP3 and the probe's ground clip to GND.

4. Determine the values of write pre-compensation that the 5.25" and 8" drives need from the drive's documentation. H/Z floppy drives all require 120 ns of write pre-compensation.

If the value of pre-compensation is higher for the 5.25" drives, or if you only have 5.25" drives, go to Step 7.

If the value of pre-compensation is higher for the 8" drives, or if you have only 8" drives, go to Step 5.

5. Format a blank 8" diskette in any of the 8" drives by running FORMAT. While FORMAT is running, turn **R3 (PRECMP1)** to adjust the pulse width displayed on the oscilloscope to the value of write pre-compensation needed by your 8" drives.

Restart FORMAT as needed until you are satisfied with the adjustment. If you do not have 5.25" drives, you have completed the pre-compensation calibration; proceed to "**Data Separator Calibration**". If you do have 5.25" drives, continue with the next step.

6. Format the 5.25" diskette. While FORMAT is running, turn **R4 (PRECMP2)** to adjust the pulse width displayed on the oscilloscope to the value of write pre-compensation needed by your 5.25" drives. Restart FORMAT as needed. Proceed now to Step 11.

7. If you have both 5.25" and 8" drives, perform the next step. If you have 5.25" drives only, go to Step 9.

8. Cut the foil on the circuit board that connects the middle hole of J2 to the "8<5" hole.

9. Format a blank 5.25" diskette in any of the 5.25" drives using FORMAT. While FORMAT is running, turn **R3 (PRECMP1)** to adjust the pulse width displayed on the oscilloscope to the value of write pre-compensation needed by your 5.25" drives. Restart FORMAT as needed until you are satisfied with the adjustment.

If you do not have 8" drives, you have completed the pre-compensation calibration; proceed to "**Data Separator Calibration**". If you do have 8" drives, go to the next step.

10. Format the blank 8" diskette. While FORMAT is running, turn **R4 (PRECMP2)** to adjust the pulse width displayed on the oscilloscope to the value of write pre-compensation needed by your 8" drives. Restart FORMAT as needed.

11. Remove the oscilloscope probe. This completes the pre-compensation calibration.

## Data Separator Calibration

While referring to Pictorial 1, perform the calibration as follows:

1. Turn the computer on and wait five minutes to reach operating temperature.

2. Make sure the disk drives are not selected.

3. Set the DVM's voltage range to 2 Vdc and attach the common lead to GND and the positive lead to CP2.

4. Adjust **R2 (BIAS)** for a reading of 1.400 Vdc.

5. Remove the voltmeter test leads.

6. Set the six-digit frequency counter to count 4 MHz.

7. Attach the shield lead to GND and the signal lead to CP1.

8. Adjust **R1 (FREQ)** for a reading of 4.000 MHz.

9. Repeat Steps 2 through 8 until there is no further improvement and the 1.4 Vdc and 4 MHz readings occur simultaneously. There will be some (but not much) interaction between these adjustments.

10. Remove the test leads and turn the computer off. This completes the calibration procedure.

**Note:** Format the blank diskettes used in this procedure again before you use them for recording files.

## Setting Z-207 DIP Switches

Please refer to Pictorial 2, next page.

The Z-207's DIP Switch is used to set both the port address and whether a drive requires double-stepping (to do 40 tracks on an 80 track drive). The old BIOS (pre-DOS version 4) only supported either 40 (48 tpi) track drives or 80 (96 tpi) track drives, but NOT both.

With ZROM version 3.x and a new ZDOS v4.01, both types of drives could be used, but the new BIOS Boot Loader required that the DIP switch reflect the number of 40 and 80 track drives connected, and the order in which they were selected (See Figure 1). But the new, required DIP switch settings caused a conflict with other operating systems.

Finally, with the new ZROM version 4 and ZDOS v4.06, the BIOS no longer cares about the mix or type of floppy drives in use, so the DIP switch can resume its original drive configuration for all operating systems. The new DRIVECFG utility now defines which type floppy drives are in use and ZDOS v4 no longer relies on DIP switch settings at all!

**DIP Switch #      Drive Types Connected      Note: 0=Off, 1=On  
DS = Drive Select**

1      0

0 (Off) 0 (Off) 4 - 48 TPI drives (standard 360 Kb drives) (DS0 - DS3)  
0 (Off) 1 (On) 1 - 96 TPI drive (DS0), 3 - 48 TPI drives (DS1 - DS3)  
1 (On) 0 (Off) 2 - 96 TPI drives (DS0, DS1), 2 - 48 TPI drives (DS2, DS3)  
1 (On) 1 (On) 3 - 96 TPI drives (DS0 - DS2), 1 - 48 TPI drive (DS3)

2 (don't care) Not used.

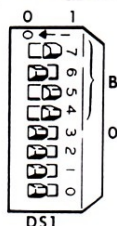
3      LSB port address  
0 (Off) = Primary Controller LSB port address (0)  
1 (On) = Secondary Controller port address (8)

4 (On)      MSB port address (0Bxh). The x indicates the LSB setting  
5 (On)      MSB port address  
6 (Off)      MSB port address  
7 (On)      MSB port address

**Switch      Description:**  
**Section**

7 Port address (MSB)  
6 Port address  
5 Port address  
4 Port address  
3 Port address (LSB)  
2 Not used.  
1 Controls status port bit 3.  
0 Controls status port bit 4.

**Standard  
Heath/Zenith  
Setting:**



On (=1) for second controller card  
Set for number of drives per above.  
Set for number of drives per above.

## Pictorial 2. Setting the Z-207 Controller DIP Switches For ZROM version 3.x and ZDOS v4.01 ONLY

Run DRIVECFG to tell BIOS what each drive is; LD (Low Density), DD (Dual Density), or HD (High Density).

### Note:

- \* Dual Density Drives count as High Density for these settings.
- \* By design, the High or Dual Density drives must occupy the lowest drive select numbers! This could leave your primary Boot 360 Kb drive set as DS4! But, this drive could still be set by DRIVECFG to Drive A:!
- \* **Hint:** To avoid having special Boot disks for each of your different computer configurations, set DRIVECFG on your 360 Kb Boot floppies so all your floppy drives are Low Density. This allows Booting your Low Density 360 Kb floppy from any of your low density drives.

Sect:	Description:
0	This section selects the 5.25" disk drive type. Position the switch section to ON (1), if you use 96 tpi drives or to OFF (0), if you use 48 tpi drives. The default is <b>OFF (0)</b> .
1	This section selects pre-compensation for 5.25" disk drives. Position to ON (1), if you want pre-compensation or to OFF (0), if you do not it. The default is <b>OFF (0)</b> .
2	This section is not used.
3-7	These sections are used to establish the port base address of the floppy disk controller board(s). Normally, for the first or only Z-207 Controller, the switches are:
	(3) (4) (5) (6) (7) OFF ON ON OFF ON

For the second Z-207 Controller, the switches are:

(3) (4) (5) (6) (7)  
ON ON ON OFF ON

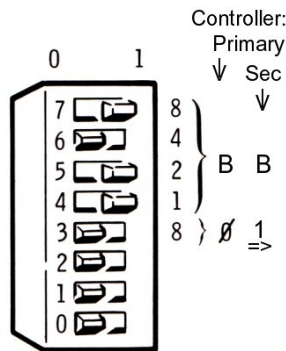
**For ALL other versions of ZROM (MTR-ROM) and operating systems, including ZDOS and CP/M, use the original settings as given in the User's Manual. These are:**

See Pictorial 2a:

## SWITCH DESCRIPTION

## STANDARD HEATH/ZENITH SETTING

SWITCH SECTION	DESCRIPTION
7	Port address (MSB).
6	" "
5	" "
4	" "
3	" " (LSB).
2	Not used.
1	Controls status port bit 3.
0	Controls status port bit 4.



Pictorial 2a.  
Z-207 Controller DIP Switch

## H/Z-207 Port Address

The H/Z-207 Floppy Disk Controller Card occupies a block of eight contiguous I/O port addresses beginning on an 8-bit boundary. The low-order six address bits in this block of eight ports are actually used.

The port address is selected by sections 3 through 7 of switch DS1 on the Card. Switch section 7 selects the most significant bit.

Heath/Zenith Computers use port address B0 hex. Switch sections 0 and 1 are used to control bits 3 and 4 (with 0= least significant bit) of the status port, which can be read at I/O address BASE + 5.

## Notes:

1. H/Z software uses switch section 0 for 48/96 tpi drive selection.
2. Early distributions of Z-DOS v4 used sections 0 and 1 for specifying the 48/96 tpi drive mix.
3. Z-DOS v4.06 and later ignores switch sections 0 and 1. The mix of drives no longer matters to the operating system.
4. Switch section 2 is not used.

## Other Configurable Options

Please refer to your Z-100 User's Manual to configure the following two items, if needed.

## Disk Controller Clock Speed

The H/Z-207 Floppy Disk Controller Card is configured to operate with a CPU that operates faster than 3 MHz. If the Disk Controller is to be used with a CPU that operates at 3 MHz or SLOWER, a minor modification must be made to the board at J1.



## Disk Controller VI Lines

The Vectored Interrupt lines (VI) are properly configured to operate in a H/Z-100 computer. If you use this Controller with a different manufacturer's computer, you may need to configure the VI lines by installing jumper wires.

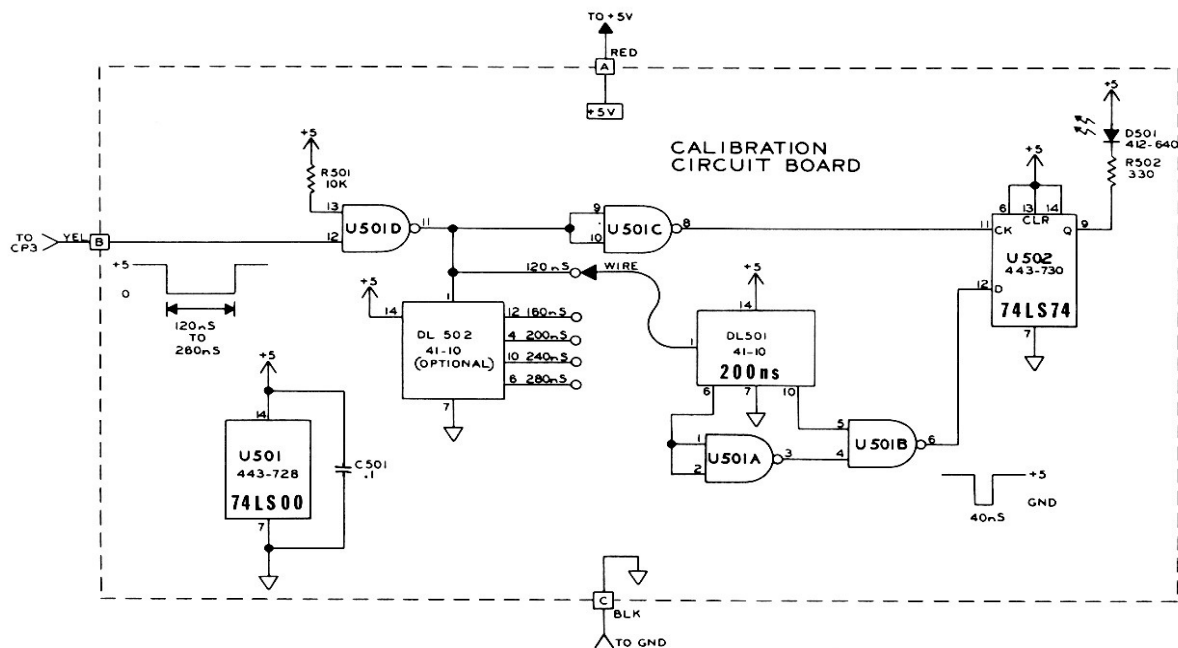
## Constructing a Calibration Board

Pictorial 4 on the last page shows the circuit board that was constructed during assembly of the H-207 Floppy Disk Controller Board. A similar board can be constructed on a standard plug board. Figure 1 (next page) shows the circuit, and Photo 1 shows the circuit on my plug board.

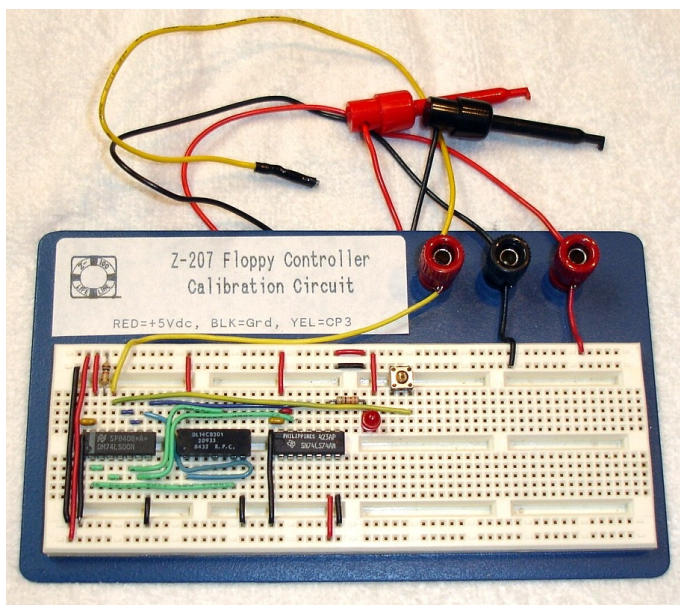
The parts are easily found from spare H/Z-100 computer boards. DL501 and DL502 are the standard 200 ns Delay Line found on the Motherboard or Z-205 Memory Card. DL502 is optional and is only needed if you intend to use this circuit with drives that require more than 120 ns of write pre-compensation.

The only critical construction note is to make the wire connecting pin 1 of DL501 to pin 9 of U501 **no less than 2" long**.





**Figure 1**  
**Calibration Circuit Schematic**



**Photo 1.**  
**Z-207 Floppy Controller Calibration Circuit**

## Heath Drive Calibration

**CAUTION:** The procedures given earlier use an oscilloscope and frequency counter, making them much more accurate and preferred over the following procedures, which can damage your controller card or even the computer if improperly used. The following procedures are only provided as an alternate method to be used if the special equipment used above is not available.

If a frequency counter is available, perform the voltage and frequency adjustment as outlined in the **Data Separator Calibration** section above. If the frequency counter is not available, perform the alternate Data Separator calibration procedures, next.

## Alternate Data Separator Calibration

### Calibration Preparation:

1. Locate **R1 (FREQ)** on the Disk Controller board and turn it 30 (thirty) turns clockwise, or until you hear a clicking sound as you rotate the control shaft.

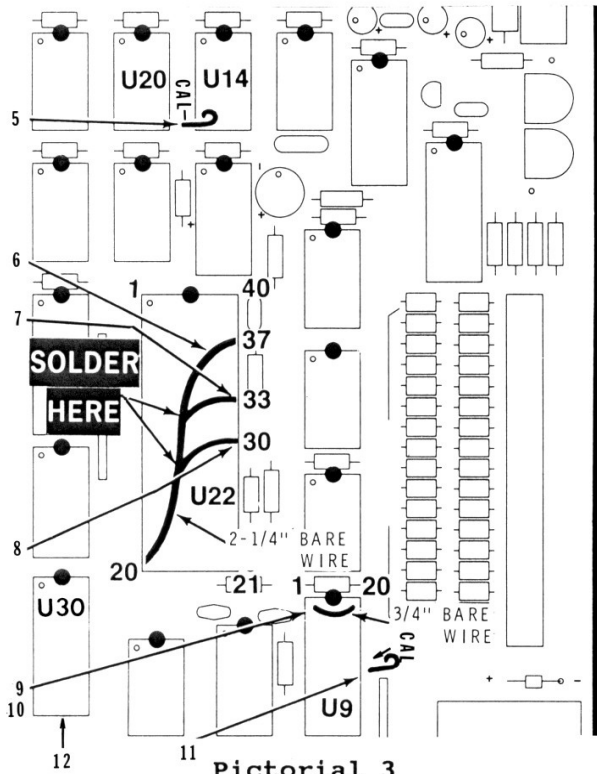
**CAUTION:** While the following procedures could be used without a spare socket, inserting wires into the board's IC sockets could severely damage the socket. Always use a spare socket.

2. Locate a spare 40 pin IC socket and bend all of the pins inward under the socket except pins 20, 30, 33, and 37.

These are the only pins that will be used.

3. Remove U22, the FD1797 controller chip, and carefully set it safely aside.

4. Install the new 40 pin socket into the empty U22 socket, ensuring that only the four pins, 20, 30, 33, and 37 are properly inserted into their respective pin sockets.



**Pictorial 3  
Board Preparation**

Refer to Pictorial 3 for the following steps.

5. Cut a 1/2" bare wire. Then bend a loop in one end of the wire and solder the wire in the **CAL** hole located between U20 and U14. Be sure the wire does not touch any other nearby foils or component leads.

6. Cut a 2-1/4" bare wire, bend 1/4" at each end, and insert the wire into socket holes 20 and 37 at U22.

7. Push a length of bare wire into socket hole 33 of U22, solder it to the 2-1/4" bare wire already installed, and cut off any excess.

8. As before, push a bare wire into socket hole 30 of U22, solder it to the 2-1/4" bare wire, and cut off the excess wire.

9. Remove U9, 74LS241, from its socket and set it carefully aside. Locate a spare 8, 14, 16, or 20 pin socket and install it into the vacant U9 socket, lining up the notched ends.

10. Install a 3/4" bare wire into socket holes 1 and 20 at U9.

11. Cut and install another 1/2" hooked bare wire at the CAL hole at the center and side of U9.

12. Remove U30, 74LS273, and set it aside.

The card is now prepared for the Alternate Data Separator Calibration procedures next.

#### **Alternate Data Separator Calibration:**

Refer to Pictorial 5 (last page) for the following steps.

1. Install the Z-207 Controller Card, less the three IC chips and prepared as given above, into the computer and connect its cables.

2. Using a high impedance DC voltmeter (10M ohm or greater), select the voltage range that is most suitable for measuring a voltage that is below 5 volts.

3. Connect the common (or negative) test lead to test point "GND".

4. Connect the positive voltmeter lead to test point "CP2".

**CAUTION:** When the all-in-one computer is turned on, high voltage is present at the video deflection circuit board and the CRT's anode. Be careful and do not contact these areas while the computer is turned on.

5. Plug in your computer and turn it on.

6. Adjust control **R2 (BIAS)** for a meter reading of 1.40 Vdc. Switch to as low a range as possible to perform this adjustment.

7. Turn off the computer, unplug the cable, and remove the Controller Card.

8. Cut a 5" white wire, remove 1/4" of insulation from each end, and temporarily solder the wire between the two wires in the CAL holes on the component side of the circuit board.

9. Reinstall the circuit board into the computer and reconnect the voltmeter to test points GND and CP2.

10. Turn on the computer.

**Note:** In the next step you will adjust the **R1 (FREQ)** control for a meter reading of 1.40 Vdc. It is normal for this voltage to start at about 1 volt. Then as you rotate the control counterclockwise, this voltage may gradually drop to near zero, and then jump to approximately 2 volts. Rotate this control backwards (clockwise) to locate the FIRST place where you can obtain 1.40 volts. If your initial voltage reading is greater than 1.4 volts, adjust the **R1 (FREQ)** control counterclockwise until you find the FIRST position at which you can obtain a 1.40 Vdc reading.



If you continue turning counterclockwise, you may find another point that will give a 1.40 Vdc reading. This second point is the wrong one; do not use it.

11. Adjust **R1 (FREQ)** counterclockwise for a meter reading of 1.40 Vdc  $\pm 0.05$  volts.

12. Place the top cover on the computer and allow it to operate for 15 minutes (to stabilize), then remove the cover and fine tune the previous step.

13. Turn off the computer, unplug the cables and remove the Controller Card.

14. Remove the 5" white wire from the component side of the Card.

15. Remove the top 40-pin IC socket from U22 and reinstall the FD1797 controller IC. Check that no pins turned under.

16. Reinstall U30, the 74LS273 IC.

17. Remove the top socket from U9 and reinstall U9, the 74LS241 IC.

Proceed with the Alternate Write Pre-comp Calibration procedures next.

#### Alternate Write Pre-com Calibration:

1. Turn control **R3 (PRECMP1)** fully counterclockwise. Leave **R4** alone.

**Note:** Some documents have you adjust **R4** fully clockwise. However, doing so may disable **Q1** by placing zero resistance across the **S** and **D** legs of **Q1**. **R4** is used to adjust pre-compensation for 8" drives. If you are NOT using 8" drives, do not adjust **R4**. If it is adjusted fully clockwise, you may not be able to get **R3** to light the LED at all!

2. Refer to Figure 2 and connect the red wire coming from the calibration circuit board to the indicated lead of capacitor C27 on the Controller Card, push the black wire connector onto the GND pin, and press the yellow wire connector onto the CP3 pin.

3. Lay the calibration circuit board on the drive shelf as shown if you have a low-profile computer, or position it away from your computer if you have the all-in-one version. Do not let the circuit board touch any metal.

4. Install the Controller Card into any of the card cage slots and connect the drive cables.

**CAUTION:** When the all-in-one computer is turned on, high voltage is present at the video deflection circuit board and the CRT's anode. Be careful and do not contact these areas while the computer is turned on.

5. Turn on the computer and boot up either Z-DOS or CP/M.

6. Locate a blank soft-sectored diskette and insert it into any disk drive.

7. Run FORMAT, and as the diskette is being formatted, adjust **R3 (PRECMP1)** on the Controller Card until the calibration board LED, D501, just lights and glows steadily. When the FORMAT program stops, the LED will remain latched "ON" as long as the adjustment was set between 120 ns and 160 ns of write pre-compensation. Be sure the FORMAT routine is running while you make any adjustment to the control.

8. Open the drive door, turn off the computer, remove the calibration circuit board, and install the Controller Card in any convenient card cage slot.

This completes the calibration of your Controller Card.

**Note:** Reformat all blank diskettes used during these procedures before you use them.

I hope you find this explanation helpful.  
Cheers,

Steven W. Vagts

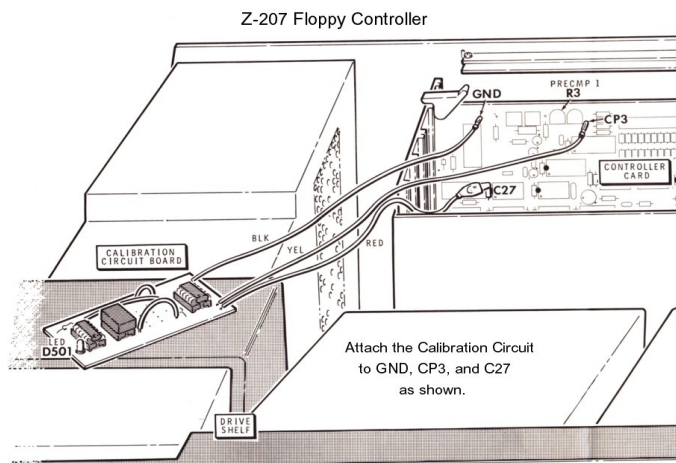
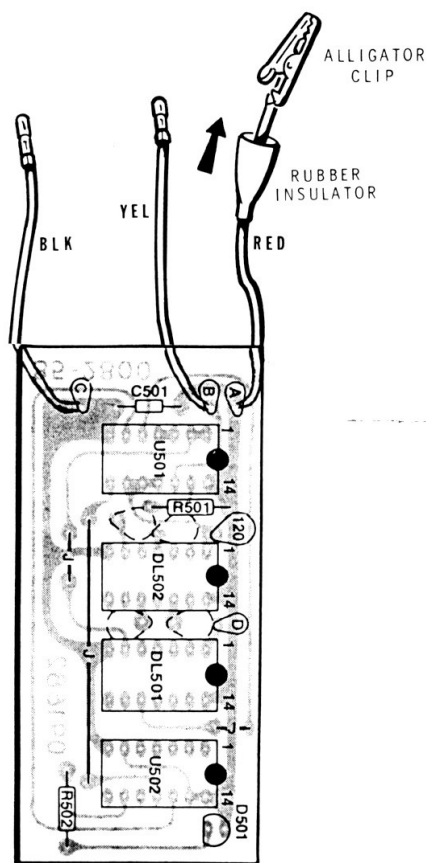
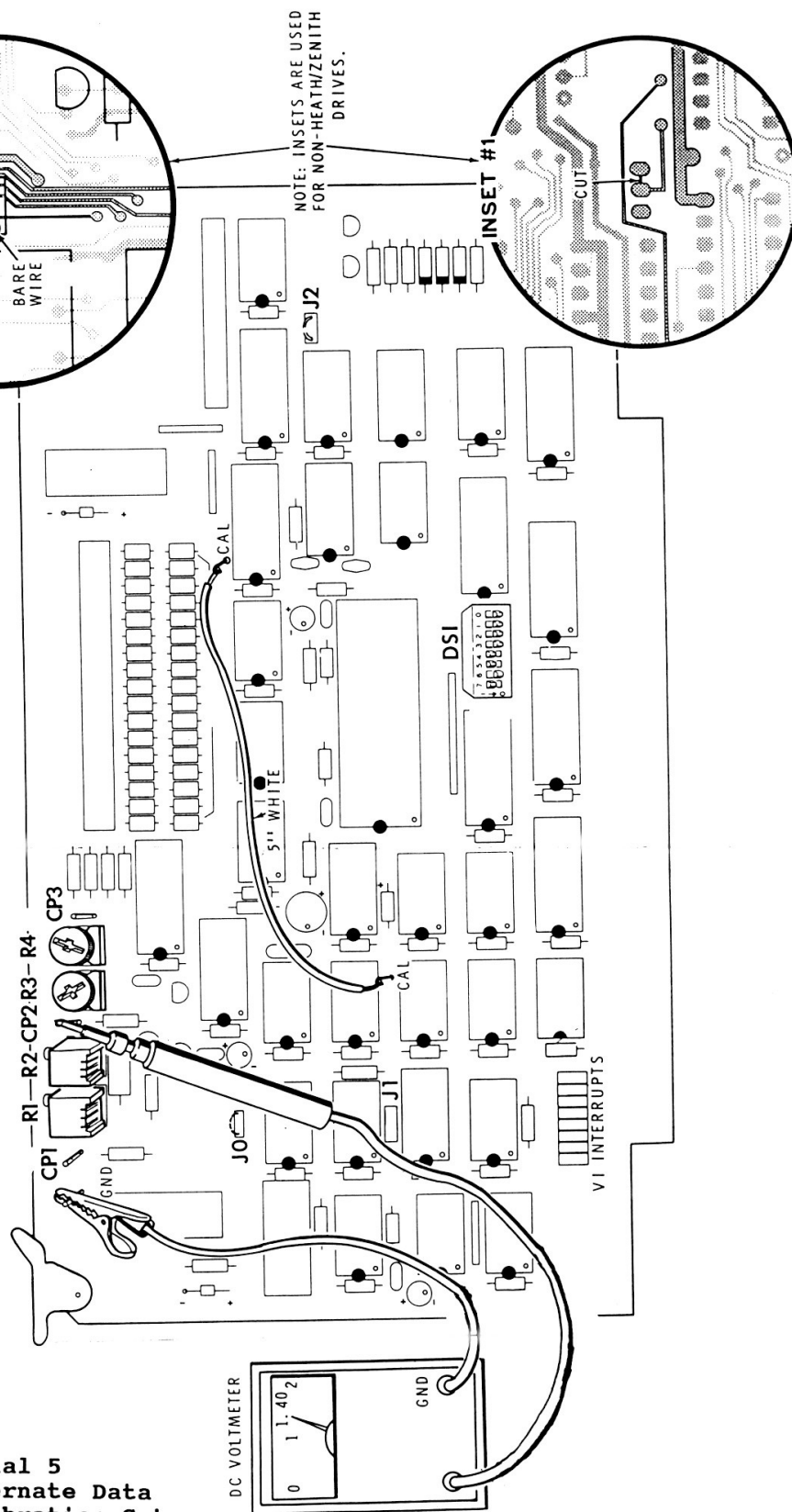


Figure 2.  
Connecting the Z-207 Calibration Circuit





**Pictorial 4**  
H/Z-207 Calibration  
Circuit



**Pictorial 5**  
H/Z-207 Alternate Data  
Separator Calibration Setup