chapter 11

MASS STORAGE

This chapter describes the mass storage devices. The computer is equipped with one easily removable 4- or 6-GB hard drive. The MultiBay supports an optional IDE hard drive, 3.5-inch high-density diskette drive, LS-120 drive or 100-MB Zip drive. Also available are either a CD- or DVD-ROM drive module for the computer optical disc bay.

The preinstalled hard drive contains software that supports PC Cards, IrDA, multimedia, and other system features.

Hard Drive Subsystem

The computer supports one removable 2.5-inch IDE hard disk drive in a fixed disk module that consists of the drive, and a bracket assembly. The hard drive automatically retracts the heads and locks them in a non-data parking zone at power-down.

The internal hard drive connects directly to the system board for data buffering and I/O address decoding. All I/O operations are 16-bit. The PCI IDE interface can run extremely short ISA-type cycles, because it uses dedicated control signals rather than the ISA control signals.

All timing aspects of the cycle are directly programmable to meet the capabilities of the drive being used. There is support for two separate IDE drives on the same bus with independent timing requirements. This feature allows the hard drive and an optional CD-ROM drive to occupy the same bus, with optimal access to both devices.

Hard Drive Programming

The hard drive subsystem supports the ATA-3 specification for hard drive interfacing, programming and control. A working draft of this specification is available from the ATA Anonymous FTP Site, fission.dt.wdc.com. The ATA directory is: /ata/ata-3. Additional information is available from the following WEB sites:

- www.computercraft.com/docs/evsterms.html
- www.lib.ox.ac.uk/internet/news/faq/archive/pc-hardware-faq.part1 (There are five parts to this collection of USENET FAQs.)

Registers

Table 11-1 lists the standard and alternate I/O addresses for the hard drive controller. Addresses in the first (1) column are the computer addresses, and addresses in the second (2) column are for the expansion base. These settings can be changed by the user in the configuration mode or by OS drivers.

Table 11-1
Hard Drive Controller I/O Addresses

I/O Address			
1	**2**	**Read/Write**	**Register**
1F0h	170h	R/W	Data
1F1h	171h	R	Error
1F1h	171h	W	Features
1F2h	172h	R/W	Sector Count
1F3h	173h	R/W	Sector Number
1F4h	174h	R/W	Cylinder Low
1F5h	175h	R/W	Cylinder High
1F6h	176h	R/W	Drive/Head
1F7h	177h	R	Status
1F7h	177h	W	Command
3F6h	376h	R	Alternate Status
3F6h	376h	W	Drive Control
3F7h	377h	R	Drive Address (see NOTE)
3F7h	377h	W	Not used for hard drive

NOTE:: Only bits <6..0> are resident on the hard drive controller. Bit <7> of this I/O address is resident on the system board.

Hard Drive Connector

Table 11-2 lists the hard drive connector signals.

Table 11-2
Hard Drive Connector Signals

Pin	Signal	Description	Pin	Signal	Description
1	HDRST_	Reset signal	23	HDWR_	IDE Bus write signal
2	GND	Ground	24	GND	Ground
3	DATA7	IDE Data bus Bit 7	25	HDRD_	IDE Bus read signal
4	DATA8	IDE Data bus Bit 8	26	GND	Ground
5	DATA6	IDE Data bus Bit 6	27	HDCHRDY	I/O channel ready
6	DATA9	IDE Data bus Bit 9	28	CSEL	Cable select
7	DATA5	IDE Data bus Bit 5	29	DMACK_	DMA acknowledge
8	DATA10	IDE Data bus Bit 10	30	LED_	Hard drive LED
9	DATA4	IDE Data bus Bit 4	31	IRQ	Interrupt request
10	DATA11	IDE Data bus Bit 11	32	IO16_	IDE bus I/OCS16_ signal
11	DATA3	IDE Data bus Bit 3	33	A1	IDE bus address bit 1
12	DATA12	IDE Data bus Bit 12	34	PDIAG_	Slave drive finished power-up
13	DATA2	IDE Data bus Bit 2	35	A0	IDE bus address bit 0
14	DATA13	IDE Data bus Bit 13	36	A2	IDE bus address bit 2
15	DATA1	IDE Data bus Bit 1	37	CS1_	Chip select for 1F0-1F7h (170-
16	DATA14	IDE Data bus Bit 14	38	CS3_	Chip select for 3F6h (176)
17	DATA0	IDE Data bus Bit 0	39	GND	Ground
18	DATA15	IDE Data bus Bit 15	40	GND	Ground
19	GND	Ground	41	+5V	+ 5V power
20	KEY	Connector Key	42	+5V	+ 5V power
21	DMARQ	DMA request	43	GND	Ground
22	GND	Ground	44	Reserved	

Hard Drive Specifications

Table 11-3 describes the specifications for the hard drive.

Table 11-3
Hard Drive Specifications

Standard Model Configurations	4-GB	6-GB
Formatted Capacity per Drive		
Logical	4,099,866,624	6,495,068,160
Drive Type	65	65
Drive Height		
Without frame (mm)	12.5	12.5
With frame (mm)	12.7	12.7
Drive Size		
Inches	2.75 x 3.94	2.75 x 3.94
Millimeters	100.2 x 69.85	100.1 x 69.9
Transfer Rate		
Media (Mb/s)	51.7 to 83.4	67.5 to 111.9
Interface (Mb/s)	16.6	16.6
Sector Interleave	1:1	1:1
Typical Seek Time (Including setting)		
Single Track (ms)	4	3
Average (ms)	13 (READ)	13 (READ)
Full Stroke (ms)	23 (READ)	25 (READ)
Disk Rotational Speed (RPM)	4009	4200
Physical Configuration		
Cylinders	6975	8960
Data Heads	6	6
Sectors/Track	114 to 240	178 to 294
Bytes/Sector	512	512
Logical Configuration		
Cylinders	7944	13,424
Heads	16	15
Sectors per Track	63	63
Bytes per Sector	512	512
Buffer Size (kB)	512	512

Diskette Drive Subsystem

There are no permanently installed diskette drives in the computer. One external diskette drive can be connected to the computer via a dedicated port and cable.

1.44-Megabyte Diskette Drive

The 1.44-megabyte diskette drive is a high-capacity diskette drive with the following features:

- 0.6-inch high, 3.5-inch diskette drive
- Two transfer rates: 250 Kb/s (low density) or 500 Kb/s (high density)
- Data storage on 80 tracks (135 tpi)
- Write- and read-compatible with low density (720-Kbyte) 3.5-inch media

Diskette Drive Controller

The diskette drive controller circuitry is contained in the SMC37C95xFR MSIO device. Through dedicated I/O port addresses, this circuitry transmits data to and from a diskette drive and controls drive functions and reads the current drive status. Table 11-4 lists the port addresses of the diskette drive controller.

Table 11-4
Port Addresses for the Diskette Drive Controller Circuits

Port 1	Port 2	Read/Write	Register Function
3F1h	371h	R	Media ID
3F2h	372h	R/W	Drive Control
3F4h	374h	R	Main Status
3F5h	375h	R/W	Data
3F7h	377h	R	Diskette Change Status/Fixed Disk Drive Status
3F7h	377h	W	Date Transfer Rate Control

Diskette Drive Controller Registers

The diskette drive controller registers are described in the following paragraphs.

Media ID (3F1h, Read Only)

The media ID register can be used to identify a 3.5-inch diskette drive and the media installed in the drive. The format for this register is:

BIT	FUNCTION
7	Media ID bit
6..0	Reserved

To identify media type:

1. Select drive, turn motor on using 3F2h.
2. Clear the DISKETTE CHANGE_ signal if it is active.
3. Read bit <7> at location 3F1. If the bit is low, 720-Kbyte media is installed. If the bit is high, then 1.44-megabyte media is installed.

Main Status (3F4h, Read Only)

The main status register of the diskette drive controller is used as the diskette drive status register. The format for this register is:

BIT	FUNCTION
7	Request for Master
6	Data I/O Direction
5	Non DMA Execution
4	Command in Process
3	Drive 3 busy
2	Drive 2 busy
1	Drive 1 busy
0	Drive 0 busy

Data (3F5h)

Commands and data are written to this port. Data and status bytes are read from this port.

Data Transfer Rate Control (3F7h, Write Only)

This register contains the current data transfer rate in Kb/s. The format for this register is:

BIT	FUNCTION
7..2	Reserved
1,0	Data Transfer Rate (Kb/s) 00 = 500 01 = 300 10 = 250 11 = 1000

Diskette Drive and Hard Drive Status (3F7h, Read Only)

This register provides both diskette drive status information (bit <7>) and hard drive status information (bits <6..0>). The format for this register is as follows:

BIT	FUNCTION
7	Diskette change
6..0	Reserved for Hard Drive

Drive Controller

The drive controller accepts commands from the computer that control most drive functions and transfers of data to the drives.

The drive controller operates in the ISA-compatible DMA mode for data transfers to and from the system. It issues a DMA request (DRQ2) signal and receives a DMA acknowledge (DACK2_) signal for each byte transferred.

All drive controller commands have three operating phases:

- The command phase, in which the drive controller receives the command from the system
- The execution phase, in which the drive controller carries out the command
- The results phase, in which the status and results are read back from the drive controller to the system

Diskette Data Transfer Rate

The system can transfer data at various rates depending on the drive and the type of media being used. The data transfer rate control register (3F7h) contains the bits that specify the transfer rate.

Table 11-5 lists the media dependent transfer rates of the diskette drive subsystem.

Table 11-5
Programmable Data Transfer Rate

Data Transfer Rate (in KB/s)	When Using:
500	1.44-MB diskette drive with 1.44-MB media
250	1.44-MB diskette drive with 720-KB media

Write Precompensation

Write precompensation is a process of time shifting write data bits to help cancel out an opposite shift induced during magnetic recording. This process increases data integrity at high data densities. The data density increases as the diskette drive head approaches the center tracks. Write precompensation is always on and is always 125 ns for all data-transfer rates (500, 300, and 250 Kb/s).

LS-120 Drive Subsystem

The LS-120 drive is supported through the Mobile 3500 Expansion Unit MultiBay. This drive is supported as a bootable device.

If the drive is present during POST, BIOS attempts to read the boot record from the drive. If a bootable diskette is inserted in the drive, BIOS will use the drive when INT 19h is called.

The drive utilizes an imbedded ATAPI (IDE) controller for the host interface. The drive is capable of reading and writing to standard SuperDisk LS-120 diskettes, industry standard 1.44-MB and 720-KB 3.5-inch diskettes, 1.7-MB Distribution Media Formatted diskettes (read only), and 1.2-MB diskettes.

Table 11-6
LS-120 Drive Specifications

	120 MB	1.44 MB	1.2 MB	1.2 MB	720 KB
Formatted Capacity (Bytes)	125,958,144	1,474,560	1,261,568	1,228,800	737,280
Sector Size (bytes)	512	512	1024	512	512
Sectors	245.760	2880	1,232	2400	1,440
Magnetic Tracks/ Surface	1736	80	77	80	80
Optical Servo Tracks/Surface	900	N/A	N/A	N/A	N/A
Sectors/track	51-93	18	8	15	9
Sector Interleave	1:1	1:1	1:1	1:1	1:1
Spare sectors	170	0	0	0	0
Zones (each side)	55	1	1	1	1
Average random seek	70 ms	70 ms	70 ms	70 ms	70 ms
Track-to-Track seek	20 ms	25 ms	25 ms	25 ms	25 ms
Max single seek	120 ms	170 ms	170 ms	170 ms	170 ms
Average Latency	41.67 ms	41.67 ms	41.67 ms	41.67 ms	41.67 ms
Motor rpm	720 ± 0.5%	720 ± 0.5%	720 ± 0.5%	720 ± 0.5%	720 ± 0.5%
Motor Start Time,	800 ms	800 ms	800 ms	800 ms	800 ms
Track Density	2,490 TPI	135 TPI	135 TPI	135 TPI	135 TPI
Track Width	8 μm	125 μm	125 μm	125 μm	125 μm
Encoding Method	(1,7)RLL	MFM	MFM	MFM	MFM
Max Flux Density	33,660 FCI	17,334 FCI	17,334 FCI	17,334 FCI	8,717 FCI
Recording Density	44,880 BPI	17,334 BPI	17,334 BPI	17,334 BPI	8,717 BPI
Nominal Transfer Rate	375-680 KB/sec	150 KB/sec	125 KB/sec	125 KB/sec	75 KB/sec
Nominal Sustained Transfer Rate across interface	313 to 571 KB/sec	110 KB/sec Read, 37 KB/sec Write	98 KB/sec Read, 33 KB/sec Write	92 KB/sec Read, 31 KB/sec Write	55 KB/sec Read, 18 KB/sec Write
Buffer Transfer rate	8.3 MB/sec	8.3 MB/sec	8.3 MB/sec	8.3 MB/sec	8.3 MB/sec

Zip Drive

Table 11-7 lists the specifications of the Zip Drive.

Table 11-7
ZIP Drive Specifications

Total Formatted Capacity (bytes)	100,663,296
Sector Size (bytes)	512
Total Number of Sectors	196,608
Number of Reassignable Spare Sectors	3220
Sector Interleave	1:1
Number of Zones (each side)	4
Sectors per Track, Zone 0	72
Sectors per Track, Zone 1	60
Sectors per Track, Zone 2	48
Sectors per Track, Zone 3	40
Magnetic Track/Surface	908
Compaq Part Number for Diskette	270928-001
Seek Times (including settling)	
Average Seek	29 ms
Track-to-Track	5 ms
Maximum	55 ms
Average Latency	10 ms
Motor Speed (rpm)	2941 ±5%
Motor Start Time (ms)	3000
Track Density (TPI)	2118
Track Width (µm)	12
Encoding Method	(1,8) RLL
Max Flux Density (FCI)	34,560
Max Recording Density (BPI)	46,000
Transfer Rate From Diskette (kb/sec.)	790-1400
Buffer Transfer Rate (maximum, MB/sec)	36.7

CD-ROM Drive

The Mobile 3500 Expansion Unit supports a modular 24X Max CD-ROM drive or DVD-ROM drive in the optical disc bay. These CD-ROM drives support the following modes:

- CD-ROM Mode 1
- CD-ROM Mode 2
- CD-Digital Audio
- CD-XA (Form 1, Form 2)
- CD-I Mode 2 (Form 1, Form 2)
- CD-I Ready
- CD Bridge

- CD-WO (fixed/variable packets)
- Photo CD (Multisession)
- CD-R
- Video CD
- CD-Extra (CD+)
- CD-G
- CD-RW

Table 11-8 lists the specifications for the CD-ROM drive.

Table 11-8
CD-ROM Specifications

Applicable Disc	CD-ROM mode 1, mode 2 CD-Digital Audio CD-XA mode 2 (Form 1, Form 2) CD-I mode 2 (Form1, Form 2) CD-I Ready CD-Bridge CD-WO (fixed/variable packets) Photo CD (singlemultisession)
Center Hole Diameter	15 mm
Disc Diameter	12 cm, 8 cm
Disc Thickness	1.2 mm
Track Pitch	1.6 μm
Laser	
Beam Divergence	53.5 ± 1.5 degrees
Output Power	0.24 ± 0.1 mw
Type	Semiconductor Laser GaA1As
Wave Length	780 nm ± 25 nm
Access time	
Random	<350 ms
Full Stroke	<750 ms
Audio output level	
Line Out	0.7 Vrms
Headphone	None
Cache buffer	128 KB
Data transfer rate	
Sustained, 10x	1500 KB/sec
Sustained, single	150 KB/sec
Burst	8.3 MB/sec
Startup Time	<8 seconds typical
Capacity	
Mode 1, 12 cm	550 MB
Mode 2, 12 cm	640 MB
8 cm	180 MB

Table 11-9 lists the specifications for the DVD-ROM drive .

Table 11-9
DVD-ROM Specifications

Disc Formats Supported	DVD-5, DVD-9, DVD-10 CD-ROM mode 1, mode 2 CD-Digital Audio CD-XA mode 2 (Form 1, Form 2) CD-I mode 2 (Form1, Form 2) CD-I Ready CD-Bridge CD-R Photo CD (single/multisession)
Center Hole Diameter	15 mm
Disc Diameter	12 cm, 8 cm
Disc Thickness	1.2 mm
Track Pitch	.74 μm
Capacity	4.7-GB - DVD-5 8.5-GB - DVD-9 9.4-GB - DVD-10 550-Mbytes (Mode 1, 12) 640 Mbytes (Mode 2, 12 cm) 180 Mbytes (8 cm)
Laser	
Output Power	5mw
Type	Semiconductor Laser GaA1As
Wave Length	650 nm ± 25 nm (DVD Mode) 795 nm ± 25 nm (CD-ROM mode)
Access time	
Random	<200 ms
Full Stroke	<250 ms
Audio output level	
Line Out	0.7 Vrms
Headphone	None
Cache buffer	128 KB (minimum)
Data transfer rate	
Sustained, 1x (CD-ROM mode)	150 KB/sec
Sustained, 20x CD-ROM CAV mode	1200-3000 KB/sec
Sustained, DVD mode	1352 to 2705 KB/s sustained, DVD mode
Burst	16.6 MB/sec
Startup Time	<3 seconds typical

MultiBay 62-Pin Connector

Table 11-10 provides the MultiBay connector signals.

Table 11-10
MultiBay Connector Signals

Pin	Signal	Description	Pin	Signal	Description
1	MULTIRST#	IDE Reset	32	MPBID1	MultiBay device ID bit <1>(Refer to Table 11-11)
2	GND	Ground	33	SA1	IDE address bit <1>
3	SD7	Data bit 7 of the IDE data	34	HDIAG_	Diagnostics complete
4	SD8	Data bit 8 of the IDE data	35	SA0	IDE address bit <0>
5	SD6	Data bit 6 of the IDE data	36	SA2	IDE address bit <2>
6	SD9	Data bit 9 of the IDE data	37	SCS1_	Chip select 1F0 … 1F7
7	SD5	Data bit 5 of the IDE data	38	SCSI3_	Chip select 3F6
8	SD10	Data bit 10 of the IDE data	39	DASP_	Drive Access/Slave Present
9	SD4	Data bit 4 of the IDE data	40	GND	Ground
10	SD11	Data bit 11 of the IDE data	41	Vcc	Logic +5 V
11	SD3	Data bit 3 of the IDE data	42	Vcc	Motor +5 V
12	SD12	Data bit 12 of the IDE data	43	FDDIDD1_	FDD present (not)
13	SD2	Data bit 2 of the IDE data	44	NC	No connect
14	SD13	Data bit 13 of the IDE data	45	GND	Ground
15	SD1	Data bit 1 of the IDE data	46	GND	Ground
16	SD14	Data bit 14 of the IDE data	47	NC	No contact
17	SD0	Data bit 0 of the IDE data	48	HDSEL	Floppy head select
18	SD15	Data bit 15 of the IDE data	49	RDATA	Floppy Read data
19	GND	Ground	50	WRTPRT*	Floppy is Write protected
20	MBPDET_*	MultiBay detect. If low, device is present	51	TRK0*	Trak Zero Indicator*
21	SDREQ	IDE DMA request	52	WGATE_	Floppy Write Gate*
22	GND	Ground	53	WDATA_	Floppy Write Data*
23	SIOW	Write active to ID device	54	STEP*	Causes floppy heads to step*
24	GND	Ground	55	1.6MODE	Determines floppy density*
25	SIOR_	Read from ID active	56	DIR_	Direction of Head Movement*
26	GND	Ground	57	MTR0_	Motor On*
27	IORDY	IDE Ready signal	58	DSKCHG_	Diskette Change*
28	CSEL2	Chip Select 2	59	DSO*	Drive select
29	SDACK_	IDE DMA request active	60	INDEX_	Index Detection*
30	MPBID0	MultiBay device ID bit <0> (Refer to Table 11-11)	61	GND	Ground
31	HD2IRQ15	IDE IRQ active	62	GND	Ground

***Diskette drive controller interface signal

When pin 20 is low, no device is present in the MultiBay. When pin 20 is high, pins 30 and 31 identify the device installed in the MultiBay. Table 11-11 shows the device that is currently installed based upon the states present at those pins.

Table 11-11
MultiBay Device ID

Device	MPBDET_	MPBID0
Zip Drive	H	H
Hard Disk Drive	H	L
LS-120	L	H
Fixed Disk Drive	L	L

Boot Order

The following describes the boot order used by the mass storage devices of the the Compaq Armada 3500 Family of Personal Computers.

The LS-120 is bootable. It will become the "A:" floppy device. ZIP drives are NOT bootable at this time. The CD-ROM is bootable, per the El-Torito specification, an industry standard. If Multiboot is NOT enabled (leaving the machine in its default boot mode), the machine will attempt to boot in the following order:

- CD-/DVD-ROM
- Diskette Drive
- LS-120 in the M35EU MultiBay (treated as a floppy)
- Internal hard drive

If Multiboot is enabled, then the boot order will depend on the way Multiboot has been defined.

If an internal hard disk is present, then the user can not boot from a second hard disk in the MultiBay. This is an operating system limitation. Specifically, MS-DOS (and all MS-DOS-based derivatives such as Windows 3.1, Windows 9x, etc), demand that they be booted from "the first primary partition on the first HDD." For all practical purposes, this means the internal hard disk.

The internal hard disk used in the computer is always the IDE Master device on the first IDE channel. While the BIOS could attempt to bootstrap from the second hard disk, as soon as the operating system detects it, it would stop booting due to an internal failure. The operating system assumes that it is on the first hard disk, and thus will not be able to continue finding/loading its own files.