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Chapter 1 - TECHNICIANS' GUIDE TO PC HARD DISK SUBSYSTEMS
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INTRODUCTION :

This booklet (now electronic) is published as a service of Data Recovery Labs. Its purpose is to provide the fundamental knowledge of concepts and terminology that is necessary to deal with the complexities of hard disk subsystems. It is not a technical reference guide and should not replace original documentation made available by manufacturers.

Every day we meet and deal with technicians and support personnel who install, upgrade and maintain hard drives, without knowing exactly what they are and how they work. Gaining a working knowledge of disk subsystems is not a simple task and requires much study - and - experience. Don't expect any book, training course, or manual to make you into an expert. However, if you read and understand most of this material, you will be off to a fine start.

The principal author is Nick Majors. He has been in the industry since 1979, designing and developing hardware and operating system enhancements and performance tools. He is an experienced machine language programmer and has provided technical training to support personnel for some of Canada's leading banks, corporations, government departments and PC service organizations. He is Manager of Technical Services for Data Recovery Labs which he founded in 1989.

While this booklet deals primarily with PC and PC compatible platforms, there is much information to benefit support personnel with other hardware platforms.

Every effort has been made to ensure accuracy, but misprints and ambiguities may still remain, so please use caution.

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HISTORY AND OVERVIEW :

The original IBM PC, introduced in 1981, did not support any type of hard drive. Program code in the BIOS did not recognize any such device and early versions of DOS precluded mass storage by limiting the maximum number of directory entries. This is not surprising when you consider that the original 4.77 MHz PC came with 16 K of RAM, expandable to 64 K on the motherboard. Even floppy drives and a disk operating system were options to upgrade the built in cassette recorder port and ROM basic.

To utilize a hard drive in a PC requires:

- a Hardware IRQ (interrupt request)
- I/O port addresses for the controller

- a DMA channel (now optional)
- low level program code
- a physical interface to the bus (expansion slot or built-in)
- operating system support
- sufficient power and cooling

After DOS 2 introduced the sub-directory system and support for mass storage devices, companies started selling hard drives for the PC. These were external cabinets that contained the disk itself, a controller card, and a dedicated power supply (since the PC's 63.5 watts were insufficient). Migrating from other architectures, these units connected to the PC through cabling to an 8 bit adapter card that plugged into an available expansion slot. These subsystems were configured to use one of the available IRQ's, DMA channels, a range of I/O ports, and program code that was made available through a device driver loaded into memory after startup (booting from a floppy).

In 1983, the IBM XT (eXTended) was unveiled with its built-in 10 MB fixed disk. IBM worked with a company (Xebec, I think) to take the controller components normally located in the external cabinet and build them right onto a bus interface card, creating what we commonly call the "hard disk controller".

Program code was provided by a ROM chip on the controller card which supplemented subroutines in the BIOS, and the internal power supply was upgraded to 135 watts to provide power for the internally mounted drive.

The XT design utilized :

- IRQ 5
- I/O port addresses 320-32f
- DMA channel 3
- Program Code from adapter ROM at c8000
- DOS 2.0 or higher

Several companies started manufacturing and selling similar drive/controller packages with various improvements including higher capacities, superior performance and built-in floppy controller components on the same card (to save an expansion slot). These third party subsystems could even be added to an original PC, so long as the internal power supply was also upgraded.

In 1984, the IBM AT (Advanced Technology) brought a complete overhaul to hard disk systems. Program code was included in the motherboard ROM BIOS, eliminating the need for a ROM chip on the new 16 bit controller card, and a higher quality drive improved access times. The system included use of newly added higher IRQ's, eliminated the use of DMA for hard drives, and changed the range of I/O addresses.

The AT design utilized :

- IRQ 14
- I/O port addresses 1f0-1f8
- DMA channel - none
- Program Code from motherboard ROM BIOS
- DOS 2.0 or higher

Hardware configuration details for the AT, including hard disk parameters, were stored in a low power CMOS chip connected to a small

battery, eliminating many of the motherboard configuration dip switches and jumpers. The battery allowed information to be maintained while the computer was turned off and information could be changed by running a setup program from disk.

The original AT supported 14 different drive types, recognizing specific hard disks ranging from 10 to 112 MB. Any drive with physical parameters that did not match one of these types needed a ROM extension on the controller card or a device driver loaded during boot-up.

DOS versions prior to 4.0 (or 3.31) did not support partitions larger than 32 MB no matter how big a drive was. This was because of sector numbering that could not exceed 16 bit values (up to 65,536 sectors). To make a larger partition required the use of special software like Ontrack's Disk Manager. This software was so popular that many drive manufacturers shipped it with their product. Unfortunately, while this offered one of the better solutions, it did pose compatibility problems for many disk utilities because, in effect, you had a non-DOS partition.

Many people opted instead to divide their drives into 32 MB partitions creating a C: D: E: etc. up to the physical capacity. Prior to DOS 3.3, even this was not possible, because DOS did not recognize extended partitions!

The number of drive types supported by CMOS has expanded to over 40 and most current BIOS's provide a user definable type to allow parameters to match any drive. Most PC's today still rely on this original CMOS drive type scheme to configure and control hard disks, though many architectures and BIOS's have changed how the information is stored and updated.

This inherently creates certain limiting factors, including a problem with more than two hard drives and BIOS/OS limits to recognizing more than 1024 cylinders, 16 heads and 63 sectors per track. Various technologies must be used to translate non-compliant physical geometries into logical parameters recognized by the system to maintain compatibility with operating system and utility programs that are tied to these limits.

With each sector holding 512 bytes of data this allows for drives no larger than 504 MB.
(1024 X 16 X 63 = 1,032,192 sectors X 512 = 528,482,304 bytes)

To understand this limit, we have to examine how hard drives are accessed by a PC.

Primarily, I/O commands are sent to the controller via a range of reserved port addresses. This is a very complicated and tedious process and the ROM BIOS includes a subroutine (INT 13) to perform these tasks for you. The DOS operating system then has certain functions that further simplify the process. They include INT 25/26 functions to read and write absolute sectors to the drive as well as higher level functions (INT 21) to Open files, Close files, Write data to files, etc. Most programs rely on these DOS functions to control access to hard drives and DOS in turn calls the INT 13 BIOS subroutines which do the actual I/O commands.

All of these subroutines are assembly language code that are loaded

into memory from either your BIOS chip(s) or Operating System files at startup.

Assembly language routines store and manipulate values in registers within the CPU. The lowest common denominator for INTEL based PC's is 16 bit registers. Any program or routine that wants to be backward compatible, must use these base registers whether run on an 8088 or a Pentium. This basic INT 13 is the backbone of PC compatibility and uses 16 bit registers in the following way:

DX - 8 bits for head number - 8 bits for drive number
CX - 10 bits for cylinder number and 6 bits for sector number

The largest 10 bit number possible is 1023 hence the limit on cylinder numbers (from 0-1023) and the largest 6 bit number is 63 (from 1-63) allowing 63 sectors per track.

But note - the DX register allows a maximum of 255 heads, not the 16 that original specifications called for. This is what allows various translation schemes to deal with drives up to 8 GB while remaining INT 13 compatible.

If the DX register allows 8 bits for drive number, shouldn't it be able to control 255 drives instead of only two?

When the INT 13 sends commands to your controller, it must know the physical geometry of the drive in question. During initialization of the PC, values for disk types are read from CMOS and stored into an area of RAM called the BIOS DATA AREA. Pointers to those entries are stored in the Interrupt Vector Table (at addresses 0:104h and 0:118h). The table only reserved pointers for two drives, so even if your CMOS held more values, the standard routines wouldn't know how to deal with them.

Why were the INT 13 routines so limited? They were written at a time when 10 and 20 MB drives were the norm, and 120 MB was unbelievable. They were designed to communicate with a specific controller interface, the ST412/506 standard (WD1003 controller), and the specs for passing parameters included only 10 bits for cylinders number, 4 bits for head number and a single bit for drive number.

Some of these limitations have been overcome in the past by replacing the PC's INT 13 sub- routines with code that could recognize and deal with different devices. That's why virtually all SCSI adapter cards include a ROM chip and you must set the drive type to ZERO. In effect, no standard drives installed for the motherboard BIOS to control.

NetWare and other advanced Operating Systems use the drive type only long enough to boot- up and then replace the INT 13 code with their own device drivers. You then need to load a different .DSK file written specifically for each type of controller.

In the past couple of years, many motherboard and controller BIOS's have been enhanced to deal with ever increasing demands, but the process of establishing new standards has led to continuing confusion and compatibility problems.

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END OF CHAPTER 1

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COMING SOON - CHAPTER 2 - Inside Hard Drives and Controllers :
- Parts and Components
- also suggestions for must reading material

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NOTICES & PERSONAL RANTS :

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INTERNET APOLOGIES : The original article, offering this booklet, was posted Jan. 29, 1995. I have had lots of replies, BUT - all kinds of people insist on replying by follow-up articles instead of private Mail. This proved downright embarrassing! I only wanted E-MAIL responses. Sorry for the clutter!

DISTRIBUTION : Chapters 1-2 will be sent by E-Mail to some 2,700 people who requested it and is being posted to various News groups. The work to maintain a mailing list is much more trouble than it's worth, therefore - future chapters will be posted to a select number of New Groups and Bulletin Boards.

Files can be obtained by ftp. Look for "hdtech??.txt"

ftp site: archive.umich.edu in /msdos/info/disk

mirror : wuarchive.wustl.edu in /systems/ibmpc/umich.edu/info/disk
(Note - This mirror is not always up to date)

ftp site: ftp.wi.leidenuniv.nl in /pub/faqs

Also Daniel Tauritz has a home page with links to this document plus a number of hard drive FAQs:
www.wi.leidenuniv.nl/home/dtauritz/ata

If anyone specifically requires E-mail, send me a note with "e-mail please" as the subject. I will be glad to accommodate them, assuming it's a manageable number. I cannot provide hard copy or S-Mail.

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COMMENTS & CRITICISM : I look forward to receiving suggestions, improvements, additions, (and yes even compliments) to this material. Please bear in mind who this has been written for - tech support personnel, not end-users and not engineers or hardware designers.

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Chapter 2 - TECHNICIANS' GUIDE TO PC HARD DISK SUBSYSTEMS

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Before we consider how to install, configure and maintain hard drives, we need a basic understanding of drive construction and design concepts. This chapter examines in some detail the parts and functional components of hard drive subsystems.

(Note : A number of acronyms are used throughout this chapter and the glossary for this booklet is not yet available. Therefore, I have attached a brief set of definitions for some of the terminology.)

HARD DRIVES AND CONTROLLERS:

A hard drive subsystem is comprised of the following components:

1. The Hard Disk, with one or more boards (PCB) attached.
2. A Controller Mechanism, either on the hard disk PCB or on the bus adapter within the PC.
3. Bus Adapter for interfacing the controller to the host PC.
4. Cables and Connectors to link it all together.

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THE HARD DISK:

Within a sealed enclosure (Head Disk Assembly or HDA) are one or more rigid platters that are "fixed" or non-removable. These are coated with magnetically sensitized material and data can be written to and read from the surface by means of electromagnetic read/write heads. When powered up, the platters are constantly rotating (except for certain pre-programmed sleep modes) and the heads are moved back and forth across the surface to access different locations. This is a sealed unit which should not be opened, except by qualified personnel in a controlled, dust free environment.

The circuit board(s) attached to the outside of the HDA provide the electronics needed for physical control of the motors within the sealed unit. They interface the source of electrical power to the disk assembly through varied connectors and cables. Most boards have some jumpers, dip switches and/or resistors that are used for configuration purposes.

Functionally, these PCB's are separate from the Hard Disk Controller, but many of the newer drives (IDE and SCSI) embed the controller chip directly onto this board (as opposed to having it on the Bus adapter).

INSIDE THE HDA - PARTS OF A HARD DISK:

1. Disk Platter(s), separated by spacers and held together by a clamp.
2. Spindle shaft onto which platters are mounted.
3. Spindle motor for rotating the platters.
4. Electromagnetic read/write heads (one per surface).
5. Access arms or armatures from which the heads are suspended.
6. Actuator for moving the arms (with heads attached).
7. Preamplifier circuitry to maximize read/write signals.
8. Air filter and pressure vent.

The Platters:

Most platters or disks are made of an aluminum alloy, though ceramic or glass platters can also be found. The diameter is normally 2 1/2", 3 1/2" or 5 1/4" with a hole in the center for mounting onto the spindle shaft. Thickness of the media can vary from less than 1/32 of an inch to about 1/8 of an inch.

During manufacture the platters are coated with a magnetizable material. Older drives used a ferrite compound applied by squirting a solution onto the surface and rotating at high speeds to distribute the material by centrifugal force. This process left a rust colored ferrite layer which was then hardened, polished and coated with a lubricant.

Newer drives apply the magnetic layer by plating a thin metal film onto the surface through galvanization or sputtering. These surfaces have a shiny chrome-like appearance.

Spindle and Spindle Motors:

Most drives have several platters that are separated by disk spacers and clamped to a rotating spindle that turns the platters in unison. A direct drive, brushless spindle motor is built into the spindle or mounted directly below it. (Sometimes this motor is visible from outside of the sealed enclosure.) The spindle, and consequently the platters, are rotated at a constant speed, usually 3,600 RPM, though newer models have increased that to 4800, 5400, or 7,200.

The spindle motor receives control signals through a closed loop feedback system that stabilizes to a constant rotation speed. Control signals come from information written onto the surface(s) during manufacture or with older drives, from physical sensors.

Read/Write Heads:

Since both sides of each platter are coated to provide separate surfaces, there is normally one electromagnetic read/write head for each side of each platter. Therefore, a drive with 4 platters would have 8 sides and 8 heads. Some drives use one side as a dedicated surface for control signals leaving an odd number (5,7,etc.) of heads for actual use.

Each head is mounted onto the end of an access arm and these arms (one per surface) are moved in unison under the control of a single actuator mechanism. When one head is over track 143, all the heads on all other sides should be at the same location over their respective surfaces.

Generally speaking, only one of the heads is active at any given time. There are some drives that can read or write from two or more heads at a time, but this represents a major design change and the technology is not yet widely used.

The spinning disk(s) create an air cushion over which the heads float. Depending on design, this air buffer ranges from 2 to 15 microns. By contrast, a smoke particle or finger print is about 30 microns in size!

The heads are not supposed to come into contact with the surface during rotation. Only when powered off should the heads come to rest on the surface, but this should be over a specific area of the surface,

reserved for that purpose. Most drives built since the late 1980's employ an automatic parking feature which moves the heads to this designated region and may even lock the heads there until powered up.

Head Actuators:

The head actuator is the positioning mechanism used to move the arms and consequently the heads, back and forth over the surface. Once again, earlier drives used a different method than is now common.

Originally, head positioning was controlled by a stepper motor that rotated in either direction by reacting to stepper pulses and moving the head assembly back and forth by means of a "rack and pinion" or by spooling and unspooling a band attached to the actuator arms. Each pulse moved the assembly over the surface in predefined steps or detents. Each step represented a track location and data was expected to be under the head. This design, still used for floppy drives, is not suitable for current drive densities and is prone to alignment problems caused by friction, wear and tear, heat deformation, and lack of feedback information needed for correcting positioning error.

The more common voice coil actuator controls the movement of a coil toward or away from a permanent magnet based upon the amount of current flowing through it. The armatures are attached to this coil and move in and out over the surface with it. This is a very precise method, but also very sensitive. Any variation in the current can cause the head assembly to change position and there are no pre-defined positions. Inherently this is an analog system, with the exact amount of movement controlled by the exact amount of current applied.

The actual position of the coil is determined by servo (or indexing) information, which is written to the drive by the manufacturer. Location is adjusted to different tracks by reading and reacting to these control signals.

Internal Electronics:

There is surprisingly little circuitry found within the sealed HDA. There are electrical and control wires for the spindle and head actuator motors and the head assembly has flex cables with a preamplifier chip often built onto it. This chip takes pulses from the heads (as close to the source as possible) and cleans up and amplifies these signals before transmission to components outside of the housing.

Air Filtering and Ventilation:

Minor wear of internal components and occasional contact of the heads with the surface can cause microscopic particles to be loosened within the HDA. A permanent air filter is mounted within the air stream to remove these particles before they can cause damage to delicate mechanisms.

Most drives also have a small vent to allow for minor air exchange from outside of the housing. This allows for equalization of air pressure so drives can be used in different environments without risk of imploding or exploding.

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CONTROLLERS AND BUS ADAPTERS:

The hard disk controller provides the logical link between a hard disk unit and the program code within the host computer. It reacts to requests from the computer by sending seek, read, write, and control signals to the drive and must interpret and control the flow of data.

Data moving to and from the drive includes sector ID's, positioning information and timing or clock signals. The controller must encode, decode and separate this control information from actual data written to or read from the drive.

Also, data is sent to and from the drive serially, in bit format, but the smallest unit that a CPU can work with is a byte (8 bits). The controller must take bits (8 - 16 - or 32 at a time) and assemble them into bytes, words, and doublewords that can be transferred to/from the computer.

"OUR INDUSTRY MUST LOVE STANDARDS - WE HAVE THOUSANDS OF THEM!"

And so it is with hard disk controllers.

Controllers can be categorized in several different ways, by :

Basic computer design (PC/XT vs AT-286-386-486,etc)

- as mentioned in the first chapter, standard AT controllers use different I/O addresses, IRQ and employ PIO as opposed to DMA.

Bus Architecture (8-16 bit ISA, 32 bit MCA/EISA/VLB/PCI, etc.)

- The adapter must be designed to interface with and use features of available expansion spots in the host computer.

Controller Card vs Adapter

- The expansion board that plugs into the PC is commonly referred to as a controller card, but for many drives (primarily IDE and SCSI) the controller mechanism is built directly onto the drive PCB and the expansion board in the PC (or built into motherboard) is actually a Host/Bus adapter.

TROUBLESHOOTING TIP - If the BIOS reports "HDD CONTROLLER FAILURE" don't assume the problems is with your AT/IO board. It might well be the drive PCB that has failed.

Controller/Drive Interface

- Both drive and controller must communicate in the same 'language' and several different standards have been established. These include ST506/412, ESDI, SCSI, IDE(ATA/XTA) and EIDE(ATA2).

Data Encoding Method

- Determines how densely data can be packed onto a track. MFM encoding is sufficient for only 17 x 512 byte sectors per track. RLL permits up to 27 and variations of ARL allow 34 or more sectors per track. This recording density is a major determinant of storage capacity, and with rotation speed and interleave are critical factors for true data transfer capability.

Support for Translation

- Some controllers present different logical parameters to the PC than the actual physical geometry of the drive.

Need for ROM Extension or Software Device Driver

- Additional program code is used to provide support for hard drives

when none exists (as in PC/XTs), to implement translation schemes (as in ST506/RLL and ESDI designs), allow for non-standard devices or features (SCSI), or for a combination of these (EIDE).

Below is a quick list of the major combinations that have been used in PCs past and present. While I am sure many others could be added, these are the ones I have come across over the years.

Computer	Bus Connection	Interface	Encoding	Translate	ROM
PC/XT	8 bit ISA Controller	ST506/412	MF	NO	YES
PC/XT	8 bit ISA Controller	ST506/412	RLL	OPTION	YES
AT	16 bit ISA Controller	ST506/412	MF	NO	NO
AT	16 bit MCA Controller	ST506/412	MF	NO	NO
AT	16 bit ISA Controller	ST506/412	RLL	OPTION	YES
AT	16 bit MCA Controller	ST506/412	RLL	YES	YES
AT	16 bit ISA Controller *	ESDI (10 Mbps)	RLL	OPTION	YES
AT	16 bit ISA Controller *	ESDI (24 Mbps)	ARLL	OPTION	YES
AT	16 bit MCA Controller **	ESDI (PS/2)	RLL,ARLL	YES	YES
PC/XT	8 bit ISA Adapter	SCSI	RLL	YES	YES
AT	16 bit ISA Adapter	SCSI	RLL,ARLL	YES	YES
AT	?? bit MCA Adapter ***	SCSI	RLL,ARLL	YES	YES
AT	32 bit EISA Adapter	SCSI	RLL,ARLL	YES	YES
AT	32 bit VLB Adapter	SCSI	RLL,ARLL	YES	YES
AT	32 bit PCI Adapter	SCSI	RLL,ARLL	YES	YES
PC/XT	8 bit ISA Adapter	IDE / XTA	RLL	OPTION	YES
AT	16 Bit ISA Adapter	IDE / ATA	RLL,ARLL	OPTION	NO
AT	32 Bit VLB Adapter	EIDE / ATA2	ARLL	OPTION	YES
AT	32 Bit PCI Adapter	EIDE / ATA2	ARLL	OPTION	YES

- * ESDI drives have some of the controller logic built onto the hard drive PCB and some on the controller card.
- ** PS/2 ESDI uses the same physical interface as other ESDI devices, but supports additional features specific to their implementation.
- *** 16 bit? 32 bit? Who knows? I have never been sure.

Not to mention hundreds of other combinations to support different interleaves, track buffers, hardware caching, bus mastering, error correction schemes, SCSI I-II-III, optional floppy control, ESDI to SCSI converters, ST506 to SCSI converters (etc., etc., etc.).

So, what does all this mean to you?

Specifically, don't be surprised if the drive you have in your left hand, does not work correctly with the controller / adapter you have in your right hand. Also, if controllers are changed it may affect performance as well as the ability to access previously recorded data.

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 END OF CHAPTER 2
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How to deal with some of this confusion will be addressed in CHAPTER 3 - Installing and Configuring Hard Drives.

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ADDITIONAL READING MATERIAL:

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I have always had difficulty finding appropriate reading material to recommend, but there are a few sources that I consider a must for technicians and support personnel.

First, a number of Internet Newsgroups have exceptional FAQ's (Frequently Asked Questions) which are updated and posted on a regular basis. These include:

"YET ANOTHER ATA-2/FAST-ATA/EIDE FAQ"
by John Wehman and Peter Herweijer
Newsgroup : comp.sys.ibm.hardware.storage

"BIOS TYPES"
by Hale Landis
Newsgroup : comp.sys.ibm.hardware.storage

"SCSI FAQ - 2 Parts"
by Gary A. Field
Newsgroup : comp.periphs.scsi

While bookstores are full of titles, most of them simply provide a rehash of basics. The following two books are an important part of my library because they cover much more than the usual:

"THE INDISPENSABLE PC HARDWARE BOOK" by Hans-Peter Messmer (1994)
Addison-Wesley Publishing Company,
ISBN - 0-201-62424-9

"THE UNDOCUMENTED PC" by Frank Van Gilluwe (1994)
Addison-Wesley Publishing Company,
ISBN - 0-201-62277-7

Other books well worth the read include:

"THE HARD DISK SURVIVAL GUIDE" by Mark Minasi (1991)
Sybex Inc.,
ISBN - 0-89588-799-1

A little dated, but full of useful information. Hopefully there is a revised and updated version.

"OFFICIAL SPINRITE II AND HARD DISK COMPANION" by J. M. Goodman, (1990)
IDG Books Worldwide, Inc.,
ISBN - 878058-08-8
Current advances are not covered, but great explanation of drive basics.

"HARD DRIVE BIBLE" by Martin Bodo (1993)
Corporate Systems Center (CSC)
My copy is the sixth edition from April, 1993. The first 50 pages of the book should be of interest (though not always clearly organized). The balance of the book (150 pages) is a listing of drive types and jumper settings. It's quite good, but keeping something like that updated is virtually impossible.

WARNING - DO NOT BUY - "The Data Recovery Bible" by Pamela Kane.
Poorly organized material, most of which has nothing to do with data recovery. Waste of a good title if you ask me!

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ACRONYM DEFINITIONS:
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IRQ (Interrupt Request) - Lines on the bus used to signal hardware interrupts.

I/O (Input Output) - Peripherals accessible by the CPU through registers at specific I/O addresses (or I/O ports).

PIO (Programmed Input Output) - Exchange of data between memory and peripherals by means of Input Output commands.

DMA (Dynamic Memory Access) - Transferring data directly between memory and peripherals without going through the CPU.

BUS ARCHITECTURES:

ISA (Industry Standard Architecture) - 8 bit and 16 bit expansion slots used by PC, XT, and AT designs. Often called IBM Standard Architecture.

EISA (Extended Industry Standard Architecture) - Developed by several independent manufacturers (Compaq, AST, Zenith, Tandy, etc.) to standardize 32 bit operation and combat IBM's MCA.

MCA (Micro Channel Architecture) - Expansion bus introduced by IBM in 1987, used by some (but not all) PS/2 models.

PCI (Peripheral Component Interconnect) - High speed bus developed by Intel to support the demands of Pentium and 486 based computers.

VLB (VESA Local Bus) - High speed, 32 bit extension to the ISA bus promoted by the VESA (Video Electronics Standards Association).

DRIVE INTERFACES:

ST506/412 - Standard interface used on XT and AT drives and controllers. Originally developed by Seagate Technologies to support their ST506 (5 MB) and ST412 (10 MB) drives. The entire controller mechanism is located on a controller card and communications between the drive and controller flow over 2 ribbon cables - one for drive control and one for data.

ESDI (Enhanced Small Device Interface) - Developed by Maxtor in the early 1980's as an upgrade and improvement to the ST506 design. While the drive does not have an embedded controller, one of the most critical functions, encoding-decoding, is performed on the drive. This allows for faster communications and higher drive capacities. Uses the same cabling as ST506 interface, but carries different signals on each line.

SCSI (Small Computer System Interface) - Based on an original design by Shugart Associates, SCSI is not specifically a drive interface, but a method of allowing different devices to communicate with a PC. For hard drives the entire controller is built onto the drive PCB, allowing for very high speed transfers to and from the drive. Fully interpreted, parallel data is then transferred to and from the PC by way of a single cable through a bus interface that has configured the device as a hard drive.

IDE (Integrated Drive Electronics) - A technology pioneered by Compaq

and Conner that embedded a controller onto the hard disk PCB while maintaining compatibility with the register level commands sent by the computer's INT 13 routines. IDE drives are configured and appear to the computer like standard ST506 drives.

ATA (AT Attachment) - Implementation of the IDE design with a 16 bit AT style controller on board the drive.

XTA (XT Attachment) - Rarely used implementation of IDE with an integrated 8 bit XT controller.

ATA-2 - Enhancement to the AT Attachment standard to provide for considerable performance improvement and more sophisticated drive identification.

EIDE (Enhanced IDE) and FAST-ATA - Various implementations of the ATA-2 standard as marketed by Western Digital (EIDE) and Seagate/Quantum (FAST-ATA).

DATA ENCODING SCHEMES

MFM (Modified Frequency Modulation) - Common technique used to encode the magnetic fluxes recorded on a drive into data. Still used on floppy drives and most original XT and AT systems. Notice that most drive types supported in CMOS have 17 sectors per track. This is the standard density for MFM encoding.

RLL (Run Length Limited) - Encoding method that allows 50% more information to be recorded on a track than MFM. Actually accomplished by recording more fluxes for every byte, but packing them more tightly onto the surface. Often called 2,7 RLL because the recording scheme involves patterns with no more than 7 successive zeros and no less than two.

ARLL (Advanced Run Length Limited) - More complex yet powerful derivatives of the RLL scheme. Include 1,7 and 3,9 encoding.

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