

Roll-Your-Own Vanilla SCSI Hard Disk Drive

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Introduction

With the advent of cheaper memory, larger software and especially the Apple IIgs, Apple // computer users are using their systems for more complex and larger tasks resulting in greater demands for high capacity disk storage systems. Since the birth of the Apple II, we have seen changes in disk storage from the original 13-sectored 5.25 inch floppy drive, to the 16-sectored 5.25 inch floppy drive (160K maximum capacity), to 3.5 inch micro floppy (800K maximum capacity) to the rise in popularity of hard disk drives from 5 megabytes capacity on up. These changing demands are not Apple // -specific but are common throughout the industry, and the advances in hard disk drive technology have been coupled with ever-decreasing costs. Where once a hard drive was the property of the wealthy few, more and more "home users" are finding hard drives are no longer dreams of their futures but realities in their dens and living rooms.

When I purchased my Sider 10 meg SASI hard drive in April 1986, I paid \$695 "mail order". When I purchased my 60 meg CMS SD60 A2S SCSI hard drive in January 1988, the mail order price was \$950. As you can see, the price per megabyte storage decreased from 69.50/meg to \$15.83/meg - quite a price decrease! And although the price of commercial hard drives has not decreased very much in the year since I purchased the CMS drive, you can easily assemble your own SCSI hard drive at a cost of about \$10.93/meg for a 64 meg SCSI drive!

I'll explain how (and how easy) it is in this document.

Why a SCSI Drive?

For Apple // owners, there are basically two types of hard disk drives which are popular: SASI and SCSI. An example of a SASI drive is the Sider series by First Class Peripherals (formerly XEBEC), and examples of the SCSI drive are the CMS, Chinook and Apple hard drives.

The SCSI (Small Computer Systems Interface) hard drives are by far the most popular devices these days, especially in light of Apple's commitment to the SCSI interface (also used on the Mac line). The SCSI interface allows you to chain several SCSI devices [HDs, tape backups & CD-ROMs] on the same "chain", and both ProDOS and GS/OS were

designed with the SCSI interface in mind. To keep pace with future design advances in CPU and software, it is highly recommended that you choose the SCSI interface type hard drives for your system.

Which Brand SCSI Hard Drive Do I Choose?

There are several manufacturers of SCSI hard drives of excellent quality: Seagate and MiniScribe are, in my opinion, two of the best around. Both manufacturers market a wide array of drive types (SCSI, MFM, RLL), capacities (10-345 megs) and speeds (65-19 milliseconds) and provide very high quality products backed by a 1-year manufacturer's warranty. The CMS drives, for example, use the Seagate SCSI series of drives in their products.

When searching for a SCSI hard drive, the first thing you need to know is how to identify a SCSI drive from another interface type (such as MFM or RLL). Seagate's SCSI hard drives are identified by numbers beginning with "ST" and ending in "N"; for example, the Seagate 20 meg SCSI drive is identified by ST255N, their 40 meg SCSI drive by ST251N and their 65 meg drive by ST277N. MiniScribe identifies their SCSI hard drives by a 4-digit number followed by "S"; their 20 meg drive is identified by 8425S and their 40 meg drive by 8051S.

Which Size Drive Do I Choose?

Which drive you choose depends upon several personal factors, such as total storage capacity you need and the types of applications you'll be running at present, what you think your future needs will be, and how much money you can afford to spend right now.

Your present needs and applications are the easiest thing to determine. Consider how many 800K micro floppies and 160K 5.25 inch floppies you have as "work disks" (vs backups) and calculate the total storage capacity that all of these collectively take to get a rough idea as to what your present hard drive usage would be. Consider how fast you accumulate disks - 10 per month, 50 per month? Most of your disk accumulations should be for data, since most folks do not accumulate program disks anywhere near as fast as they do data disks.

Next, consider which of all your programs you would actually be running off the hard drive. Note that many games are copy-protected and thus can not readily be moved to hard disk unless (a) you can remove the copy protection (or in rare cases, the copy protection only applies to floppy copies and the copy protected program can be moved to high capacity storage devices) and (b) the program was written such that it is not dependent upon a specific volume name "hard coded" into the program itself (if it does

require a specific volume name, even when run off the hard drive, it will require the floppy to be in the drive and will most likely use that version rather than your hard drive version). All of these considerations are guidelines for getting some rough idea as to your current hard drive needs; the bottom line is that you will have to give serious thought to exactly what it is you'll be putting on your hard drive.

The hardest thing to determine is what your future hard drive needs will be. This is especially difficult because, in many regards, the requirements of future software applications is not only out of your hands but remains unknown to even the developers themselves! If you are using an Apple IIgs, about all that can be said is that software is growing at an unbelievable rate and even now many IIgs-specific products come on multiple 800K microfloppies. Look to the Mac and MS-DOS and OS/2 worlds to get a taste in the trends: single applications requiring a dozen or more high density floppies are not uncommon by any stretch of the imagination.

Just like buying a new car, determining what you can afford on a new hard drive is extremely difficult in large part because the cost per megabyte of storage decreases dramatically as the overall capacity of the drive increases. For example, ComputAbility's prices for Seagate SCSI hard drives in February 1989 were \$319 for 20 megs and \$419 for 65 megs: \$15.95 per meg vs \$6.45 per meg. Considering the per meg cost, it really does pay to stretch your wallet to the max and get the largest hard drive you can possibly afford if you're looking for both the best dollar value and the maximum expandability for the future.

Finally, consider the sizes of the data files with which you'll be working, and their number. Many database programs, for example, use "virtual memory" - using the disk in lieu of RAM memory. An example of such an application is Managing Your Money. Applications which use virtual memory require not only disk space for the file but more (which can be double the size of the disk file itself) for virtual memory. Again, there is no global rule-of-thumb for this - it varies from user to user based on specific software applications running and the amounts of data being maintained and manipulated.

What Speed Drive Do I Need?

To the greatest majority of folks, Speed Is King. In addition to large storage capacity (and the concomitant elimination of constant swapping of floppy disks during your application), hard disk drives offer great improvements over floppies in I/O (input/output) times. Several factors play a role in the effective I/O speed of the device: seek time (how fast the drive itself can find specific blocks on the disk surface), transfer

rates (how fast the data can be moved between drive and computer), and CPU speed (how fast your computer can handle data movements within itself).

"Slow" hard drives have a speed of approximately 60 msec or greater. "Fast" hard drives have speeds in the range of 18-28 msec. The most common "average" SCSI hard drives operate in the 40-42 msec range. [Most 'common' drives now run at 23ms - Access times DO make a difference.] Of course, you pay for increased speed (nothing is free in life), and to give you a rough idea of how much you pay for the speed increase, consider these prices from Hard Drives International on identical type (non-SCSI) and sized drives which differ ONLY in access speeds: the Seagate ST251 40 meg drive at 40 msec runs \$329 whereas the exact same drive running at 28 msec is \$399. That's \$1.75/meg added to the cost for increased speed alone.

The most popular speed today on the Apple // series is 40 msec since neither the CPU nor the host adapter cards (plugged into the Apple's slots and connected to the hard drive itself) can handle drives much faster than this. Of course, this will change in the future, but for now spending more money on drives faster than 40 msec does not give you any direct benefit. If today is your main concern, you are better off spending the extra dollars to get a larger capacity drive; if you are concerned with tomorrow as well, and speed is your main concern, getting the faster drive today may pay off in the near future. About the only other suggestion I can offer is to NOT get a drive slower than 40 msec (i.e., an access time whose number is greater than 40, e.g., 65 msec).

Rolling My Own - A Short History

Last year, when my BBS needed to expand its hard drive storage beyond the 10 megs it had, I was faced with again spending \$950 for another commercially-available 60 meg hard disk drive. And my pockets just weren't that deep, especially after having blown \$950 several months earlier. I was also somewhat green with envy at all my MS-DOS friends (yes, I admit it - I do have MS-DOS friends!) constantly bragging about just how cheap their hardware was. These were the circumstances which lead me to buy my first copy of Computer Shopper and thus began my journey into the unknown world of assembling my own vanilla SCSI hard disk drive.

Having a CMS drive already, I popped open the hood and looked inside. I found that the CMS hard drive - once mysterious and magical - was nothing more than a Seagate ST277N SCSI drive and power supply unit inside a metal box. It appeared that CMS did no alterations whatsoever to the Seagate drive itself; that is, all of the interfacing to my Apple IIgs was done via their SCSI Host Adapter card which plugs into a slot inside the Apple itself. Time to call in my chips with all my contacts in the industry, so off I went through

CompuServe, GENie, a series of telephone calls and numerous letters. To my surprise, no-one seemed to know if my assumptions about the CMS were correct. I was on my own, with a lot of "Best wishes and let me know how you make out!"

I obtained a loaner Seagate ST277N in plain, no-frills case with power supply. I replaced my CMS drive with this generic drive and booted the system. After several attempts, I got it to work flawlessly off the CMS SCSI Host Adapter. My suspicions were indeed true!

Out came the Computer Shopper and in went my orders to vendors. Here's the hardware I went with and highly recommend:

Hardware Required:

- Seagate STxxxN SCSI hard drive. I used the exactly same 65 meg drive that CMS uses in their 60 meg SD60 A2S model (the difference in size is explained below; the drive itself is indeed 65 megs unformatted capacity).
- The Tulin Apple Hive case with 30 meg power supply, fan and all internal cables and hardware.
- The CMS SCSI Host Adapter Card with external cable and formatting software.

As of the February 1989 advertised prices in Computer Shopper, this same drive subsystem will run approximately \$653 without shipping if you use the ST277N model (65 megs). I supply a list of vendors and February 1989 advertised prices at the end of this document; you can bargain hunt through Computer Shopper and local computer faires and flea markets and save a few extra dollars if Lady Luck is on your side.

The Roll (Assembly)

Assembly is truly a piece of cake if you have mastered the fine art of using a Phillipshead screwdriver, and total hardware assembly time is less than 5 minutes (taking your time). Since all cases are basically identical in terms of assembly of the unit, I will be relying upon my personal experience using the Tulin Apple Hive here.

Secure the Seagate drive to the base of the case using the supplied 4 screws and tighten securely but be careful not to exert too much torque (if this is at all possible). Take one of the two power cables coming from the power supply and plug it into the back of the drive itself. The power line terminates in a D-shaped male connector which plugs into a D-shaped female socket on the back of the drive; the D-shape prevents you from plugging the power cable into the drive in the wrong orientation, so this is fool-proof.

Next, plug the cable coming from the twin DB-25 pin connectors on the back of the case into the drive. This cable terminates in a 50-pin connector. Examine this connector closely and you will note that there is a guide on it which will allow you to insert it onto the connected on the back of the drive ONLY in the proper orientation, so you can't possibly install this cable wrong.

Next, examine the 4 sets of pins on the lower left back side of the drive itself. If any of these pairs have jumpers (small black plastic tabs which slide over a pair of pins), remove them. Without too much discussion on their function, suffice it to say that without any of these pin sets "jumped", the drive will have a device number of 0 (zero). [This is ok, as long as the hard drive is the ONLY SCSI device online. Otherwise, you'll have to give it an ID to keep it from interfering with other SCSI devices on the bus.] Next, connect the two single-stranded lines running from the power supply to the green LED light on the front of the case. This light is the power ON/OFF indicator.

Finally, replace the top of the case, securing to the base with the 3 screws provided, and insert the external power cord into the back of the case (but don't plug it into the wall just yet). Assembly of your hard drive system is now complete and ready for attachment to your Apple //.

The Interface

How you interface your SCSI to your Apple depends upon the specific host adapter card you are using. In this example, I'm using the CMS SCSI Host Adapter card; if you are using another brand card, follow the manufacturer's directions for setting up the card. You will need to know that your hard drive has a device number of 0 (zero).

The CMS card is configured using jumpers (exactly like those which may have been on the back of your Seagate drive that you removed). These jumpers control such things as capacity of the drive, volume partitions (start locations and size), device number, etc. Note that GS/OS will allow you to access volumes greater than 32 megabytes but if you are using any ProDOS-8 or ProDOS-16 applications, you must partition your drive so that no single volume exceeds the ProDOS limitation of 32 meg maximum volume size. Thus, in this example, we'll be partitioning the drive into 2 30 meg volumes.

The CMS card has 6 banks of 8 pairs of jumpers to control Device ID (DID), Host ID (HID), Partition Starting Point and Size (PS₁ and SZ₁) for the first partition and Partition Starting Point and Size (PS₂ and SZ₂) for the second partition. Since we set our drive to a device ID (DID) of zero, none of the pin pairs should be jumped. To select a host ID (HID) of 7, the first 4 pin pairs (1-4) should be jumped and the last 4 pin pairs (5-8)

should be open. Our first partition will start at a location of zero and be 30 meg in size, so the jumper settings for PS₁ should be all open (none jumped) and SZ₁ should have jumpers ONLY on pin pairs 1, 3, 4 and 5 (pin pairs 2, 6, 7 and 8 should be open). The second partition will begin at location 30 and be 30 megs in size, so the jumper settings to accomplish this are PS₂ should have a jumper ONLY on pin pair 4 (all others are open) and SZ₂ should have jumpers on pin pairs 1, 3, 4 and 5 ONLY (2, 6, 7 and 8 are open).

Having set the card for the correct configuration, insert the card into an open slot in your Apple // (6 or 7 is preferred), connect the short ribbon cable coming from the card to the back of the // at an open panel in the back plate. Connect one end of the heavy- shielded cable supplied with the host

adapter card to the DB-25 connector at the back of the Apple and the other end to one of the two (either one) DB-25 connectors on the back of the Apple Hive case. Make sure all connections are secure. Plug the hard drive power cord into a wall socket and turn the hard drive ON using the ON/OFF switch on the front of the Apple Hive case. Put the utilities disk supplied with the host adapter card into your floppy drive and boot your computer.

Before you can use your hard drive, you must perform two tasks. One is the "low level" formatting of the disk surface itself. The software to do this is supplied on the CMS utilities disk that comes with the Host Adapter card. The other task is the ProDOS formatting of the drive, which is done after the low level formatting.

Use the CMS Utilities Disk to low-level format the new drive surface. This will take several minutes to perform. When done, it is an excellent idea to run the test procedure. This test procedure performs read/write activity on each and every block on the disk surface repeatedly until you stop the test. It takes quite a bit of time to do one "pass" - that is, to read/write/verify every block on the disk - and it is recommended you let this procedure do several passes. Take the time to do this, since the procedure will mark as "unavailable" those bad blocks it finds and this will prevent you from loosing valuable data in the future. Don't worry if your system turns up several bad blocks - hard drives all have bad blocks, and thus the manufacturers allow extra tracks on the disk for replacement blocks.

After the test for bad blocks has been performed, you can exit the utilities and you're ready for the last step in preparing your hard drive for use: the ProDOS formatting. I use Prosel's CAT.DOCTOR utility exclusively (more on this later) but any utility which allows you to ProDOS format a disk will do.

Run your ProDOS format utility and select S6D1 (assuming your hard drive host adapter card is plugged into slot 6) for formatting. You will see that this takes less than 2 seconds to perform! Next, select S6D2 for formatting. Remember, we had to partition the drive into 2 30 meg volumes, and these are mapped as Drive 1 and Drive 2 in the slot in which your host adapter card is plugged into. You can name each of these volumes with any valid ProDOS volume name, such as /HARD1 and /HARD2.

Congratulations! Your hard drive is now fully ready to use.

Where Do I Order From?

In addition to the vendors that I have purchased from, there are several others advertising in Computer Shopper. Here is a list, by no means exhaustive, of some of the dozens of vendors selling various hardware you'll need:

Hard Drives International (1-800-234-DISK) is an extremely reputable firm dealing ONLY in hard drives. HDI provides near rock bottom prices, usually delivers quickly (if item is not out of stock), and provides a full technical support team.

ComputAbility (1-800-558-0003) offers rock bottom prices:

Tulin Corporation (1-408-432-9025) provides an excellent case - sturdy and quite attractive - in the Apple Hive. The Apple Hive cases come complete with power supply, fan and ALL internal hardware and cables necessary - you only need to buy a drive. They also now provide "kits" including everything (except the SCSI host adapter card) needed:

- ❖ Apple Hive with 30 watts power + fan \$119
- ❖ Apple Hive with 60 watts power + fan \$169
- ❖ 30 meg SCSI Drive System w/ Formatting Software \$425
- ❖ 40 meg SCSI Drive System w/ Formatting Software \$489
- ❖ 61 meg SCSI Drive System w/ Formatting Software \$529

* SCSI Drive Systems do NOT include host adapter card

* Each Seagate SCSI drive (STxxxN) requires 12.5 watts power so the 30 watts Apple Hive will sufficiently power two hard drives.

HardTimes (1-408-452-1929) offers an inexpensive alternative to the Apple Hive case by Tulin. The HardTimes case (\$79) features a fan, 50 watts power supply, brackets, room for 2 half-height or 1 full height drive and room for a controller. (*Note: the Seagate STxxxN drives contain a SCSI controller embedded within the drive and do NOT require an external controller board.)

CDA Computer Sales (1-800-526-5313) is an excellent source of SCSI host adapter cards, both CMS and Apple. Both brands run approximately \$115. CDA provides excellent service and is reliable and priced competitively.

Alternative Life Styles

You do NOT absolutely need to get a hard drive mechanism with SCSI embedded.

Adaptec markets controller cards which allow you to use MFM or RLL hard drives off an Apple SCSI host adapter. The basis for this card (Adaptec 4000 series) is that the card is positioned between the drive mechanism itself and the host adapter card in the link. The non-SCSI drives generally can be had for about \$80 less than their SCSI counterparts, but then you need to shell out approximately \$100 for the Adaptec card; its therefore usually cheaper, and a whole lot neater, to simply obtain a SCSI drive. But if you're lucky enough to obtain a non-SCSI drive for free, you can indeed use it with the proper Adaptec card. Hard Drives International is the best source of information on the Adaptec cards, so give them a call.

Warren T.

One of the most important questions (after "What is the price?") is "What kind of warranty do I get?" Most people are afraid to assemble their own vanilla hard drive for fear that, unless they purchase a designer name brand drive, they will be left out in the cold in terms of warranty. Not so. Seagate warranties all their drives for a period of 1 year; other manufacturers offer similar warranties on their hard drives. If you don't particularly liked dealing directly with the manufacturer, some vendors, such as Hard Drives International, will provide a limited coverage in addition to that offered by the manufacturer - simply return the defective drive to them within a certain period of time and they will replace it. After that, you must go directly to the manufacturer.

What about the case? Well, the case is a non-mechanical item and short of having an elephant stand on it or backing your pickup truck over it, there is little that can go wrong with the case itself. The internal power supply and fan are something else, though: they are electronic components subject to wear, tear and failure. Tulin, for example, warranties their power supply and fan for a period of 6 months. If you decide to go with the HardTimes or other brand case/power/fan, ask about the warranty BEFORE you purchase. Should your fan and/or power supply unit go out after the warranty expires, you can always purchase a brand new replacement part inexpensively. For example, replacement power supplies run \$35-\$50, and since you are saving approximately \$300 by building your own hard drive to begin with, that savings can purchase a lot of new replacement parts before you "break even".

Miss A. Laney

If you opt for the HardTimes or other brand case, other than the Tulin Apple Hive, you may be faced with needing to order a cable or some other internal hardware. Before you ask, tell the vendor exactly what you'll be using the case for and ask what internal hardware (cables, brackets, etc.) is provided and what is not provided (and thus what you will need to secure elsewhere). In this sense, the Tulin Apple Hive is the easiest, most hassle-free case to get.

In case you find the need to make your own cable, I provide the pinouts below. Seagate provides a short 50 line ribbon cable, terminating at both ends in a 50-pin connector. Thus, you may need to make (or otherwise obtain) a heavy-shielded cable going from 50-pin at one end (drive end) down to DB-25 pin at the other end (computer host adapter end). If you're not good at soldering, or simply faint-of-heart, Mytech (1-800-527-7435) might be able to provide you with exactly the cable you need at extremely reasonable prices.

The Home Brewed External SCSI Cable

The pinout needed for the SCSI external cable (host adapter to drive) is as follows:

From DB-25 male	To 50-pin connector	Actual Pin Views	
1	48	1	2
2	42	3	4
3	50	5	6
4	40	7	8
5	38	9	10
6	36	11	12
7	1*	13	14
8	2	15	16
9	1*	17	18
10	8	19	20
11	12	21	22
12	14	23	24
13	16	25	
14	1*		
15	46		
16	1*		
17	32		
18	1*		
19	44		
20	18		
21	4		
22	6		
23	10		
24	1*		
25	NC		

NOTE: all odd pins are grounded on a SCSI 50-pin connection

NOTE: 1* implies a connection to 1 or any other ODD pin/wire (which is GRND)

Apple II SCSI Card: Spec Sheet

I believe this spec sheet is directly from Apple Corporation, but can not state that for sure. It is something I pulled from one telecommunications services but long forgot which one.

I. Technical Specifications

A. Hardware:

- Provides an electrical interface between external SCSI devices and the CPU.
- Provides the address and control lines required by the Apple II's microprocessor for accessing and controlling the SCSI chip and Smartport firmware.

1. NCR 5380 SCSI IC

a. Implements SCSI bus

b. 5380 data sheet in Chapter 2 of the hardware technical reference manual

2. Other circuitry to interface the 5380 IC with the Apple II CPU control signals

3. RAM:

- 8 banks of 1K
- Accessed with special logic circuits
- Used for status of devices at SCSI bus initialization (including the status of the Apple II SCSI card itself)

4. ROM:

- 8 banks of 1K
- Accessed with special logic circuits
- Used for storing Smartport firmware

5. Interface: 25-pin SCSI connector

B. Input/Output:

Parallel transmission

1. Two modes for data i/o operations:

- a. PDMA (pseudo-DMA)
 - default
 - b. Block Move
 - only supported by 65816 CPUs
 - must be enabled by the application
2. Maximum storage area under ProDOS: 32 megabytes

C. Firmware: Smartport program

- converts the microprocessor commands or calls issued by CPU to format compatible with external SCSI devices
 - issues calls to the microprocessor to give it the status of the external SCSI devices and allow the CPU to control their operation
1. Commands supported: STATUS, READ BLOCK, WRITE BLOCK, FORMAT, CONTROL, INIT, OPEN, CLOSE, READ, WRITE
 2. Boot capability with Autostart ROM when you install the card in the slot with highest priority, which may depend on the operating environment
 - When Smartport does not find the SCSI device capable of booting the system, Smartport returns control to the environment of the Apple II and the boot search continues through lower-priority slots.

D. Electrical

1. Voltage requirement: 4.75 to 5.25 volts DC
2. Power consumption in milliamps (ma)

Standby: 340 ma

Operating: 390 ma

E. Environmental

Ambient temperature: 10 to 40 °C/50 to 104 °F

Relative humidity: 20 to 95 percent (noncondensing)

II. System Configuration

A. Cable: Apple SCSI System Cable

B. One or more SCSI-compatible peripherals

- Can be a high-speed printer interface

1. Daisy chaining

Apple II with the card in slot 5 and no card in slot 2, except a card for a serial printer or modem:

- Running ProDOS 1.2: 4 external devices
- Running ProDOS 16: 7 external devices

C. Additional SCSI system components as required:

- Cable Terminator
- Peripheral Cables
- Cable Extenders

Note: Maximum total length of cables: 20 feet (6.5 meters)

Important: Read the manual for the Apple SCSI Cable System before trying to connect any devices!

D. Computer with disk drive

- Apple IIGS
- Apple IIe
- Apple II Plus

Card fits into standard slot to connect to Apple II Internal bus for Apple II standard I/O and control (Slot 3 reserved for 80 column capability).