SyQuest SQ-312RD 10Mb
Cartridge MFM Hard Drive

SyQuest 5Mb SQ-306 & 10Mb SQ-312 Removable Cartridge Hard Drives Operations Manual

The SyQuest SQ-312RD disk drive is a random access storage device utilizing a 3.9-inch aluminum disk with a plated recording layer overcoated with sputtered carbon as storage media in the form of a removable cartridge. Each disk surface employs one movable head to service 615 data tracks. The total formatted capacity of the SQ-312 with its two heads and surfaces is 10 megabytes (32 sectors per track, 256 bytes per sector, 1224 tracks).

The SQ-306 is similar but with half the tracks and half the capacity.

A complete description of the SyQuest SQ-312RD can be found in the article, "SyQuest SQ312RD OEM Manual on this "*Z-100 LifeLine*" Website.

Operational Functions

Mounting Orientation

The drive measures about 4.8" wide, somewhat smaller than the standard 5.25" drive, and will require spacers in most computer installations.

Otherwise, it is a standard ½-height drive and measures 8.5" deep.

The recommended installation orientation is either vertical on either side or horizontal with the PCB (Printed Circuit Board) down. Air flow must be provided to cool the PCBs. The drive mounting frame has perforated holes to allow air flow over the PCB.

The drive, just standing loose on its side on my dining room table next to my Z-100 test bed, does become quite warm to the touch during operation - this is normal.

Track Format

Like most storage media, the disk surface is laid out in tracks, with Track 0 toward the outside diameter of the disk.

The purpose of a format is to organize a data track into smaller sequentially numbered blocks of data called sectors. The format is a soft sectored type which means that the beginning of each sector is defined by a pre-written identification (ID) field which contains the physical sector address plus cylinder and head information. The ID field is then followed by a user supplied data field.

The format is a slightly modified version of the IBM System 34 double density format which is commonly used on floppy disk drives. The encoding method is Modified Frequency Modulation (MFM).

Power Sequencing

One of the first things you will notice upon power up is the delay before coming on-speed and ready, at least with my CDR-317 controller. Unlike most hard drives, this cartridge drive has a delay of about 8 seconds even before spinning begins. And an additional 23 seconds before it reports Ready. Even a warm boot takes 12 seconds to return to the hand prompt!

While +5 and +12 volts may be applied in any order, +12 volts must be applied to start the spindle drive motor. A speed sensor measures this index time to within 2% of operational speed. After the spindle drive motor reaches operating speed, the on-board microcomputer initiates a calibration procedure:

1. Find track 0 and set track 0 true.
2. Seek to track minus 4.
3. Read the pre-recorded Reference track.
4. Divide the 615 cylinders on the cartridge into 20 different zones.
5. Seek to each zone, read the servo info, & store head offset in memory.
6. After all 20 zones have been read successfully, seek to track 0.
7. Set Seek Complete and Ready true.

If the drive is unable to read the reference track, the spindle motor will power-down and the LED on the front panel will rapidly flash red. The operator should remove and reinsert the cartridge.

The drive will not perform read, write, or seek functions until Ready becomes true and the front door LED turns green. When the drive is selected, the LED will turn orange.

During the power-up sequencing, the computer monitors the Write Fault condition. If a Write Fault is detected, the drive will not become Ready. The controller can also cause a Write Fault condition if Drive Select and Write Gate are true during the power-up sequencing.

If the fault option is selected, the drive circuit will latch on for a fault condition. This latch can be cleared by deselecting and reselecting the drive.
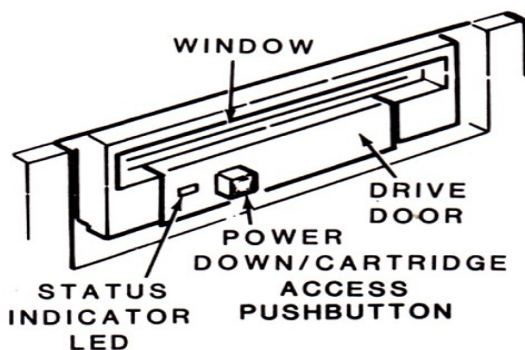
LED Operation

Figure 1.

The SyQuest Cartridge Disk Drive has a status indicator LED on the front panel. Its dual-color capability and ability to stay steadily lit or flash, either slowly or rapidly, indicates the five states of drive status:

* State 1 is RED - The drive may be in a power up initialization process or head motion may be in process. Seek Complete is false.

* State 2 is GREEN - The drive is Ready, Seek Complete is true, the drive is not selected.

* State 3 is ORANGE - The drive is Ready, Seek Complete is true, the drive is selected.

* State 4 is SLOW FLASHING RED - The drive is in a spin-down sequence.

* State 5 is RAPID FLASHING RED - Indicates an excessive runout condition with the Q-PAK. Remove the Q-PAK and reinsert.

Physical Interface

The electrical interface between the SQ-312RD and the host controller is via three connectors:

* J1 - Control signals (multiplexed)
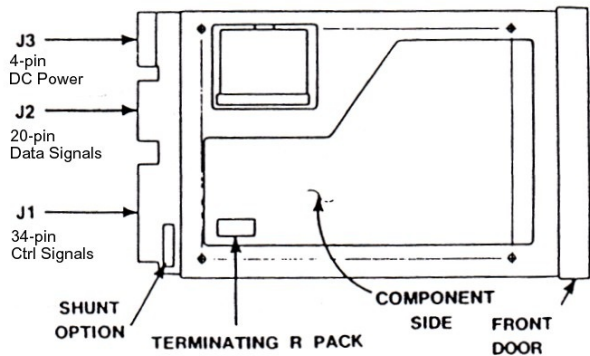* J2 - Read/write signals (radial)
* J3 - DC power input

Figure 2.

J1/P1 Connector - Control Signals

Connection of J1 is through a 34-pin edge connector (see Figure 2). The even pins are located on the component side of the PCB. Pin 2 is located closest to the DC Power connector J3/P3 and a key slot is provided between pins 4 and 6. All odd pins are ground.

J2/P2 Connector - Data Signals

Connection to J2 is through a 20-pin edge connector (see Figure 2). The even pins are located on the component side of the PCB.

J3/P3 Connector - DC Power

DC power connector (J3) is a 4-pin AMP connector (see Figure 2), mounted on the edge of the PCB. The following table shows the DC power requirements at each pin and the motor start current requirements.

DC Power Requirements

Pin:	Voltage:	Amperage:
1	+12 Vdc ±5%*	1.0 A maximum
		0.8 A typical
2	+12 Vdc Ground	
3	+ 5 Vdc Ground	
4	+ 5 Vdc ±5%	1.0 A maximum
		0.8 A typical

* ±10% at power-on or seeking, +5% for reading or writing
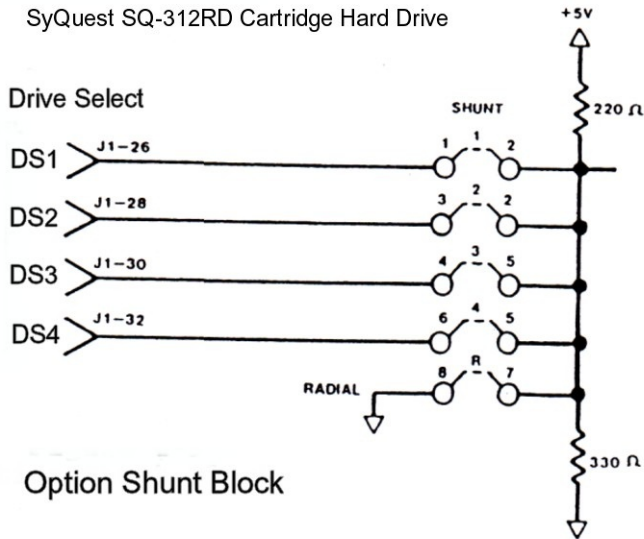
Drive Selection

Figure 3.

The Option Shunt Block is a single row of 8 pins (see Figure 3). Drive selection is done by placing a jumper across two pins representing the drive desired, thus activating the corresponding Drive Select line. Only the selected drive will respond to the input signals, and only that drive's output signals are then gated to the controller interface. The shunt block is normally plugged in the "1" position, enabling daisy chain operation.

The Drive Select signal will go active only when the drive is also programmed as drive x, where x= 1, 2, 3, or 4 (Figure 3) by moving the shunt on the drive.

Outputs are not active until the drive is selected.The Radial Option is implemented via a shunt block position "R" (the two right-most pins) on the main printed circuit board for customer configuration of drive functions.

Moving the shunt block to the "R" position results in radial operation. In this case all output signals are active and the drive is always selected.

Here are some more pictures of the SyQuest SQ-312RD cartridge hard drive:

SyQuest SQ-312RD 10Mb Cartridge MFM Hard Drive

SyQuest SQ-312RD 10Mb Cartridge MFM Hard Drive

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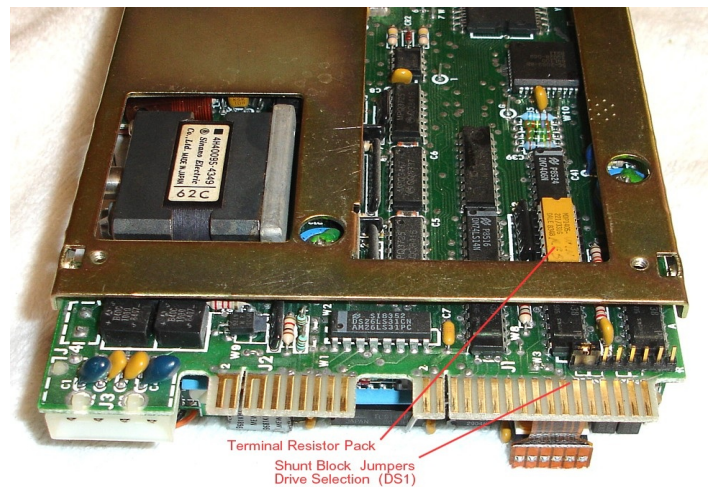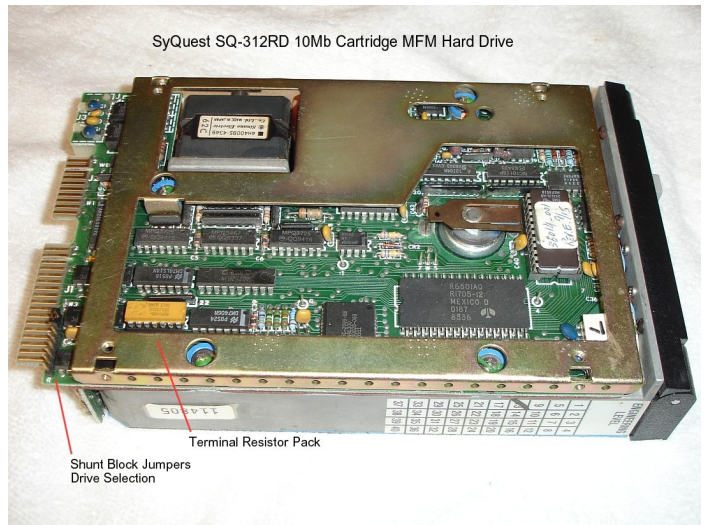
The SQ-200 Cartridge Insert

As mentioned earlier, the cartridge insert utilizes a 3.9-inch aluminum disk with a plated recording layer overcoated with sputtered carbon as the storage media. Each disk surface of the disk has 615 data tracks. The total formatted capacity of the SQ-200 storage cartridge provides 10Mb (32 sectors per track, 256 bytes per sector, 1224 tracks) formatted capacity.

The SQ-100 cartridge is similar but with half the tracks and half the capacity.

The cartridge measures about 4.3" wide x 4.4" long x 0.44" thick.

SyQuest SQ-200 10Mb MFM Cartridge
for Syquest SQ-312RD Hard Drive

SyQuest SQ-200 10Mb MFM Cartridge
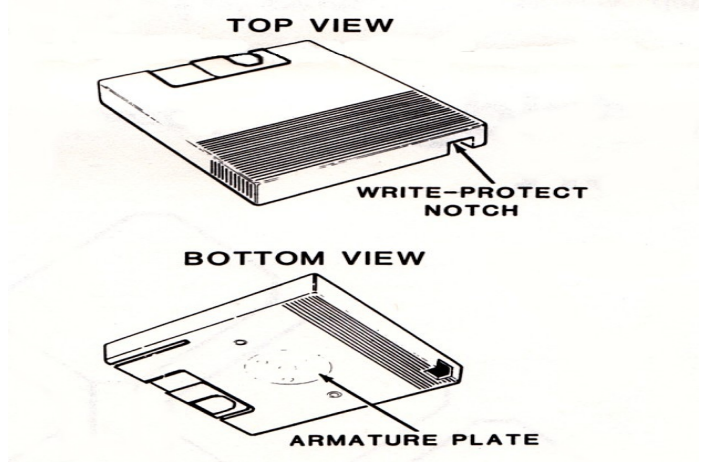for Syquest SQ-312RD Hard Drive

Write Protecting

Figure 4.

When a cartridge is write-protected, you can only read information from the disk; new data cannot be recorded on the cartridge and you can not change the data that is on the cartridge.

When the write protect plug is removed from the cartridge, you can put new files on the disk (write or store data), change the data on the cartridge, and read (retrieve) data.

To remove the write protect plug, simply slide it off the cartridge using thumb pressure. When you remove the write protect plug, store it in a convenient place in case you want to reinstall it later.

CAUTION: The write protection DOES NOT protect against data loss from age. Like other magnetic media, data retention is lost over time simply from the weakening of the magnetic media to hold data. During my testing of 12 cartridges (probably over 40 years old), I found that 8 had BAD sectors scattered randomly across the entire storage media in such numbers as to render the media unusable. I DO NOT recommend use of this media for long term data storage.
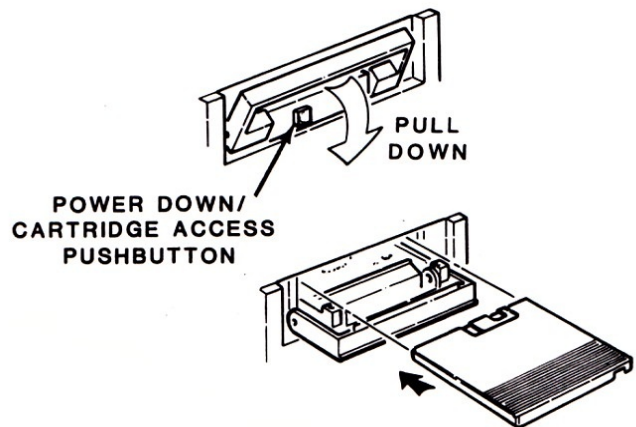
Inserting and Removing Cartridges

Figure 5.

Note: A cartridge can be loaded into the drive prior to turning the system on. If a cartridge is already in the drive, follow the steps under "To remove a cartridge:" before inserting a new cartridge.

To Insert a Cartridge:

1. Press the pushbutton on the front panel of the drive. The drive door will open partially.

2. Carefully lower the door until it lies flat.

3. Gently slide the cartridge into the disk drive as shown in the Figure 5. until it snaps in place.

4. Close the drive door. It should snap and lock when fully closed and the LED should glow red, indicating the drive is powering up.

To Remove a Cartridge:

1. Press the drive door button. The LED will become a slowly flashing red and the motor will slow to a stop.

2. WAIT until the flashing stops, then press the pushbutton again; the drive door will partially open.

3. Gently lower the door to the full-open horizontal or 90 degree position. Place your hand in front of the drive door as you open it further (about 15 degrees below the horizontal position) to ensure that the cartridge does not accidently drop out as it ejects.

4. Remove the cartridge and place it in a protective box.

Caution: If you have any of these original SQ-200 protective boxes, you may wish to inspect them for deteriorating foam. Some of the foam in my boxes were deteriorating so badly that they disintegrated into a sticky dust - something that you do NOT want to keep near your data cartridges. Find another means of protection and storage.

Operating Notes

* Handle the disk drive with extreme care.

* Your computer will boot DOS or CP/M from the SyQuest SQ-312 rigid drive just fine when it is powered up. If a cartridge is not inserted, the monitor will display an error message. To enter the monitor-ROM program, press {CTRL}-{Reset} to get to the hand prompt.

* Remove power to the drive ONLY AFTER the drive has been powered down by pressing the drive button; otherwise, the sensitive read / write heads will contact the disk and be damaged.

* Keep the drive door closed when not in use.

* Do NOT blow into a disk drive to remove dust or other contaminants, or for any other reason.

* Do NOT move the disk drive with a cartridge installed.

Z-DOS v2: Insert the cartridge into the rigid disk drive BEFORE booting the system and do NOT remove it until you are ready to reset or reboot the computer. After booting, use the ASSIGN command to assign any partition on the cartridge to a drive letter.

ZDOS v3+: Cartridges can be replaced anytime it would be valid to replace floppy disks. This, and later versions, automatically assigns a drive letter whenever a new cartridge is inserted into the rigid disk drive.

My Testing Configuration

Reportedly, the SyQuest SQ-306 and SQ-312 can be directly connected to the Heath/Zenith H/Z-217 MFM Hard Drive Controller in the same manner as any normal MFM hard drive. But, I could NOT get this configuration to work at all - more later!

However, I also had a C.D.R. (or CDR) Systems SCSI Controller that I wanted to check out with the SyQuest SQ-312 Cartridge Hard Drive. The CDR-317 SCSI hard drive controller can be paired with an XEBEC S1410A SCSI to MFM Adapter to use a normal MFM hard drive. It works great with my Seagate ST225, so I was anxious to try it with the SyQuest. The arrangement looks like this:

CDR-317 SCSI Ctrlr <=> XEBEC SCSI to MFM Adapter <=> SyQuest SQ-312 HDrive

NOTES:

When used with the CDR-317/XEBEC S1410A SCSI Controller combination, there are several unique considerations that must be taken into account.

The XEBEC S1410A formats a drive with a maximum of 17 sectors per track with 512 byte sectors, consistent with PC's and their clones:

* This tends to allow for a higher drive reliability.

* This enables use of imbedded servo drives which utilize the extra gap space not available when using 18 sectors per track.

* There is a 5.6% lower formatted capacity on the drive than when formatted with 18 sectors per track.

* The H/Z PREP program expects to format drives with 18 sectors per track. The CDR-317 controller controls the drive sectoring so that PREP still thinks that it is formatting 18 sector tracks while the drive is actually using 17 sectors per track. However, the number of cylinders to be formatted must reflect the smaller number of sectors per track. The number of cylinders may be calculated as:

  Cylinders=1 + [(actual cylinders) * 17/18]

  If the total number of cylinders are speci-fied when using PREP, the PREP program will report a TOO MANY BAD SECTORS error for the drive, because it is trying to access sec-tors beyond the drive's capacity.

* To use SYQUEST drives with the XEBEC S1410A, the Reduced Write Current field is used to specify the type of SYQUEST drive. The following HEX numbers are used to identify SYQUEST drives:

  SYQUEST SQ-306 5Mb drive: RWC = 4000
  SYQUEST SQ-312 10Mb drive: RWC = 6000

* When the CDR-317/XEBEC S1410A combination SCSI controllers are used, the three term-inating resistors MUST be installed on the CDR-317 Board in sockets R8, R9, and R10, with the dot (ground side) away from the + symbols.

* **PREP Entry for XEBEC & SYQUEST Drives:**

  - SYQUEST SQ-306, 2 heads, 122h cylinders, 4000h reduced write, 0 precomp, step=2, ship=134h.
  - SYQUEST SQ-312, 2 heads, 244h cylinders, 6000h reduced write, 0 precomp, step=2, ship=269h.

For the normal Zenith Z-217 MFM Hard Drive Controller use the following PREP parameters for SyQuest Drives:
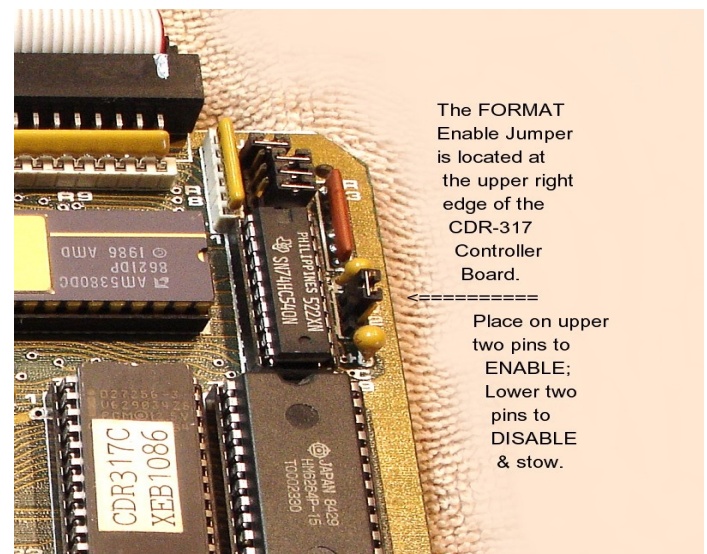
Drive:	Hds:	Cyl:	RWC:	Pcmp:	Step:	Park:
SQ-306	2	132h	133h	133h	2	135h
SQ-312	2	267h	268h	268h	2	26Ch

As noted earlier, I could not get these values, or even lower values in any combination, to work. All sectors were reported to be bad!

CDR-317 SCSI Hard Drive Controller

XEBEC SCSI to MFM Hard Drive Controller Adapter
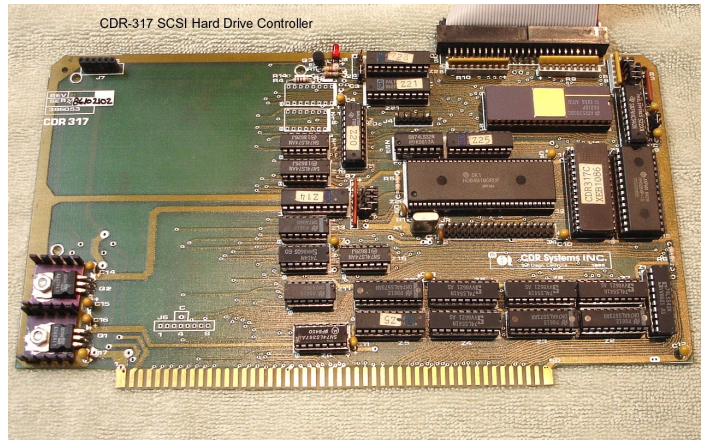
For my Testing, I used the arrangement pictured on my test bed Z-100 with a full 768Kb RAM on a new motherboard running at 9.44MHz.

Remember to install the FORMAT Enable jumper, whether running with a H/Z-217 or the CDR-317 hard drive controller. On the CDR-317 it is located at the upper right edge of the board:

The FORMAT Enable Jumper is located at the upper right edge of the CDR-317 Controller Board.
<==========
Place on upper two pins to ENABLE; Lower two pins to DISABLE & stow.

While using the standard H/Z-217 Hard Drive Controller, if you neglect to install the FORMAT Enable jumper, ZDOS V4 PREP will warn you to install the jumper. However, if you neglect to install the jumper on the CDR-317, PREP just continues to list bad sectors as:

"Formatting CYLINDER, format error."
"Formatting CYLINDER, format error."
...continuously...

So if you see these being listed continuously, check that the FORMAT Enable jumper was installed correctly.

The testing procedures used were simple.

I booted to the ZDOS v4.06 hard drive utilities disk and ran PREP using the SQ-312 parameters:

Drive: Hds: Cyl: RWC: Pcmp: Step: Park:
SQ-312 2   244h 6000h 0   2   269h

I entered each parameter, when asked by PREP. Then, PREP v4.06 would normally begin:

"Formatting DRIVE...completed"
"Media test in progress, Pass 1 Writing CYLINDER (CYL#)" where (CYL#) would run from 0 to 578 cylinders. If there were bad sectors detected, it would list them as the testing progressed.

When the Writing CYLINDER was complete, the message would change to:

"Media testing in progress, pass 1 Writing CYLINDER Reading CYLINDER (CYL#)"
Again, if there were bad sectors detected, it would list them as the testing progressed.

When complete, the format would begin again:

"Formatting DRIVE...completed"
"Re-checking final format. Reading CYLINDER (CYL#)"
"A:\>"

As you may recall, at this point, while using the lower versions of ZDOS, you would need to perform a cold boot between the commands PREP, PART, and FORMAT. But I was using ZDOS v4, so the cold boots were no longer necessary.

I ran PART to create the partitions:
  ZDOS3   40%   4165.5 KB
  ZDOS4   50%   5206.5 KB
  CPM85   10%   1040 KB

Next, I ran **ASGNPART 0:ZDOS4 F:**
So I could then run **FORMAT F:/s/v**

Finally, I could load the rest of my desired ZDOS v4 programs.

Rebooting to my ZDOS v3 floppy disk, I ran:
  ASGNPART 0:ZDOS4 E:
  FORMAT E:/s/v

And loaded my ZDOS v3 files.

After testing the drive was working properly, I dug out my CP/M-85 manual and disks, and loaded the operating system to the SyQuest SQ-312 for testing. It also worked great.

Overall, the procedures worked as advertised, but only on 4 of the 12 SQ-200 cartridges that I had.

Now, let us cover the dark side...

Problems

I had two SyQuest SQ-312 drives, and I checked ALL the cartridges on both. Additionally, I also tried to run both drives and several of the cartridges on the standard Heath/Zenith Z-217 hard drive controller in two separate Z-100s, one at 9.44MHz and the other at 5MHz, so the testing was pretty thorough.

While using the CDR-317 Host setup, the failures were pretty obvious:

"Formatting drive...completed"
"Media test in progress, Pass 1 Writing (CYL#)"
"Bad sector (#,#h), continuing Writing (CYL#)"
"Bad sector (#,#h), continuing Writing (CYL#)"
...continued...

There may be a few listed until we got to the last cylinder, then it would begin again, but

"Bad sector (#,#h), continuing Reading (CYL#)"
"Bad sector (#,#h), continuing Reading (CYL#)"
...continued... listing dozens, until I quit.

The errors were usually random, no particular clusters indicating damage to a platter, but spread pretty evenly across the entire disk. It seemed to indicate the surface of the media could no longer hold the data (weak?), probably due to the age of the media. When I took the cartridge apart and studied the media, there seemed to be no indication of damage.

I trashed each cartridge after it failed in each drive on two separate Z-100 computers (a second Z-100 running at only 5 MHz in the garage). I even tried reconfiguring the Z-100 in the garage back to ZROM v2.5 (the most popular ROM), but there was no change.

I tried two versions of PREP, version 4.06 and version 2.01, with no luck. Yes, I remembered to install the FORMAT Enable Jumper on the Z-217 hard drive controller.

PREP v4.06 was most helpful. I tried varying all the parameters, cylinders, step rates, etc, but it always ended the same way:

After entering the parameters, Prep v4.06 would begin:

"Formatting drive...completed"
"Bad sector 0(00h). Continuing with Pass 1, Writing CYLINDER"
"Bad sector 1(01h)...Writing CYLINDER"
"Bad sector 2(02h)...Writing CYLINDER"
...listing them all in order...

You will get the same sequence if you get the PREP parameters wrong, such as inputting too many cylinders or not using 6000 for the reduced write current with the SyQuest Hard Drive.

Enter {CTRL}-{C} to abort the testing.

With each bad sector the drive detected, it would cycle the heads back to track zero and try a couple of times to read the bad sector. So the retries slowed the process considerably! Then, if allowed to continue, it would do it all again, this time Reading each cylinder!

PREP v2.01 was less detailed:

"Initializing the disk...completed"
"Media Test in progress, pass 1"
"Track (0) contains bad sector(s)"
"A:\>"

While I could understand seeing this on those cartridges that had so many bad sectors identified by PREP v4.06, the error was also reported on those few cartridges that showed NO BAD SECTORS!

Even PREP v4.06 identified and reported all bad sectors on those cartridges that were previously identified as having no bad sectors.

Further, I tried to operate the SyQuest drives with cartridges that had been successfully formatted by PREP and partitioned with PART for ZDOS v3, ZDOS v4, and CP/M-85. All three partitions were bootable with the CDR-317/XEBEC combination.

However, NONE were recognized by the standard H/Z-217 hard drive controller combination. Even ASGNPART 0: only beeped, and the partitions were not recognized!

If you error and place the 6000 response to the reduced write current while using PREP v2.01 with the standard H/Z-217 hard drive controller, PREP does recognize the error and reports:

"Initializing the disk..."
"Error during the formatting of the drive."

So, that is something...

Conclusions
While I was impressed with the cartridges that worked - they had no bad sectors identified, even when the label on the cartridge from the manufacturer listed one or two... And they worked perfectly. I was able to partition them for ZDOS v3 and ZDOS v4 and even CP/M-85. They were all bootable in each operating system.

The failures were catastrophic on most of the cartridges - listing tons of bad sectors, scattered randomly across the entire media. Whether from old age (>40 years), bad media, mold, who knows? But the media was rendered useless. I disassembled each and recycled the aluminum, steel, and even the plastic.

Finally, it was very evident that the cartridge format was NOT compatible between the CDR controller and the standard Heath/Zenith Z-217 controller, even though the same operating system utilities were used. I have been unable to determine the reason.

If you have one of these SyQuest drives and have any valuable data stored on the cartridges, I would recommend that you check on their condition. Of particular concern is the condition of the foam in their storage boxes. Several of my boxes have literally turned to a dusty, sticky mass, but the cartridges were pretty well sealed while in their box and I removed them quickly after seeing the condition of the foam. I do not believe that the foam condition had any impact on the cartridge failures.

If any of you had actually gotten these drives to work on a normal Z-217 MFM hard drive controller, I sure would like to know how you got them to work. I would love to report your success here in an update.

Finally, if you have an uncontrollable desire to actually purchase the SyQuest SQ-312 cartridge drive, the drives alone are available in unknown condition on Ebay for about $100.00. And some of the cartridges are still available also.

However, having seen the actual results of my testing, I do not recommend using this system due to the high failure rate of the 40+ year old cartridges.

But, that said, it is an alternative to the scarce hard drive systems capable of use in the Z-100.

I have two SyQuest SQ-312 drives available, fully tested and working, with a few working cartridges. Let me know if you are interested.

If you have any questions or comments, please email me at:
        z100lifeline@swvagts.com

Cheers,

Steven W. Vagts